Kadirli Uygulamalı Bilimler Fakültesi Dergisi
Cilt 2, Sayı 2, 281-305, 2022

Journal of Kadirli Faculty of Applied Sciences
Volume 2, Issue 2, 281-305, 2022

Kadirli Uygulamalı Bilimler Fakültesi Dergisi

Journal of Kadirli Faculty of Applied Sciences

Reviewing the Impact of the Interventions to Reduce Water Scarcity in Farming Practices

Rophinah T. LEBEPE[1], Marizvikuru MWALE[2]*, Simbarashe KATIVHU[3], Jethro ZUWARIMWE[4]

[1-4]Institute for Rural Development, Faculty of Science, Engineering and Agriculture, University of Venda, P. Bag X5050, Thohoyandou, South Africa

[1]https://orcid.org/0000-0001-7687-2698
[2]https://orcid.org/0000-0002-8042-6014
[3]https://orcid.org/0000-0001-8076-3021
[4]https://orcid.org/0000-0002-8196-5896
*Corresponding author: mukudzeishe@yahoo.com

Review Article

Article History:
Received: 11.12.2021
Accepted: 23.04.2022
Published online: 09.12.2022

Keywords:
Agriculture
Climate change
Crop farming
Water scarcity
Water conservation

ABSTRACT

Water scarcity is constraining socio-economic development and threating livelihoods the worldover. Increasing water scarcity exerts pressure on agricultural production given current and growing food demands. Without water, farm production decreases and food security is negatively impacted. Hence, this paper reviews an array of literature focusing on interventions implimented to reduce effects of the scarcity of water among crop farmers. Publications and reports between 1999 and 2021 were reviewed to isolate and establish trends of water scarcity challenges and interventions. Key terms such as agriculture, water scarcity, crop farming, climate change and water conservation were used to identify appropriate material. 210 articles were identified from search engines like EBSCOhost, Science Direct, Google Scholar, Emerald, African journals online and Sabinet. Only 109 articles were relevant to the review paper questions which included identifying the causes of water scarcity and interventions used by farmers. It was discovered that most of the interventions utilised were survivalist in nature as they did not translate to increased productivity. Hence, the need for transformative interventions to water security was apparent. If no external assistance, farmers may not continue producing sufficient food to meet the demand of the ever increasing human population. This could jeopardise the achievement of sustainable development goals such as zero hunger by 2030 and reduced poverty.

Tarım Uygulamalarında Su Kıtlığını Azaltmaya Yönelik Müdahalelerin Etkisinin Gözden Geçirilmesi

Derleme

Makale Tarihçesi:
Geliş tarihi: 11.12.2021
Kabul tarihi:23.04.2022
Online Yayınlanma: 09.12.2022

Anahtar Kelimeler:
Ziraat
İklim değişikliği
Tarla tarımı
Su kıtlığı
Su tasarrufu

ÖZ

Su kıtlığı, sosyo-ekonomik kalkınmayı kısıtlamakta ve tüm dünyada geçim kaynaklarını tehdit etmektedir. Artan su kıtlığı, mevcut ve artan gıda talepleri göz önüne alındığında tarımsal üretim üzerinde baskı oluşturmaktadır. Su olmadan çiftlik üretimi azalır ve gıda güvenliği olumsuz etkilenir. Bu bağlamda bu makalede, mahsul çiftçileri arasında su kıtlığının etkilerini azaltmak için uygulanan müdahalelere odaklanan bir dizi literatür gözden geçirilmiştir. Bu amaçla 1999 ve 2021 yılları arasındaki yayınlar ve raporlar, su kıtlığı sorunları ve müdahalelerine ilişkin eğilimleri belirlemek ve izole etmek için gözden geçirilmiştir. Uygun materyalleri belirlemek için tarım, su kıtlığı, mahsul çiftçiliği, iklim değişikliği ve su koruma gibi anahtar terimler kullanılmıştır. Bu kapsamda EBSCOhost, Science Direct, Google Scholar, Emerald, Afrika çevrimiçi dergileri ve Sabinet gibi arama motorlarından 210 makale tespit edilmiştir. Su kıtlığının nedenlerini ve çiftçiler tarafından kullanılan müdahaleleri tanımlamayı içeren inceleme makalelerinden yalnız 109 makale araştırma soruları içeriyordu. Kullanılan müdahalelerin çoğunun, üretkenliği arttırmadığı sadece doğaları gereği hayatta kalmaya yönelik oldukları keşfedilmiştir. Bu nedenle, su güvenliğinde dönüştürücü müdahalelere duyulan ihtiyaçların belirgin olduğu gözlendi. Sonuç olarak; dış yardım olmazsa, çiftçiler sürekli artan insan nüfusunun talebini karşılamak için yeterli gıda üretmeye devam edemezler. Bu durum, 2030 yılına kadar sıfır açlık ve yoksulluğun azaltılması gibi sürdürülebilir kalkınma hedeflerine ulaşılmasını tehlikeye atabilir.

