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Drought Mitigations Measures on Cuvelai Watershed

Arlon André[1,2], Quissengo Viegas[2], and Ana Tati[2]

1. Civil Engineering Department, Hydraulics, Water Resources and Environment Division, Faculty of Engineering, University of Porto, Portugal

2. Group of Hydrology and Water Resources, Faculty of Engineering, Agostinho Neto University, Angola

Abstract: This research aims to characterize the drought phenomena and water scarcity in Angolan agriculture, specifically in the Province of Cunene where the Cuvelai Watershed is located, and to also analyze the impacts on crop yield. Several precautions should be taken to mitigate the adverse effects of drought and water scarcity. Drought commonly forms part of the Angolan climate, as recently, it depicted that plenty of cities are drastically affected by too long periods of drought due to a lack of precipitation. To analyze the drought levels in the Watershed, two (2) drought indexes namely SPEI and SPI were used, allowing the calculation of both the Hydrological and Weather Drought Category, the Alert Level as well as the Level of Intervention. Certain measures used to amend drought include modernization of existing irrigation systems, soil restoration, crop rotation, effective use of irrigation water, rehabilitation, and optimization of water distribution, thus, to achieve this goal, big-scale water retention projects, and irrigation development programs are implemented in many provinces of Angola; The need to increase water supply in Angola is intensifying, thus there is an urge to improve uniform national drought and water scarcity mitigation plans with inclusion of prevention, guidelines to counteract the effects. To solve the numerous water scarcity problems in agriculture, the most appropriate Contingency and Mitigation Measures for the Cuvelai watershed should be taken and together with the issue recommendations are to be applied in vigor.

Key words: agriculture, drought, mitigation, water scarcity

1. Introduction

Drought is defined as a temporary decline in average water availability due to a lack of rainfall, occurring naturally or caused by human wrong agricultural practices and activities. Drought is considered a temporary natural phenomenon and is defined as lower than average or usual water availability [1].

Water scarcity occurs when water resources are inadequate to meet average long-term needs. It refers to long-term water imbalances, combining low water availability with a level of water demand higher than the supply capacity of the natural system [2]. Water scarcity is inextricably linked to different types of droughts (meteorological, soil, hydrological, agricultural).

Drought can sometimes be mistaken for water scarcity. Their characterization is somehow controversial and not consensual, some scientists, engineers, experts, and policymakers consider drought to be water scarcity; others point out that water scarcity is due to drought, or prefer to simply write about drought water scarcity. The two concepts differ from each other as there are plenty of differences and in this research, agricultural water scarcity is presumed to be caused by meteorological droughts and is treated as agricultural droughts defined and quantified by soil moisture. Water deficit and stress affecting crop growth and productivity [3]. The frequency and severity of droughts have increased in recent years and are very likely to increase in the near future due to projected climate change [4]. There is an urgent need for reliable information on the effects of drought and how to mitigate the threat of drought. To amend the risks and impacts of drought, Contingency and

Corresponding author: Arlon André, Ph.D., E-mail: engaaa-hidraulica@outlook.com

Mitigation Measures for the Cuvelai Watershed are to be implemented in vigor. The overall objective the Contingency and Mitigation Measures is to support regional initiatives through the implementation of preparedness and mitigation measures; the norms stipulated on it contain the following elements: drought-related data and information on its formation, exposure and impacts; a set of drought countermeasures for various applications based on readily available information; drought assessment and forecasting methods; drought risks and vulnerabilities; identification of the drought management approach (immediate response or decrease vulnerability) to recover or mitigate the direct and indirect impacts of drought in economic, environmental and social contexts [4]. The same or similar approaches and elements should apply to water scarcity. As part of the norms stipulated by the Contingency and Mitigation Measures, a recommendation is made for the operational support system for drought risk management. These recommendations should be sectoral. They can be seen as guidelines that aim to leverage the entire work experience. Providing integrated policies to mitigate water scarcity is a step towards establishing drought management policies.

The challenge in developing a drought risk management scheme is the integration of different approaches and concepts from different national, regional, and sectoral contexts. Recommendations on how to assess drought risk, how to mitigate drought impacts, and create a catalog of mitigation tools are the frameworks for drought risk management. The general objective of the study is to define and indicate possible actions and mitigation measures with the aim of minimizing water scarcity in agriculture and its impacts in the context of practical experiences of using different methods and tools.

