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INTERNATIONAL JOURNAL OF CURRENT RESEARCH

International Journal of Current Research
Vol. 13, Issue, 09, pp.18945-18951, September, 2021

DOI: https://doi.org/10.24941/ijcr.42273.09.2021

ISSN: 0975-833X

RESEARCH ARTICLE

AGRICULTURAL WATER UTILIZATION EFFICIENCY: ISRAEL'S INNOVATIONS AS LESSONS FOR CHINA'S ARID AND SEMI-ARID REGIONS

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ARTICLE INFO

Article History:
Received 29th June, 2021
Received in revised form
24th July, 2021
Accepted 19th August, 2021
Published online 30th September, 2021

Key Words:

Agricultural water-utilization-efficiency; irrigation water innovations; water management; arid/semi-arid region; China and Israel

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ABSTRACT

Water scarcity in China's north and northwestern regions is very serious and agricultural water use inefficiency is likewise high. This condition calls for immediate attention, drastic and a decisive shift towards innovative water-saving agriculture like that accomplished by the state of Israel. Therefore, this article followed a comprehensive literature review approach to explore Israel's agricultural water utilization efficiency innovations and recommended lessons for China's arid and semi-arid regions. For Israel, agricultural water utilization efficiency is not simply water-saving irrigation but also the inclusive exercise exhausting every conceivable economic water-management measure in holistic farm production, including the full utilization of limited natural precipitation, wastewater reuse, desalinated seawater and efficient management of irrigation network. It can be asserted that such commitments have the potential even for China to decrease groundwater abstraction rates, increase agricultural yields, and enhance food security by enlarging crop assortment while sustainably conserving water and the environment. Furthermore, the lessons and recommendations presented in this article are not only important for China but also several other countries and regions across the world facing similar problems.

Citation: Bornwell Mutale. *"* Agricultural water utilization efficiency: Israel's innovations as lessons for china's arid and semi-arid regions*", 2021. International Journal of Current Research, 13, (09), 18945-18951.*

INTRODUCTION

Background: The world's population is expected to increase to over 10 billion by 2050, and whether urban or rural, this population will need enough food to meet its basic needs. With the increased demand for more compound foods as a result of increased income especially in third world countries, the[1] approximated that global agricultural production will need to expand by 70% before 2050. Furthermore, the now and expected rise in population and the issue of climate change is likely to cause an increase in demand for water due to its importance in agricultural food production [1-4]. Already, water security is a major and frequently rising problem across the world. Worldwide climate change models forecast that there will be a further decline in rainfall, recurrent droughts and floods [5,6] in years to come especially in regions that are currently facing water stress. To meet the world's demand for food security, human health and environmental sustainability, innovative water management techniques like wastewater treatment and efficient utilisation of agricultural water resources need to be embraced [7,8] especially in agricultural production which currently consumes more freshwater [1,6,9].

However, innovation encompasses more than just a transformation from one entrenched way of doing things to another well-established way; and so, agricultural water innovation in this case like any other innovation must involve a change that needs substantial imagination, breaks with conventional ways of production, and fashions new production capacity. Modern agriculture is an evolving approach to agricultural innovations and farming practices that helps farmers increase efficiency and reduce the number of natural resources; water, land, and energy necessary to meet the world's food demand. It is driven by continuous improvements in digital tools and data, as well as collaborations among farmers and researchers across the public and private sectors. It can also be seen as one in which the success of the process depends on the use of technology, access to resources, management, investment, market characteristics and support. This article, therefore, provides a comprehensive review of Israel's modern agriculture water utilization efficiency innovations with particular emphasis on agricultural water for irrigation and suggests lessons for China's arid and semi-arid regions where water scarcity is a critical problem.

China's arid and semi-arid regions where water scarcity is a critical problem. The lessons and recommendations are intended not only to benefit China's arid/semi-arid regions but also several other countries across the world with similar environmental conditions and where agricultural water management is still a problem. Israel is suitably selected for this study because, for a long time, the Israeli farmers have had to struggle with a challenging environment and inadequate water resources. However, despite the rampant shortage of water, Israel's agricultural production has been constantly increasing over the years. This has been made possible through various innovations in agricultural water management, notably in the irrigation system. Agricultural development remains a priority for Israel and it has innovated technologies and methods to deal with an array of challenges facing farmers around the world. The most remarkable achievements have been the development of a water-efficient drip irrigation system and the use of recycled wastewater and desalinated seawater for irrigation [10,11].