To Cite: Lebepe RT, Mwale M, Kativhu S, Zuwarimwe J., 2022. Reviewing the impact of the interventions to reduce water scarcity in farming. Kadirli Uygulamalı Bilimler Fakültesi Dergisi, 2(2): 281-305.

Introduction

Ganoulis (2018) defined water scarcity as the lack of adequate water to meet all water requirements and the lack of adaption to associated critical water disasters. Water plays a fundamental role in agriculture. It is an essential component of plant tissues and animal cells (Wang et al., 2020). Successful agriculture that enables farmers to provide food for the fast-growing population is dependent upon access to sufficient quality water (Schyns et al., 2019). Farmers across the world are increasingly facing water scarcity challenge and this is due to both natural and human causes (Doh et al., 2019). Common causes of water scarcity discussed in this paper include drought, water pollution, water overuse, overpopulation and climate change.

This review paper unpacks the causes of water scarcity that hamper agriculture and strategies that are implemented by crop farmers to reduce the effects of water scarcity. Having a clear understanding of the causes of water scarcity is important because it will help water users including farmers and different industries to guard against using water unsustainably. It will also be of great importance to world leaders and policymakers in finding solutions to conserve and protect water resources. The paper is a systematic review that refers to the process in which a body of literature is aggregated, reviewed and assessed in a logical manner (Shea et al., 2007). The goal is to identify, appraise, and summarise the existing evidence concerning a clearly defined problem (Shea et al., 2007). It also evaluates the consistency and generalization of the evidence regarding the specific objective of a study (Shea et al., 2007).

Materials and Methods

Water scarcity causes and ways commonly used to deal with its effects were identified and assessed from peer-reviewed literature in different and similar environments. Publications and reports between 1999 and 2021 were reviewed to isolate and establish trends of water scarcity challenges. The search parameters used were all the frequently used terms related to agriculture, water scarcity and crop farmers. A total of 210 articles were identified from search engines such as Ebscohost, Science Direct, African Science Journals, Google scholar and Sabinet. Only 109 articles were relevant to the review paper questions of identifying the causes of water scarcity and interventions for addressing water scarcity (Figure 1). Excluded articles included those that had research on the general effects of water scarcity, indicators of water scarcity and scarcity of water in other sectors other than agriculture. Not all manuscripts on water scarcity causes and mitigating strategies were exhausted.

Data was extratced from articles via Atlas. Ti Version 8.4 software and analysed thematically. Atlas. Ti is used in the analysis of huge texts, audios, and picture information scientifically (Panuccio, 2021). Data was arranged and categorized into themes of drought and farmers's response to drought; water pollution, its causes and farmers's response to water pollution; overpopulation, its effects and farmers's coping strategies; overuse of water for irrigation and farmers's management practices; and climate change, its effects and farmers's coping strategies. The data was categorized into themes using open, quick and In-Vivo coding. In-Vivo coding is instant coding of text that could be used as a major theme to explain related statements while open coding is the grouping of discreet variables that broadly explains a phenomenon (Panuccio, 2021). This process was repeated several times through the process of coding, decoding and recoding until emerging factors and their descriptive statements or items were developed. Furthermore, the process enabled the visualization of networks showing relationships between concepts and variables.

Drought and farmers' response to drought

According to Loon (2015), drought is the experienced prolonged period of dry weather. During such a period low rainfall is received and this subsequently causes a reduction of the quantity of water in aquifers. This subsequently leads to shortages of water thereby impacting agricultural activities. Drought may result in unavailability of water for quite some time. Water sources such as streams, ponds, rivers and lakes quickly dry up (John et al., 2019).