2. Study Area

The study area is the Cuvelai Watershed, located in Angola, in the Cunene province, municipality of Cuvelai in the Mucolongodijo capital consisting of 16,270 km² and about 48 thousand inhabitants.

The climate on climate of the Cuvelai Watershed is tropical and dry or semi-arid; its agriculture is described between the channels on higher ground there are cambisols and calcisols that have formed as a reworked mixture of alluvial and aeolian sediments. These soils are therefore not very dense or clayey; They are also not too sandy, infertile, and porous. The presence of this combination is essential for a large part of the population of Cuvelai, as it provides fertile soils for agriculture. Together with fresh water from shallow wells or ponds, these soils have been attracting populations to settle and practice agriculture, for 500 or 600 years.

3. Material and Methods

3.1 Impacts of Water Scarcity in Agriculture

The negative effect of droughts and water scarcity in the Cuvelai watershed is complex and can be observed in various branches of the national economy. It is particularly visible in agriculture. Most commonly, agricultural drought is defined as the lack of soil moisture in a particular crop at a particular time or time, affecting crop productivity and resulting in a significant reduction in crop productivity. Decreased productivity is the end result of a lack of soil moisture and is highly dependent on the duration and intensity of the drought. Soil drought and a lack of soil moisture have a negative impact on crops, but the impact depends on the crop, soil, and geographic region.

3.2 Vulnerability to drought and drought risk

In the definition of risk, three determinants are considered: danger, exposure, and vulnerability [5], hazard refers to the possible occurrence of natural or human-induced physical events that may have adverse effects on vulnerable and exposed elements; Exposure refers to the inventory of the elements of the area where hazardous events may occur. Vulnerability refers to the tendency of exposed factors, such as people, their lives, and property, to be negatively affected when impacted by risk events; it also shows the degree of societal susceptibility to a hazard, which can vary both as a result of coping skills, which include protection and mitigation, and as variable exposure to danger. The purpose of vulnerability assessment is to identify appropriate actions that can be taken to reduce the vulnerability before the potential for harm is realized [6]. Taking into account the definition of vulnerability formulated in relation to the impacts of climate change [7-9], drought vulnerability can be defined as the degree to which a system is susceptible or unable to cope with the adverse effects of drought.

In the event of drought, crop vulnerabilities depend on several parameters. The Cuvelai region consists of Xerophytes (plants that have morphological and physiological features to adapt to an environment with scarce water like in deserts) and crops that adapt to water stress and its growing environment (soil, climate, water available in the soil). Due to the complexity of the vulnerability issue, assessments are often subjective and vary by region and exposure. DOWNING and [10] Water scarcity mitigation measures can be divided into three groups, depending on the time of implementation (actions): operational — carried out when the drought begins and during its duration; short-term — carried out before the drought up to 5 years in advance; long-term — carried out in a long-term perspective of up to 25 years.

Mitigation measures of both SPI and SPEI indexes are as shown below in the flowchart Fig. 1, with an inclusion of the identification of droughts that consists of the data survey which is divided into both drought indexes alert levels and finally resulting in the contingency monitoring measures as shown in Table 1.

Among the operational actions, the most important and commonly used are irrigation, control of water management in a river basin, control of flow in rivers, and control of water withdrawal from rivers and lakes. Short-term measures that should be taken mainly at the local level include adjustment actions to optimize agricultural production without major systemic changes in the agricultural production system. Key actions and measures should help achieve the strategic objectives, as drought and adverse climate change may increase water scarcity in agriculture. Gain of local water resources and their availability, increased efficiency in the use of water, decrease in water needs for crops, intensification of irrigation (irrigation of larger surfaces). To achieve these objectives, the following measures stand out: Increasing the retention of water (in open water) available for agriculture, mainly irrigation-Increasing the retention and availability of water in the soil for plants changes in the technology of using dry agricultural water, its impacts, and countermeasures; All the above-mentioned actions can lead to the achievement of different strategic objectives.