Rationale: China's arid/semi-arid regions have been facing water problems that need quick and special attention and lessons from the Israeli approach may be helpful. Over 300 Chinese cities are water-starved, and about 115 face serious water scarcity causing substantial economic losses which have further affected people's living standards. Water scarcity has seriously constrained the sustainable development of China's agriculture and the nationwide economy, not only instigating substantial economic damages but also intensely deteriorating the environment. This has been caused in part by the slow approach to constructing a water-saving agricultural system wherein the promotion of dynamic water-utilization efficiency and management at the farm level must be the core element. With the rise of a steady social economy and the speed up process of urbanization in China, industrial and domestic water utilization has been rising so sharply while agricultural water use has been inevitably declining. This is because water resource demand has increased dramatically while the resource remains limited and this will be very serious especially in the already water-starved regions. Innovative agricultural water efficiency management procedures have not been extensively promoted in China and water waste is very severe[12] compared to Israel. For instance, China's main irrigation drainage utilization coefficient is only around 0.5, indicating that, about half of the agricultural water is not utilized by the crops but wasted. Furthermore, due to the use of surface irrigation, each irrigation water and the total irrigation quota is too large. The irrigation quota for instance, in the northern region, is about an average of 3.5 times higher than the actual crop needs. The main explanations for the low and unstable agricultural productivity of China's arid and semi-arid regions are poor soil quality, severe soil erosion, strong soil surface evaporation, use of backward crop varieties and unsustainable cultivation methods, all of which results in low water-utilization efficiency of crops. Therefore, the promotion and development of agricultural water utilization efficiency in China are not only indispensable, because the agricultural water resources are slowly diminishing, but also conceivable since there is still a lot of waste of agricultural water due to poor agricultural management and unsustainable irrigation systems. For instance, China's arid/semi-arid water utilization and exploitation rate surpass 40%, the global standard warning level [13]. Enhancing the utilization rate and developing water-efficient agriculture like Israel's is the basic demand for modern agriculture and the essential means to address China's agricultural water scarcity.

BRIEF DESCRIPTION OF CHINA AND THE STATE OF AGRICULTURAL WATER UTILISATION MANAGEMENT: China's total area is about 9.6 million km^2 and is composed of mountains which account for 33%, plateaux 26%, valleys 19%, plains 12% and hills 10%. Arable land is only estimated at 110.0 million ha [14], China is conventionally divided into four main agro-climatic zones according to [15]. Hydrologically, China is divided into the northern and southern regions. While the northern region receives a somewhat low annual rainfall of around 650mm and equivalently low groundwater recharge, such that the sedimentary aquifers become exceedingly susceptible to over-abstraction, the southern regions generally receive sufficient precipitation and has a somewhat stable climatic condition [16].

China comprises more than 20% of the world's population, with about 6% of the world's fresh water and 9% of the world's farmlands. However, the per capita freshwater availability of China is very low[14] compared to the global average and the current situation is thus, more people, less water. To feed its huge population on one-tenth of its arable land, China has to increase total agricultural production by almost 30% by 2030 [17]. Thus, the hurdle of feeding a rising population on a diminishing supply of arable land whereas antagonising with severe water shortages in the country's main agricultural regions has long been a major concern for China. For instance, northern China, which accounts for more than 60% of the country's food production suffered its worst drought in 2009 [14] which resulted in low production. Besides, rising temperatures and over-use of water resources have continued to cause desertification, cutting the existing arable land even further. Whereas the southern region experiences flooding nearly every year, the northern region experiences severe water shortages and it is the region with a very dense population and produces about half of China's cereals[18]. Droughts in China affect an average of 15.3 million hectares of arable land each year which account for nearly 13% of the total farming area [19]. Therefore, promoting water-saving agriculture is not only able to increase water use efficiency, but also facilitate the structural adjustment needed by the agricultural sector [7,20].