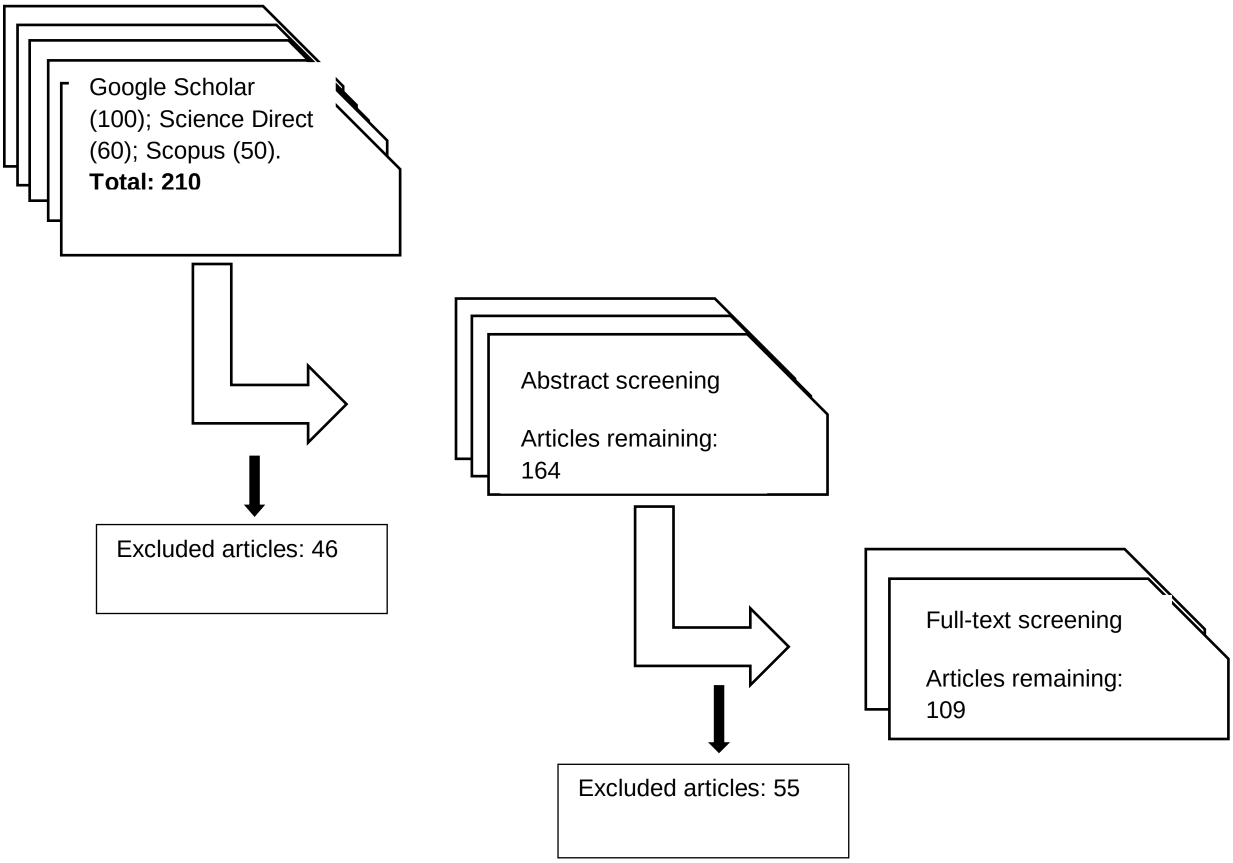

Figure 1. An illustration of the process of selecting relevant studies in a systematic literature review

Drought severely affects crop-livestock productivity (Loon, 2015). For instance, it negatively affects grazing lands leading to reduced forage for livectock (Ahearn, 2018). Poor grazing in turn hampers livestock growth and development. Livestock physical condition deteriorates and may lead to death (Ahearn, 2018). Because crops have different water requirements, Rasual (2016) state that some crops are capable of using water in efficient ways compared to others. Crops such as finger millet, cotton and sorghum can survive water stress compared to maize (Ray et al., 2018). Severe drought reduces yield of crops due to unavailability of water and moisture in the soil for crop growth and development (Rasual, 2016). Pribyl et al. (2019) state that if a drought occurs immedietaly after seeding, germination may not occur. The worst scenario and loss is experienced if drought occurs at later stages of crop development in which withering of the whole crop happens. The authors went further to state that in the event that there is enough moisture in the topsoil, seeding is promoted and the crops may thrive through to the harvesting stage due to availability of water in the sub-soil to sustain the plants through the remainder of their growth cycle (Pribyl et al., 2019).

Drought in China is the most severe natural disaster for socio-economic development and natural ecosystem due to the domination of typical East Asian Monsoon climate (Ali et al., 2020). Increasing temperature and less predictable weather patterns pose a serious challenge to Chinese farmers (Huang et al., 2014). According to Huang et al. (2014), drought affect nearly 800, 000 hectares of crops in north China. This being the case, farmers employ different strategies in order to cope with drought. Xia-Jun et al. (2012), stated that some of the strategies adopted by farmers to cope with drought includes: crop diversification and the adjustment of growing schedules. Farmers adjusted the time of planting crops and the type of crops based on the weather forecast. Furthermore, farmers adopted new irrigation technologies such as Sprinklers irrigation. Xia-Jun et al. (2012), stated that adoption of improved irrigation technologies could lead to cooler surface temperature and reduced water use intensity. In addition, farmers also make use of cover crops in order to protect the soil. According to Xia-Jun et al. (2012), there are several reasons that cover crops can increase soil moisture and reduce yield losses caused by drought. One reason is that cover crops help improve rainfall infiltration through an increased earthworm activity. Once the rain has soaked into the soil, it is more likely to stay in the root zone, partly because cover crop residue on the soil surface reduces evaporation (Xia-Jun et al., 2012). A study conducted by Xie et al. (2019) on the role of Chinese milk vetch as cover crop in complex soil indicated that the use of cover crop reduced soil erosion, increased fertility and improved water infiltration.