Where the operation of the facilities is adequate and the water supply is provided, the negative effects of droughts can be avoided and even higher productivity can be achieved. To achieve high efficiency of these systems during drought, systematic maintenance of ditches and plant networks during the pre-drought period is required. Lack of modernization and

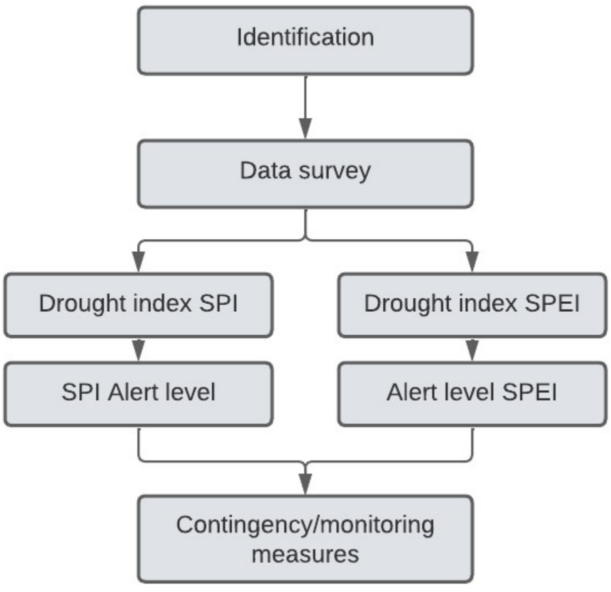

Fig. 1 SPI and SPEI Alert Levels, mitigation measures.

Table 1 Mitigation and contingency measures on the Cuvelai Region.

Contingency and Mitigation Measures for the Cuvelai Watershed				
Measures	**Action**	**Effects**	**Duration of the action and main objective**	**Sectoral Scope/Responsibilities**
Construction of small water retention reservoirs — Different small water retention measures	Increase the retention of water resources (in open waters) available for agriculture,	Adaptation of existing sources of small retention to agricultural needs, possibly extended in the future — more water available for irrigation Water abstraction from local reservoirs	Long-term short-term — Increasing local water resources and their availability	Monitoring of the drought situation with the creation of a work management committee to combat drought in the province of Cunene.
Soil cultivation technologies that increase soil moisture and water use (e.g., soil loosening, deep ploughing, organic fertilization)	Increase soil water retention and availability to plants	Improvement of the physical and water properties of the soil layers — increased infiltration — enlargement of the active layer of water absorption by the roots — deeper rooting	short-term increase in local water resources and their availability. increasing water efficiency and water use; decrease in the water needs of crops; intensification of irrigation	Intensification of awareness-raising campaigns; Publications in the local media; Application for Flight Warning and the interdiction measures adopted.
Modernization of irrigation and water distribution systems to increase their efficiency in water supply and drainage	Modification of water use technology in farms, fields, river basins	Increase water use efficiency through multiple water use — minimize useless water discharges from recovery systems, including drainage outlets — limit water consumption for evapotranspiration	Short-term operational increase in water use efficiency; decrease in the water needs of crops; intensification of irrigation	Increase in the withdrawal of existing groundwater in the Cuvelai Basin, when future recovery is guaranteed, through fundraising, the opening of new abstractions, and rehabilitation of abandoned abstractions. Considering the abolition of the closed season for some species of fish in reservoirs
Training – brochures, leaflets, bulletins – Internet – radio, television, newspapers	Improving social awareness of droughts, their effects and countermeasures	Raise awareness of drought issues and their mitigation	Short-term long-term operating All of the above	Enforcing the elimination or reduction of discharges into waterways that are highly vulnerable to pollution, through the use of retention dams

inappropriate use of systems and facilities limit competent water management and lead to reduced agricultural production. Proper use of systems and equipment can improve effective water management and yield stability in irrigated areas. Decision support systems can also play an important role in effective irrigation performance.

Currently, we are seeing an increase in the irrigated area, particularly the drip cultivation of vegetables and fruits. The development of this type of irrigation is expected to accompany the development and strengthening of agriculture. The increase in the frequency and intensity of droughts, the intensification of agricultural production, the imposition of internal and free market competition across Europe, and the need to achieve high quality. Often, the impediment to irrigation is water scarcity due to the simultaneous drying up of rivers and low groundwater levels, resulting in reduced available capacity. of lakes and retention reservoirs. So, the important role in water management is the regulation of flows, which consists of creating favorable conditions for water retention and controlling water discharge in the periods. Excess water after spring and heavy precipitation, that is, when water is retained in a soil network and drains. This can be achieved by the construction of small water retention reservoirs and small dams that flow water through small water structures to restrict the flow of water from the fields [11].