Agriculture Water utilisation efficiency in China is very low[13]. [21], argued that about 94% of farmers in the north and northwest China still use traditional furrow or flood irrigation techniques, with an annual water demand of about 7320 m^3/ha. In contrast, sprinkler or drip irrigation, which account for about 6% of the irrigated area, demands only 3250 m^3/ ha or less. Moreover, more than 70% of the irrigated land in China does not apply any kind of water-saving measures. Yet, as population increases, water-efficient irrigation would have to play an even more important role in China to increase production, since farmland expansion becomes a limiting factor [17]. Currently, China's agricultural sector uses about 65% of the total water and this is mainly from groundwater, which represents nearly 80% of the total water sources, and has recently become a major concern of sustainability due to the rapid industrialization and intensification of the agricultural sector [14,16,22]. Only about 40% of the 65% irrigation water is consumed by crops and the rest is wasted, which can be attributed to the inefficiency of the country's irrigation system. Surface water is mainly utilised in the southern region while the northern region highly utilises groundwater in a bid to compensate for the deficit of surface water in meeting demand[18]. Thus, the intensive use of groundwater resources has resulted in the lowering of water tables and the rapid depletion of groundwater reservoirs[18]. China's irrigation depends on either groundwater, 31% or surface water 69% and the main irrigation technique is surface irrigation representing 94% while sprinkler and localised irrigation represent only 5% and 1% respectively[14].

BRIEF DESCRIPTION OF THE STATE OF ISRAEL: The state of Israel is a small yet diverse Middle Eastern country with a long coastline on the eastern Mediterranean Sea and a small window on the Red Sea at the Gulf of Eilat. It has its borders with Egypt and the Gaza Strip to the southwest, Jordan to the east, and Syria and Lebanon to the north. It also shares borders to the Jordan River and the Dead Sea with the West Bank and Jordan[23]. Israel is largely an arid nation [24], with over 60% of the country been the desert yet one of the world's densely populated countries. The country has long been confronted with many of the water issues facing several other nations today. Therefore, Israel's first Prime Minister, David Ben Gurion, made it a top priority to overcome this challenge by applying cutting-edge irrigation technologies to Israel's arid landscapes. Israel has since prioritized the development of efficient technological solutions for cultivating and managing scarce water resources and has significantly expanded its cultivated land and crop yield under irrigation[25]. Although the primary constraint of Israel's agriculture is water scarcity [25], the commitment to develop modern efficient water technological innovations has seen the country thrive in its agricultural activities.

ISRAEL'S AGRICULTURAL WATER UTILIZATION EFFICIENCY INNOVATIONS WORTHY OF EMULATING BY CHINA: This section discusses some of the most important innovations that have made Israel's agriculture flourish. The primary concentration is on those water efficiency innovations that pertain to agricultural water use from where lessons can be drawn and appreciated by China's arid and semi-arid regions and other countries facing similar problems around the world. These innovations have made Israel stand out as a global front-runner in providing scientifically rigorous, efficient, cost-effective and sustainable agricultural water technological solutions, thus positioning its water and agriculture sector for continued growth despite the country's desert condition.

Efficient Irrigation technologies: Israeli farmers have been the global pioneers in modern efficient irrigation technologies. The efficiency in irrigation systems has been a major factor making possible the reduction in the average water supply to agricultural land, down from 7,000 m^3/ha in 1990 to 5,000 m^3/ha in 2000 and still expected to decline further by 2030. The successful development of a low-consumption irrigation system has allowed the development of a thriving irrigation industry in Israel. The most modern irrigation innovations include low discharge sprayers, computer-controlled compensated drippers, automatic valves and sprinklers, moisture-sensitive automated drips and mini-sprinklers. The most water-efficient of these and suited for arid/semi-arid regions is drip irrigation technologies [25]. These technologies enable the proper volume of water with the right concentration of fertilizers to be supplied to the crops' roots and are combined with control systems to ensure optimal application and timing. The systems work under low pressure, and each dripper supplies only a few litres per hour. They can also work efficiently with different types of water resources and in different environmental conditions. Drip irrigation enables about 90% efficiency in water utility compared to about 75% and 60% for sprinkler and surface irrigation respectively. It has proven to expand the amount of available land for crop growing that would meet the demand of the rapidly growing population since it is suitable even in arid /semi-arid regions. Therefore, drip irrigation is a crucial component to having a significant influence on resource-saving, cost of cultivation, the yield of crops and farm profitability. Using a wide range of water including treated wastewater, brackish desalinated water etc. and combining with chemical fertilizers, drip irrigation has enabled Israel's crop output per unit of water to grow significantly while maintaining the abundance of agricultural water resources.