In India, drought is related to the scarcity of rainfall and mismanagement of water resources (Berchoux et al., 2019). The Indian economy is agrarian based and most people depend on agriculture and its related activities for their livelihood (Berchoux et al., 2019). Agriculture, in India, depends on the advent of the monsoon (Quamar, 2018). Showers from nature are an indispensable part of Indian Agriculture (Quamar, 2018). Deficiency in rainfall results in lower agricultural production which in turn adversely affects the economy and the gross domestic product (GDP) rate (Berchoux et al., 2019). Sharma et al. (2018) assert that agricultural activities account for about 14.6% of the country’s GDP and employment in the agricultural sector is around 45.5% of the rural population. In addition to this, 40% of the cultivable area in India is under irrigation. The impact of drought is thus catastrophic to the country. Majority of the population involved in agriculture are poor farmers who depend on rain for growing crops (Hans, 2018). The situation of drought affects the farmers who solely depend on the rains for the yield; especially concerning the crop like *Kharif*, rice, pulses and oilseeds (Hans, 2018). Therefore, it is clear that drought is one of the major challenges faced in the country, most especially in rural areas. It has a direct effect on agriculture and food production and indirectly affects livelihoods. It results in reduced incomes and economic losses.

In order to cope with drought, farmers in India use organic practices like the application of cow dung-based manures to increase the soil's ability to retain water (Das et al., 2017). As such, farmers indicated that about 2-5% water saving is possible due to these practices (Das et al., 2017). Furthermore, an Indian start-up has developed greenhouses to help farmers cope with droughts (Marcela, 2019). Greenhouses permit steady, year-round crop growth and development, while at the same time reducing water usage (Bonsignore and Vancate, 2017). This is key for offering a reliable alternative to traditional farming practices. The trapped moisture in greenhouses, solar radiation diffused and blocked wind help to maintain a controlled microclimate condition essential for protecting crops from the vulgaris of weather experienced in open-air conditions (Bartz et al., 2017). The authors further state that less water is required for producing crops in greenhouses but associated with high yields.

In Mozambique, drought affects agricultural activities of crop farmers, including the production of their stable crop maize. As such, drought affects the availability of food and income because most farmers depend on maize (Nagothu, 2018). Drought coupled with the predominant practice of using seed from selected previous season harvest agravates the effects of food insecurity in the country (Almekinders et al., 2019). Use of such seed is a good indigenous knowledge practice, however, such seed requires constant supply of water until the crop reaches maturity. Hence, drought negatively impact crop productivity (Almekinders et al., 2019). The application of mulch is widely used among crop farmers in Mozambique as a means to cope with drought. Mulching is considered to be one of the most beneficial practices a farmer can adopt to keep the farm healthy because the mulch prevents the excess sun from drying out the ground, which would otherwise cause the roots of the plants to become dry and need continuous watering (Kader et al., 2017). Hence, farmers make use of straw, plastic and wood chips mulch to retain more water in the soil during dry seasons (Zaman and Ladha, 2018). Furthermore, extension officers in different parts of Mozambique have trained farmers to maintain and operate the infrastructure for effective water use at several irrigation schemes (Goncalves, 2019). The Mozambican Ministry of Agriculture and Food Security has invested in water scarcity community awareness campaigns, water pollution, efficient use of water and possibilities of storing and reusing water (Goncalves, 2019).

Maize is a staple food in South Africa and is widely grown in the country (Dwivedi et al., 2017). The crop is grown by all types of farmers and so drought effects are felt across all farming sectors. In 2016, the commercial maize crop was estimated at 7,161 million tons which was a decrease of 2,794 million tons or 28,07% from the 2015 production season

(Setimela et al., 2017). The same authors indicate that in 2015 the estimates were 9,955 million tons, which was 49,75% or 7,089 million tons less than the 2014-crop of 14,250 million tons. The main cause of reduction in maize yield was attribted to severe drought. Hence, farmers are implementing different adaptation strategies to cope with drought.

Shifting to crops that require less water is among the most frequently used adaptation measures by farmers in South Africa (Elum et al., 2017). Tardieu et al. (2017) allude that drought-tolerant crops such as sorghum, cotton and finger millet have built-in features that help to use water efficiently. In some instances farmers innovatively used locally available material like plastic bottles for irrigating crops, resembling drip irrigation system (Ncube and Swikwambana, 2016). The single used plastic water bottle is hung above every plant with the rope in a multi-layer cultivation system. Water trickles down to the root zone and ensures availability of moisture in the soil for the entire day. The system has proven to conserve water and ensures that plants get a regular water supply without much wastage (Ncube and Swikwambana, 2016). It is particularly effective in areas where water is a scarce commodity. On the other hand, this system is not suitable for crops planted so close to each other and it is laborious. This is because the plastic bottles have to be refilled with water more often. Therefore, it is more suitable for small fields and unlike large fields (Mgolozeli et al., 2020).

Water pollution, its causes and farmers' response to water pollution

Water pollution is a huge problem worldwide. This is a situation where water bodies including rivers, oceans and streams, ground water included, are contaminated (Weldeslassie, 2018). Human activities epsecially result in the discharge of pollutants such as waste matter and harmful substances into water bodies leading to contamination. (Weldeslassie, 2018). This subsequently makes the water unsafe for use and subsequently scarce (Kabos et al., 2019). Agriculture is not only a victim but also a cause of water pollution. Major agricultural contributors to water pollution are residues of drugs, chemicals, pesticides, sediments, salts, organic carbon and some pathogens (Basnyat et al., 1999). Yadav and Sanjay (2018), explained that if higher quantities of fertilizers are applied in crop fields than required, residues remain unfixed by the soil particles or they are exported from the soil. Subsequently, leeching of excess nutrients occurs thereby leading to the development of algae and contamination of ground and surface water with nitrates (Yadav and Sanjay, 2018).