Drainage also plays a large role in mitigating the negative effects of droughts on crop yields. The role of drainage is to lower the water table at the spring, which allows fieldwork to be started earlier and therefore earlier plant growth and root development, allowing root systems to absorb water from the deeper parts of the soil during drought conditions. Excess water after spring and heavy precipitation, that is, when water is retained in a soil network and drains. In plant technologies, processes should be recommended to obtain the beneficial effects of plant growth under drought conditions. The economic losses resulting from the decrease in productivity can be minimized with the introduction of rooted plants with low water requirements in the most affected regions. Growing climate-resistant or climate-resistant varieties, using fertilizers, and providing adequate water will help farmers combat the effects of water stress. New plant varieties, seasonal changes, and sowing times are the adaptation methods used. Fertilizer application, sufficient planting density, cultivation methods, small-scale field retention measures, and other field operations are all adaptation methods used to reduce the effects of water scarcity on agriculture. Agricultural recovery measures, especially soil loosening and deep plowing can also mitigate the negative effects of drought. These measures consist of improving the soil structure and the physical and water properties of the deeper layers of the soil, which enables deeper rooting of plants and increases the amount of water available to plants.

Among the operational actions, the most important and commonly used are irrigation, control of water management in a river basin, control of flow in rivers, and control of water withdrawal from rivers and lakes. Short-term measures that should be taken mainly at the local level include adjustment actions to optimize agricultural production without major systemic changes in the agricultural production system. Key actions and measures should help achieve the strategic objectives, as drought and adverse climate change may increase water scarcity in agriculture. Gain of local water resources and their availability, increased efficiency in the use of water, decrease in water needs for crops, intensification of irrigation (irrigation of larger surfaces). To achieve these objectives, the following measures stand out: Increasing the retention of water (in open water) available for agriculture, mainly irrigation-Increasing the retention and availability of water in the soil for plants changes in the technology of using dry agricultural water, its impacts, and countermeasures; All the above-mentioned actions can lead to the achievement of different strategic objectives.

Where the operation of the facilities is adequate and the water supply is provided, the negative effects of droughts can be avoided and even higher productivity can be achieved. To achieve high efficiency of these systems during drought, systematic maintenance of ditches and plant networks during the pre-drought period is required. Lack of modernization and inappropriate use of systems and facilities limit competent water management and lead to reduced agricultural production. Proper use of systems and equipment can improve effective water management and yield stability in irrigated areas. Decision support systems can also play an important role in effective irrigation performance.

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However, it also has some negative effects, as it reduces the up flow of water and increases deflation. In addition, various technical, recovery, hydrological and anti-erosion measures can be used, which mitigate the negative effects of droughts on agriculture. They help improve watersheds, recultivation systems, water circulation, and water balance in the soil. They should lead to changes and optimization of productive use of space, changes in crop rotation, selection of appropriate drought-tolerant plant species and cultivars, and changes in agricultural technology. It is desirable to establish a list of drought-tolerant plant varieties that are commonly grown in a given area. All of them can greatly restrict the negative effects of droughts in a given area. One of the basic precautions is drought forecasting and early warning. Forecasting and early warnings are of great importance in planning and preparing for actions to avoid or minimize the negative effects of droughts. There is a strict link between water management in agriculture, particularly with the status of land reclamation (improvement) and the actual determinants of abundance activities against drought and water scarcity in Angolan agriculture The basic reasons for the restricted possibilities of drought fighting in agricultural areas lie in the neglect of the proper use of agricultural water systems and recovery systems and facilities. Improving the management, operation, and maintenance of these systems will make mitigation measures more effective. There are certain risks, restrictions, harvests, and income losses to consider.

4. Results and Discussion

4.1 Actions and Measures for Drought and Water Scarcity

The measure to evaluate the Mitigation Measures Drought and water scarcity mitigation actions in Cuvelai should be identified within pre-impact programs aimed at reducing vulnerabilities and impacts [12]. A number of measures can be recommended, all of which are means to achieve strategic objectives and control the negative effects of water scarcity on the people living in Cunene specifically at the Cuvelai, agriculture (crops, animals' plants, trees), infrastructure.

The values of SPI (Standardized Precipitation Index) of the drought series can be classified according to the drought intensity degree as shown aside in Table 2. As per the SPI results attained, the droughts in Cuvelai read as -2.00 to -2.99; the depiction of the drought alert level illustrated in Table 3, show that both the Hydrological Drought Category and the Weather Drought Category for all the years is extreme drought and moderate drought; the Alert level is Pre-Alert with an Intervention Level A.1.

Table 2 Classification table for dry conditions SPI (Font: Palmer 1965).

0.99 to -0.99	Approximately normal
-1.00 to -1.99	Slightly dry
-2.00 to -2.99	Moderate drought
-3.00 to -3.99	Severe drought
≥ -4.00	Extreme drought

Table 3 SPI drought alert level.