Re-use of treated wastewater for irrigation: Israel is one of the few countries globally that practice large scale wastewater treatment and reuse. Due to rampant water scarcity in the country, it was made compulsory to reuse treated water for irrigation by farmers. According to [26], properly treated wastewater irrigation can significantly impact the reduction of water demand and nutrient reuse while improving soil quality and reducing the number of contaminants discharged into the waterways. Thus, for Israel, retrieved wastewater has become a chief source of water for agriculture currently providing more than 40% of the country's water requirements for irrigation and more than 87% of wastewater being reused[27].

The country currently has 67 large Waste Water Treatment Plants (WWTP), treating more than 1,500 cm^3/day, and the 10 largest WWTPs treat approximately 298.5 million cm^3/year, accounting for about 56% of the total water volume[28]. Shafdan WWTP has been Israel's leading project for wastewater reuse for agricultural purposes. Besides, the well-known third Line to the Negev pipeline is the largest in Israel and treats about 140 million cubic meters per year from Tel Aviv to farmers in the Negev Desert. It supplies treated effluent that has undergone tertiary treatment after secondary biological treatment in the Shafdan WWTP. The tertiary treatment is attained through an innovative aquifer recharge technique called soil aquifer treatment. Wastewater treated to a secondary level is introduced into specially designated recharge basins, where it naturally filtrates through the sand. However, to elude contamination, there is complete separation between the reclaimed effluents introduced and the aquifer water, which is accomplished by controlling the outline of an artificially created water level depression, which creates a hydrologic trough that prevents the reclaimed water from spreading. The treated water is later collected in peripheral reclamation wells after 6 to 12 months and pumped to the Negev desert for farming[29]. The high treatment benchmarks permit unrestricted irrigation of all types of crops without any risk to public health[30].

Farmers are strongly encouraged to use this reclaimed treated wastewater for their irrigation through favourable pricing policies attached to it. Israel's treated wastewater costs less than half the global cost of freshwater for agriculture per cubic meter while freshwater for agriculture is expensive. The deliberate higher prices of freshwater for irrigation compared to reclaimed wastewater has played an obvious role in encouraging farmers to improve their efficiency of water use, thus, promoting demand management. Consequently, the economic benefit of using treated wastewater in agriculture authenticates the policy of supporting recycling plants, thus, allowing the conservation of expensive and diminishing freshwater.

National Water Supply to connect all water infrastructures: Yet another key and decisive innovation that has made the state of Israel meet its water needs has been the implementation of storage and transmission water points from the southern to the northern part of the country. From the integrated use of surface and groundwater through a giant pipeline that carries water from the sea of Galilee to the major agricultural centre, Israel has since developed more water conveyance infrastructures, establishing a national bulk water transmission scheme that transports about 95% of the county's filtered water resources including, groundwater, surface and desalinated water to the regional providers that supply end-users for domestic, industrial and agriculture utility[29]. The enormous water infrastructure comprises as many as 3,000 installations and 12,000km of transmission pipelines controlled by 10 main command centres throughout Israel. This has allowed Israel to control the use of fresh-water resources liable to hydrological situations, conveying excesses of water from one resource to store in other resources, in a bid to meet water demand in different regions. Further innovations in this regard include the interception of surface water run-off and recharge, making Israel control and manage its agricultural water efficiently.

Large scale seawater/ brackish water desalination: About two decades ago, the Israeli government decided to develop large scale desalination plants in response to the major question of water scarcity. The aim was to ensure that most of the country's water consumption, including agriculture would come from desalination as opposed to freshwater. Since then, desalinated water now supplies about 85% of domestic urban water consumption and 40% of the country's total water consumption[31] and Israel today boasts of being the global leader in large scale brackish water desalination. Israel's desalination technology has achieved high energy efficiency and the costs for desalinated water is relatively lower. This is because fixed costs are absorbed through a larger production volume for a given desalination plant capacity which results in a lower average rate per cubic meter. Furthermore, the national average energetic and financial cost of production per cubic meter of desalination water in Israel is very low. The Reverse Osmosis method of desalination is used, and it involves the separation of the salt molecules from the water by use of special-purpose membranes that were developed by Israeli Professor, Sidney Loub in the 1960s. The use of desalinated water for irrigation has proved to work successfully in Israel and it has the potential to promote sustainable irrigated agriculture in the world's arid and semi-arid regions [10,32,33]. Furthermore, [34], argued that an extra course of technological advance in Israel has been the identification and development of salt-tolerant crops that can be grown on brackish, saline, or desalinated water. This has helped Israel achieve high crop yields with no major stress on water resources.