Several management practices implemented by farmers have been successful in protecting water quality. Farmers in China reduce the risk of water pollution by storing, handling, reusing and treating manure safely thereby preventing them from entering into water bodies. Stockpiles are used for storing dry manure while detention ponds and lagoons are used for liquid manure (Takahashi et al., 2020). Both solid and liquid manure are utmost efficient during the time when crops are growing at a slow rate (Rigby et al., 2016). This permits manure in solid form to be easily tilled in the land soon after application, and manure in liquid form to be inoculated into the soil (Rigby et al., 2016). This manner of handling manure ensures effective utilisation of nutrient fertilizer by the crops while reducing risks of ground and surface water contamination (Rigby et al., 2016).

Similarly, Ndambi et al. (2019) stated that in sub-Saharan Africa the three most common ways of treating manure includes drying (active and inactive), solid storage, sometimes with composting, and anaerobic digestion. According to Ndambi et al. (2019), drying has many advantages to farmers including an increase in the number of days available for application as well as less potential for runoff. Ndambi et al. (2019) further stated that, by providing organic matter and soil nutrients, composting improves the structure of the soil, allowing for better aeration, improving drainange, water retention, and reduced risk of erosion. Anaerobic digestion is a low-oxygen biological process that results in the production of gas which is a mixture of methane and carbon dioxide that can be collected and stored for use (e.g. for cooking or lighting) (Tran et al., 2022). This method is common in most parts of Africa. Ndambi et al. (2019), stated that in Ethiopia farmers store and dry solid manure that is later used for fuel, while in Malawi farmers store solid manure for later use as a fertilizer.

Overpopulation, its effects and farmers' coping strategies

Overpopulation is whereby the human population increases beyond the ecological system carrying capacity (Weizman and Filgueira, 2019). This consequently exert pressure on the available water resources (Weizman and Filgueira, 2019). Overpopulation also disturbs majority of global freshwater systems (Garg, 2020). This is worsened by the fact that most surface and ground water sources for freshwater are unreachable or polluted (Garg, 2020).

Per Kin et al. (2019) ascert thats activities influenced by overpopulation have resulted in little (<1%) freshwater readily accessible and available for use by humans. Water vulnerability is already affecting many overpopulated areas, especially in developing countries because the demand for water is higher than the available and accessible water (Furuni, 2019). Catchment areas like forests are continuously being ruined due to deforestation to create more space for human settlement (Brierley, 2020).

Gude (2018) reports that nearly 25% of the worlds’ population is living in water-stressed regions where the demand for water surpasses the available amount, either due to lack or poor quality of water (Hertel and Liu, 2019). Shah et al. (2019), stated that since 1990, the world population increased by an average of eighty million people and this worsened the global demand for fresh water by approximately 64 billion cubic meters of water per annum. This continued demand for water is already influencing production of food in water-stressed areas such as China, the Middle East, India and the south-western United States (McNabb, 2019). In California, water intensive crops like almonds use close to 8% of all available freshwater while one ton of grain requires one thousand tons of water (Wichelns, 2018). Furthermore, worldwide grain and staple crop production use between 75 and 90% of accessible freshwater (Mekonnen and Hoekstra, 2017).

Linkage between a growing human population that has high demand for water for drinking and agriculture is a clear evidence that water scarcity is felt in many regions of the world subsequently causing severe effects to lives of millions of people (Cumming and Slaymaker, 2018). Hence, farmers use different innovative practices to cope with water scarcity under the growing population.

Israel has been working hard to conserve water over the last couple of years with significant success. The country devised farming and irrigation techniques to solve many and complex developmental challenges faced by crop farmers (Troter and Perrier, 2018). For instance, SupPlant company invented a unique artificial intelligence system using big data and cloud services, and davanced technology to promote water saving and increasing agricultural productivity (Sapkota, 2019). This system optimizes water use through computing the required exact amount of water by a plant for a particular soil type and climatic condition to ensure the righful amount of water has been supplied to the plant based on its water requirements (Sapkota, 2019). Sapkota (2019), stated that the system's unique algorithm is based on the correlation between the plant's stress level and the volume of water in the soil. This completely autonomous irrigation system is essentially best for water saving and determining actual plant requirements after relevant data has been captured and analysed. Furthermore, Israel is now a world leader in recycling wastewater, 85% of its domestic wastewater is being recycled and used for agriculture (Castellanos et al., 2020). Recycling wastewater for agriculture has allowed the state to become relatively water solvent (Castellanos et al., 2020). The state can transport its treated wastewater to farms all across the country.