Years	Hydrological Drought Category	Weather Drought Category	Alert Level	Intervention Level
1998 to 2003	extreme drought	Moderate drought	Pre-Alert	A.1
2004 to 2009	extreme drought	Moderate drought	Pre-Alert	A.1
2010 to 2015	extreme drought	Moderate drought	Pre-Alert	A.1
2016 to 2020	extreme drought	Moderate drought	Pre-Alert	A.1

The intervention for the moderate drought Alert Level 1 for the Cuvelai Basin of the SPI index is expected to trigger voluntary drought mitigation measures with information and control measures, including reductions in water consumption as described below.

- Creating awareness campaign in the Cuvelai Municipality for the possible drought situation, appropriate to the local reality and aimed at voluntary water saving in the different sectors, in addition to national campaigns;
- Reinforcement of supervision in catchment protection areas in Cuvelai;
- Verification of the functioning of necessary resource infrastructure in drought situations for the Municipality of Cuvelai.

The values of SPEI (Standardized Precipitation Evapotranspiration Index) of the drought series can be classified according to the drought intensity degree as shown below in Table 4. As per the SPEI results attained, the droughts in Cuvelai read as -2.00 or less; the depiction of the drought alert level illustrated in Table 5, show that both the Hydrological Drought Category and the Weather Drought Category for all the years is extreme drought and extremely dry; the Alert level is Pre-Alert and classified as A.2.

Table 4 Classification table for dry conditions SPEI (adapted from Loukas and Vasiliades 2010).

2.00 or more	Extremely wet
1.00 to 1.99	Severely wet
0.00 to 1.00	Normal (wet)
-1.00 a 0.00	Normal (dry)
-1.99 a -1.00	Severely dry
-2.00 or less	Extremely dry

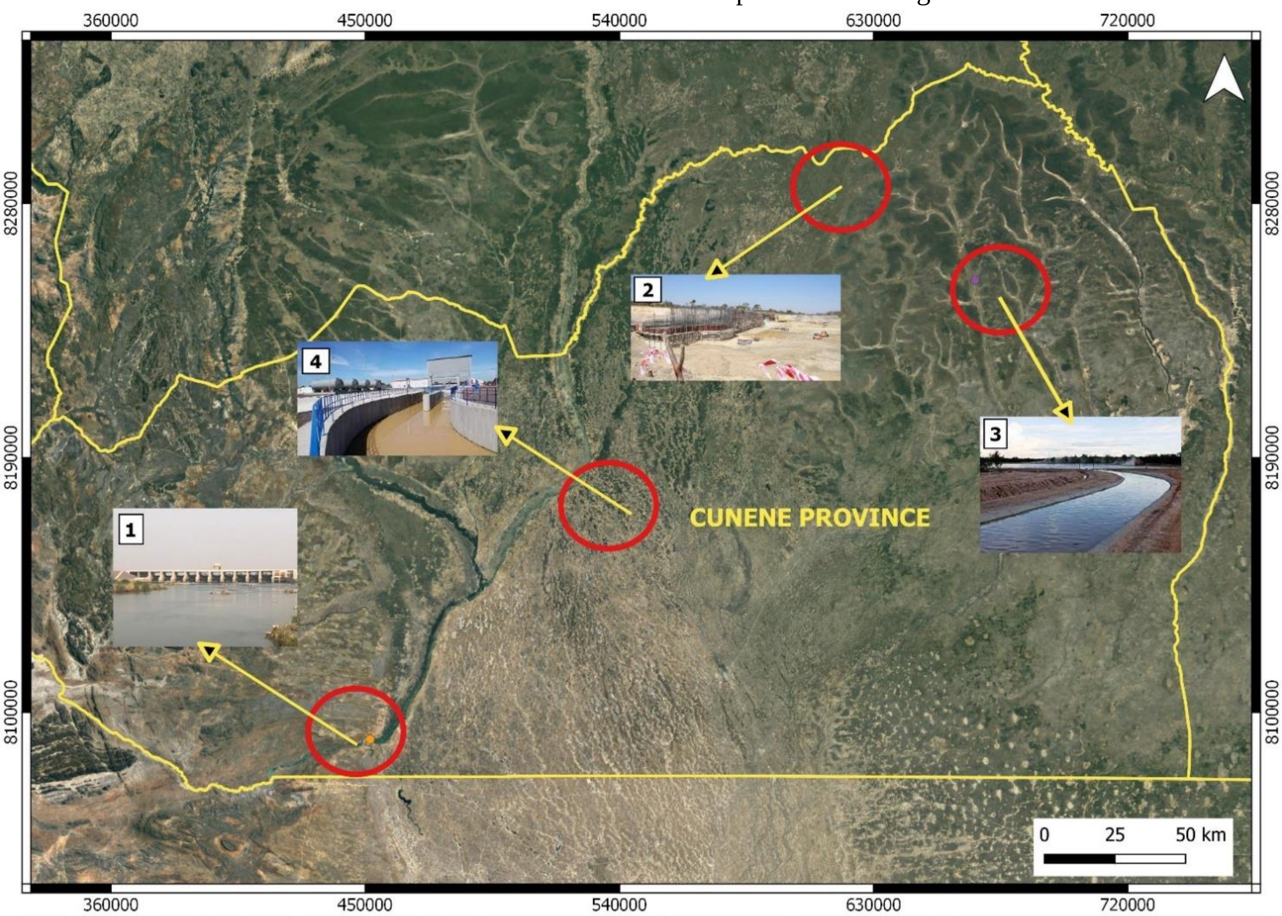
Table 5 SPEI drought alert level 2.