IMPLICATIONS AND LESSONS FOR CHINA'S ARID AND SEMI-ARID REGIONS: As farmers across the world endeavour to feed the world's growing population with limited available resources, improvements in technology, such as water use innovations are key to the future of agriculture. A response development, induced by the Israeli government has been the reduction in the use of limited freshwater resources for agriculture compared to an increase in the sector's use of recycled effluent and desalinated water [35]. Israel's agriculture is the success story of a long, hard struggle against hostile ecological conditions and water scarcity. Its capacity to increase the efficiency of agricultural water use in technical terms per ton of irrigated output is a marvel. As a result, Israel is now a world leader in the management and technologies related to irrigation in arid and semi-arid environments. The invention and development of drip irrigation in Israel have been the key innovation behind the rise in technical water use efficiency, as well as the shifting to other pressurized irrigation systems like sprinklers, micro-sprinklers and micro-jets. Flood irrigation, which wastes so much water, is no longer used in Israel. Besides, the existing inventory of freshwater in Israel would not meet all of the domestic, industrial and agricultural demand, hence a decisive shift to wastewater reuse and desalination. By combining the use of treated wastewater, desalination water and drip irrigation, agricultural output has tremendously increased without increasing water consumption. Therefore, amid continuous water struggles around the world and the tenacious need to augment processes from irrigation to desalination to detoxification, Israel stands out as a global leader in modern wastewater reuse and large scale seawater desalination for Irrigation.

China though not as much water-stressed as Israel, can learn important lessons from the Israeli water success story. These lessons are suggested for inclusion into the fundamental water governance agenda to meritoriously address water scarcity and inefficient utilization challenges in arid/semi-arid regions. The first and probably most important lesson for China is the public awareness of the value of water if efficiency in water management and utilization is to the achieved. It is very vital to sensitise the public on the importance of water together with demand management and moving toward pricing water at its real cost. Water price policies must be strengthened and adjusted according to the market economy and water supply situations. These water price regulations should be framed according to the various water conservancy categories such as domestic, industrial or agricultural use, paying attention to whether it is social public welfare or production and operation. Therefore, the formation of a scientific water price scheme is indispensable to the rational allocation of water resources. Wasteful use of water must be discouraged in public campaigns at all costs.

Secondly, large scale seawater/brackish-water desalination for domestic and industrial use is yet another lesson for China. The relatively low price acquired for desalinated water overbuild operate-transfer schemes for Israel's desalination plants were dependent on a cautious strategy of the Public-Private Partnership (PPP) contracts with more government assurances being provided to private investors than what is typical for such PPP projects. This allowed Israel to get bid prices for desalinated water that are among the lowest in the world, in turn making large-scale access to desalination water financially viable. China has enough brackish/saltwater and other poor quality water which includes industrial and domestic sewerage water, all of which have the potential to be transformed into harmless agricultural water resources. Therefore, resourcing and recycling of these poor quality waters may be China's great practical move towards meeting the increasing agricultural water demand. However, to meet the standards for the irrigation of a wide range of crops, serious attention must be given to the engineering and chemical techniques in the treatment of such waters, then rationally allocate the treated waters to promote agriculture water utilization efficiency. Thirdly, Israel went further to make the use of treated wastewater compulsory for irrigation, which is another innovation worthy of emulating by China. However, because achieving this is relatively costly, it calls for the government to be involved with substantial subsidies. These subsidies must be focused on the treatment of wastewater and storage of recycled water, while farmers pay the incremental expenses of conveying the water to respective irrigation areas. Despite the cost of this water, Israeli farmers have achieved high levels of water utilization efficiency, focusing on high-value crops. Wastewater reuse for irrigation is truly an innovation to undertake in the face of water scarcity and declining agricultural production conditions[26,36] like in north and northwest China.