Similarly, in California the use of recycled water for agriculture has significantly gained popularity (Qian, 2019). Water recycling is the reuse or reclamation of waste water through water treatment to make it safe for human use (Ormerod, 2017). The municipalities are responsible for treating the waste water before it is channelled to farmers for irrigation purposes (Gaudi et al., 2018). Recycled water also contains substantial amounts of plant nutrients, which is important for crop yield and minimize costs for fertilizer requirements at production level (Mouheb et al., 2018). Furthermore, farmers harvest and store rainwater to address the problem of water scarcity (Yannopoulos et al., 2019). With the increasing population, practicing water conservation methods such as rainwater harvesting plays a huge role in providing additional sources of water, food production and ultimately food security (Sixt et al., 2018). Hence, many crop farmers in California have built their farm ponds, dams and have water tanks to capture and store rainfall for use throughout the year (Swartz and Miller, 2019). This reduces their reliance on other sources of water supply such as wells (groundwater) or municipal water (Swartz and Miller, 2019).

In addition, researchers at the Institute for Soil for the Agricultural Research Council in South Africa developed an in-field rainwater harvesting technique (IRWH) which acts as a secondary water storage facility (Heerden et al., 2010). This technique has been specifically designed for ecotopes that have marginal potential for crop production farmers. It traps and stores runoff water in shallow dams and basins (Heerden et al., 2010). At the runoff area, when the basins have been created, farmers avoid loosening the soil through cultivation or ploughing. This further helps to necessitate runoff (Heerden et al., 2010). The authors report that water collected this way can infiltrate deep into the soil below the surface layer.

According to Mzezewa and Rensburg (2019), the IRWH technique could reduce water runoff totally and evaporation from the soil surface. Thus, more water becomes available to the root zones of plants thereby increasing crop yields (Mzezewa and Rensburg, 2019). This is supported by Muthelo et al. (2019) who report that the IRWH technique increases yield of maize by 40%, sunflower by 30% and dry beans by 90%. Furthermore, a study on assessing the potential adoption of infieled rain water harvesting technique in the farming areas of Free State, showed that IRWH increases maize and sunflower yeilds by as much as 50% compared to conventional production techniques (Tesfuhuney and Dzvene, 2021). Further, research has proven IRWH technology to be sustainable, not only in terms of increased agronomic productivity, but also in terms of water conservation (Tesfuhuney and Dzvene, 2021). Therefore, the use of rainwater harvesting systems has a series of advantages. It is an effective way to conserve water and also helps to alleviate periods of scarcity.

Overuse of water for irrigation and farmers' management practices

In many regions of the world, ground water has depleted rapidly due to overuse of water for various purposes such as domestic use, irrigation use and tree species which cause major problems as invaders of natural ecosystems. Certain trees have roots systems capable of reaching deep into groundwater supplies (Hruska et al., 1999). That helps them to survive in arid and semiarid climates where soil moisture is scarce (Hruska et al., 1999). For example, the black wattle tree which tree originates from the Southeast Australia (Victoria to New South Wales and Southern Queensland) and Tasmania (Chan, 2019). There are many benefits associated with black wattles in South Africa. Many of these arise from formal plantations, but some (including firewood, charcoal and building materials) are also derivied from stands of invading plants (Reynolds, 2021). Similarly, there are a range of negative impacts that can be attributed to both wattle plantations and invasions. Both for example, reduce surface runoff and affect water avalialibily (Reynolds, 2021). Eucalyptus tree is also known to cause a number of environmental hazards like depletion of groundwater, dominance over other species by allelopathic effects, loss of soil fertility and negative impacts on local food security issues (Nazli et al., 2020). Engel et al. (2005), during their study of hydrological consequences of eucalyptues in Argentine pampas found that it utilized groundwater (67% of its total water use) as well as water from upper vadose zone, which is the source of supply to groundwater.

When water is overused, a shortage occurs which leads to more water being wasted and further escalates the crisis of water scarcity. Pan and Liu (2018) state that globally, the largest source of usable fresh water is groundwater. In cases where surface water is unavailable, water needs are met through the use of ground water (Pan and Liu, 2018). Thus, surface and ground water are interlinked. Consequently, if groundwater is depleted, streams, rivers and lakes linked to ground water will be depleted too (Bierkens and Wada, 2019). Besides, overdrawing water from rivers regularly causes drying up of these water sources and thus they would not flow into the lake or ocean that they are connected to.

Overuse of water leads to food and water insecurity. If the used water could not be replenished, crop and livestock productive is hampered (Broeck et al., 2018). Essentially, desertification results and this is usually difficult to reverse. Once this has occured, farmers are forced to continually look for another arable land (Boali et al., 2018). Thus, marked threat to sources of freshwater is caused by agricultural activities (Ramankutty et al., 2018). At the same time, increased demand for food due to rise in human population has led to increased demand for water (Huang et al., 2019). According to Nigussie et al. (2020), in sub-Saharan

Africa, agriculture is the largest consumer of water, and a rapidly growing population is increasing food demand and water scarcity. Montwedi et al. (2021), stated that South Africa's agriculture uses almost 60% of available water.