Years	Hydrological Drought Category	Weather Drought Category	Alert Level	Intervention Level
1998 à 2003	extreme drought	Extremely dry	Pre-Alert	A.2
2004 à 2009	extreme drought	Extremely dry	Pre-Alert	A.2
2010 à 2015	extreme drought	Extremely dry	Pre-Alert	A.2
2016 à 2020	extreme drought	Extremely dry	Pre-Alert	A.2

The intervention for Severe Drought Alert Level 2 of the SPEI index for the Cuvelai Watershed entails the imposition of restrictive measures on some water usage and practices and the reinforcement of controls as described below.

- Intensification of awareness-raising campaigns with dissemination in the media of the Cuvelai region requesting leakage warnings and the interdiction measures adopted;
- Increased groundwater abstraction in Cuvelai Municipality, to grant future recovery through resource abstraction, opening of new abstractions, or recovery of abandoned abstractions;
- Adequacy of the frequency of water quality in the Cuvelai region accounting for the control and adaptation of the treatment systems to the quality of the sources or receiving media (where necessary).

Plenty of projects on drought mitigation measures were carried out in Angola with the objectives to, serve the population of Cunene, the region of Cuvelai in terms of irrigation systems, livestock and human needs and Consumption after treatment, Supply water to Namibia, and lastly, serve the population of Quilengues; along with the research done on the drought alert levels using the two indexes SPI and SPEI as shown below, Fig. 2 tabulates all the projects done in some provinces of Angola.



1 - Construction of the Elevation System of the Calueque Dam in the Commune of Naulila Povoação de Calueque
2 - Construction of the 128 Calucuve Dam and its Adductor Canal in the municipality of Cuvelai, municipality of Calucuve
3 - Construction of N´due Dam 71 and its Adductor Canal
4 - Construction of the Water Transfer System from the Cunene River, in the Cafu section, to supply the Oshanas area, mainly to the towns of Namacunde and Cuamato

Fig. 2 Google Art image on plenty projects in Angolan Provinces on drought mitigation measures.

5. Conclusion

Actions and measures to mitigate the effects of droughts and water scarcity in the Cuvelai region, as well as uncertainties about how the climate will change and how it will influence agriculture Challenges faced by planners, planners, farmers, agriculture and extension services. From the calculation of both drought indexes SPI and SPEI it was noted that, for SPI the Cuvelai region is prone to moderate drought conditions under the weather drought category with a result of -2.00 to 2.99, and for the SPEI it was noted that region is prone to extremely dry conditions under the weather drought category with a result of -2.00 to less. The research also entailed how agriculture and agricultural water management need to adapt to climate change is a serious question to be answered in the near future. All of the above-mentioned actions and measures were addressed by the Contingency and Mitigation Measures norms for drought control, to mitigate its effects, water scarcity and observed climate change, as well as the adaptation of agriculture and agricultural water management to predicted climate change. Considering the measures designed to limit the adverse effects taken in Cuvelai during the drought, it can be concluded that the system constitutes of a consistent system and a partial drought control strategy.

There is momentum to implement and improve uniform national plans for water scarcity and drought mitigation. including a national water-saving policy and its legislation. Further work can be expected to result in documents providing for the implementation of regional small-retention development programs and irrigation development programs.

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