Similarly, in the United States, consumption of water through agriculture plays a huge role in water overuse with irrigation accounting for 42% of the nation's total freshwater withdrawals (Tuninetti et al., 2019). This is of great concern in the arid areas of the United States empeding production of crops (Tuninetti et al., 2019). Eventually, this causes food scarcity. Per Marston et al. (2018), competing activities for water requirement such as urban growth and irrigation adversely affects availability of water. This is axercerbated by climate change (Marston et al., 2018). For example, Arkansas is the 33rd most populous state and is the fifth in terms of water withdrawal for mostly irrigation (Marston et al., 2018). According to Dieter (2018), 63.5 million acres (25.7 million hectares) of land were irrigated in 2015 which is a 2 % increase over 2010.

With Agriculture accounting approximately 80% of the US water, crop farmers use different innovative practices like irrigation scheduling to reduce over-usage of water (Njuki and Ureta, 2018). The irrigation schedule indicates how much irrigation water has to be given to the crop, and how often or when this water is applied (Studer and Spoehel, 2019). The purpose of irrigation scheduling is to provide the exact amount of water needed at the required level to replenish soil moisture in order to maximize irrigation efficiency (Studer and Spoehel, 2019). Farmers adapt their irrigation schedule to the current conditions to avoid overwatering crops using a variety of devices such as rain gauge, wind vane and aqua meters (Sianturi et al., 2018). They do so by monitoring the weather, as well as monitoring the soil and plant moisture (Sianturi et al., 2018).

Similarly, there is a variety of innovative practices to help farmers reduce over-usage of water in Africa. For example, Nyam et al. (2020) stated that 'Leaders in Innovation' (LIF) in South Africa created a tool named Nosetsa. This is a smart water management tool to regulate water use on farms, without human intervention. This not only saves water, but also accurately hydrates plants, conserves resources, and saves real and virtual costs (Nyam et al., 2020). Nyam et al. (2020), stated that Nosetsa was developed to support farmers to practice more sustainable irrigation methods, which also helps achieve Sustainable Development Goals. It also adopts to existing irrigation equipment to reduce moisture that can damage equipment, harm crops and affect revenue. It prevents excessive leaching of water with nutrients that can damage soil health, thus protecting and saving water (Nyam et al., 2020). In addition, Sup-plant, an Israeli based agritech startup is assisting South African farmers to increase their crop fields while reducing water usage with their innovative technology. Accroding to Smidt (2021), the agritech startup has assisted South African farmers to reduce their water usage by 37%.

Furthermore, farmers use drip irrigation to avoid overwatering crops. With drip irrigation, water is directed to the crop root zone thereby keeping the soil surface dry (Rahman et al., 2018). Thus, evaporation and runoff is reduced. The drip irrigation system necessitates efficiency of water use by over 95% meaning that farmers are reducing water usage by over 60% compared to traditional flooding methods (Gercek, 2017). Furthemore, drip irrigation benefits the environment, supports crop development and yield and promotes farmer to spend less time irrigating the crops (Ncube and Swikwambana, 2016). The soil is kept moist throughout the day.

Climate change, its effects and farmers' coping strategies

Climate change significantly transforms the water cycle (Rahmasary et al., 2019). Upsurged temperature increases evapotranspiration from vegetation, land, surface water, and oceans (Zhan et al., 2019). Humans and livestock water needs increases as temperature increases (Zhan et al., 2019). This is in addition to other different and many important economic activities such as energy production at hydro power stations (Hertel and Liu, 2019). Therefore, as the earth warms up, there is less water available for these activities and also availability of water becomes difficult to predict and manage (Hertel and Liu, 2019).

According to Mann et al. (2017), climate change is a global phenomenon associated with unsual climatic conditions (extreme temperatures, precipitation, wind, e.tc.) due to human activities or natural causes. Although climate change affects the entire world, some regions like the developing world, African continent for instance, is affected most (Gosling and Arnell, 2016). This is because the continent highly depend on agriculture for survival and economies. Increases in temperature and rainfall reduction lower agricultural production and substantially contributes to food insecurity (Tigchelaar et al., 2018). For example, Agriculture accounts for 18-20% of Zambia's GDP and is a fundamental source of livelihood for half of the country (Thurlow and Dorosh, 2018). However, the increased occurence of droughts, altered rain seasons and shorter rain period has resulted in increased loss of crops and degradation of the grazing land leading to loss of livestock (Thurlow and Dorosh, 2018).

Moreover, floods have threatened production of food, especially in northern part of Zambia (Chonabayashi et al., 2020). There are several effects of previously occuring floods. These include destruction of crops and farmland leading to heightened hunger and malnutrition, soil erosion and loss of livestock (Chonabayashi et al., 2020). Egypt is not an exception, according to Fawaz and Soliman (2016). Production of tomatoes and oil crops in the Nile Delta has been negatively impacted for the past 15 years. Fawaz and Soliman (2016) further state that not only crops are affected but even livestock. Increased heat and rapid spread of microbes cause poor appetite and hence reduced growth and development of livestock. Therefore, it is clear that climate change is a serious threat to food and water security.

To cope with drought occurences and unpredictable weather patterns, farmers have adopted an array of climate-smart strategies. In Zambia for example, one of the strategies used by farmers is to lay a black plastic polyethylene film around certain crops which keeps the soil moist (Esser, 2017). This process is called plastic mulching, which refers to the type of mulching that utilizes polyethylene film to suppress weeds and conserve water in crop production (Briassoulis and Giannoulis , 2018). According to Briassoulis and Giannoulis (2018), the polythene bag mulch prevents evaporation of soil water and hence conserves soil moisture making it available for plants (Briassoulis and Giannoulis , 2018).

In Ethiopia, the use of black plastic polyethylene film is also common for open field or greenhouse crop production. For instance, Yaun et al. (2019) observed that polythene plastic mulch significantly retains soil moisture compared with none mulched plots. Moreover, yield of okra and squash was remarkably high for covered soil in comparison with uncovered soil (Yaun et al., 2019). The total yield for okra and squash was approximately 140 and 61%, respectively (Yaun et al., 2019). This signifies that black plastic mulch significantly increased crop yield and reduced evaporation of soil water and assisted in retaining soil moisture.

Farmers in Egypt use subsurface drip irrigation technology to manage water better as well as reduce wastage, which in turn increases yields of crops and efficiency of water use (Malash et al., 2008). In a study conducted by Mahmoud and Bably (2017) in Egypt, the tomato plant improved through various types of subsurface drip systems in comparison with surface irrigation systems. This is attributed to the characteristics of subsurface drip irrigation alluded to by various scholars (Ismail and Almarshadi, 2013; Mahmoud and Bably, 2017). This system is suitable for both arid and semi-arid regions, as well as hot and windy areas that are characterised with insufficient supplies of water (Mahmoud and Bably, 2017). The system is also commonly used in South Africa, mainly in Lucerne fields. Lucerne is a perennial crop that requires plenty water, has a deep root system and unique demands (Schoo et al., 2016). Lucerne provide good forage for livestock.

Stress caused by inadequate or oversupply of water has signifcant adverse effects on crop productivity and quality (Schoo et al., 2016). Hence, a subsurface drip irrigation system has been used in South African Lucerne fields for over 18 years (Adetoro et al., 2020). Apart from the significant savings in water consumption, one of the great advantages of subsurface drip irrigation technology is that the field can be irrigated directly after the crop has been cut out and while the bales are still in the field (Adetoro et al., 2020). Growth can, therefore, be stimulated faster to achieve more cuttings per year (Adetoro et al., 2020).

Furthermore, Kimutai et al. (2020), conducted a study about the "Effect of Moisture and subsurface drip irrigation on cowpea production in South Africa in which the highest grain water use efficiency was achieved for 70% subsurface drip irrigation. Therefore, to cope with the changing weather patterns on-farm productivity and water use efficiency could be improved through effective irrigation systems like the subsurface drip irrigation technology.

Conclusion

The causes of water scarcity are both natural and manmade. Climate change is amongst the major causes of water scarcity and it affects a variety of aspects, some of which are associated with drought. Severe drought episodes have a direct effect on agriculture and food production. In countries such as South Africa and Mozambique, there has been a decrease in the production of maize, in major maize-producing areas due to drought. Overpopulation is also a huge challenge that exerts a lot of pressure on available water resources for the ever-increasing human population. In nations like the United States, China and India water pollution is a growing challenge contributing to water scarcity. It is a serious threat to sustainable development in India as some water sources are unsafe for industrial and human use. Furthermore, when water is overused, a shortage occurs. On average, agriculture accounts for 70% of global water use and threatens freshwater resources. With these results, it could be concluded that employing environmentally friendly farming practices is very essential as well as using the available water sparingly through the use of more advanced water-saving techniques. It is plausible that crop farmers in different parts of the globe have already started adopting these water-saving techniques like rainwater harvesting, use of drip irrigation and recycling water among others.

Implication for practice

Several factors contribute to shortage of water for agricultural activities. As such, many solutions are implemented the world over. These include water harvesting techniques, efficient irrigation methods, selection of drought resistant crop species and creating buffers that stop contamination of water sources. Some of the reviewed techniques are not ideal for small fields but for medium and large fields. Therefore, it is key for agricultural advisors or other stakeholders to co-decide and co-design water use and water saving methods ideal for different crop and livestock farmers. This will enhance adoption and sustainability leading to acceptable strides towards achieving water security for agriculture.

Future studies

Research gaps do exist on which methods are applicable for specific types of crops and their effectiveness. Also, studies on ways of measuring water use and amount required for each crop is essential. Establishing and implementing relevant methods to curb water pollution is key. All these require to be done with the grassroots. Involving them at the beginning identifying and confirming research needs with them is key. This is fundamental for co-designing the projects and/or initiatives, co-deciding, co-implementing and co-learning with the grassroots communities and hence achieving the set milestones.

Statement of Conflict of Interest

Authors have no conflict of interest

Author's Contributions

RTL, SK, MM and JZ conceptualized the idea, designed the paper structure and wrote the paper; RTL searched for literature, ran the Atlas ti analysis, developed the draft and addressed comments; SK, MM and JZ reviewed the paper and provided mentorship.

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