Fourthly, putting up a strong national transmission water system infrastructure proved indispensable in achieving agriculture water utilization efficiency in Israel, thus, promoting alternative water resources, and being able to mitigate and manage adverse hydrological variations at high economic efficiency. This too is worth emulating by China to be able to optimize water management under conditions of scarcity while allocating supplies and water utility across the country especially in arid/semi-arid regions. On the other hand, putting up comprehensive, probabilistic, and timely data have been crucial undertakings for Israeli water-efficient integrated management that China can learn from. The Israeli Water Authority relies on its Hydrological Services Unit to collect, analyze, and model water data and factors in the effects of global warming on Israel's natural water resources, thus, allowing the authority to allocate and manage all water resources on a real-time basis. China can similarly enhance the allocation of agricultural water through the construction of the strong support water source project and the employment of the regional water resources allocation projects. The overall agricultural water scarcity in important production regions of China can be reduced further by enhancing the country's water structural system, following a comprehensive water-saving approach that includes both the engineering and the non-engineering integrated agricultural water-utilization efficiency technologies. This approach has not been utilized to its full potential in China though easy to implement, user-friendly, presents quick results and is cost-friendly. It has the potential to enhance the development of a water-utilization efficiency system that covers the entire water utilization process from various water sources through water transmission, distribution to crop intake and utilization and finally translation into harvest without any major water losses. This can also be complemented by making thorough use of precipitation as a renewable resource and employing a rational distribution of surface and groundwater, constructing reasonable cross-water basins diversion facilities while paying attention to the use of unconventional water sources. Consequently, a decisive and completely shift to a full water-efficient irrigation technical system, namely, a low-water consumption drip irrigation combined with a suitable selection of crop varieties, fertigation and rational adjustment of planting structure has made Israel manage its agricultural water efficiently. Besides, a large percentage of irrigation water comes from treated wastewater and desalinated water. This has made Israel self-sufficient in agricultural water with supply exceeding demand despite the country's desert condition. This is an important lesson for Chinese farmers who still depend highly on surface and groundwater for irrigation and relatively low efficient irrigation techniques such as furrow irrigation. Drip irrigation in China has not been exploited to its full potential despite its several advantages like saving water, occupying less space, saving labour and adapting to a wide range of soil quality and topography. Water utilization efficiency in drip irrigation is very high due to a significant reduction in deep percolation, evaporation and surface runoffs. Furthermore, due to the decrease in percolation which in turn reduces the flow of fertilizers and other agricultural chemicals, the risk of aquifer contamination is highly decreased [25]. However, the government must provide subsidies, especially to new farmers to meet the costs of water-saving drip irrigation equipment. There is a need for China to follow the water-oriented agricultural production, hasten the modification of planting structure, manage food security and agricultural water management while paying attention to input costs and outputs. Furthermore, there is a need for the promotion of drought-resistant, salt-tolerant and efficient crop varieties, gradually reduce high water consumption by adopting wide-scale drip irrigation systems and consolidate the development of agricultural water-utilization efficiency results while strengthening policy support. This is in line with the assertions of (18) who argued that China's key agricultural regions need to embrace some all-inclusive water-efficient utilization measures according to local settings under the circumstance of the existing planting structure and irrigation water level. Precedence in the improvement of water-efficient drip irrigation should be given to key grain-producing regions with delicate ecological conditions and severe water scarcity, namely, arid/semi-arid regions. In such regions, there must be strict regulations to discourage the husbandry of high-water-consuming crops while highly encouraging the cultivation of low-water-consuming yet high-value-added crops.

CONCLUSION

Israel though being one of the world's most water-stressed country has achieved tremendous water security with supply exceeding demand especially concerning agricultural water. This has been made possible through several decisive reforms and innovations in the sector. Starting with drip irrigation to water recycling, reclamation, wastewater reuse and seawater/brackish water desalination, Israel has turned into a global innovative force for agriculture water efficiency use and management. Thus, even irrigation water is not constrained anymore by volume but only by the ability of the farmer to pay for its price. Furthermore, Israel has achieved food security because of the availability and sustainable use of a wide range of water resources in its drip irrigation networks. Conversely, the demand for agricultural water in China's arid and semi-arid regions is higher than the supply and this has significantly affected crop yield. Therefore, to resolve this paradox between demand and supply, firstly, more water sources must be vigorously developed to upsurge agricultural water supply volume while enhancing the efficiency in the utility of existing water resources. As it improves the irrigation system to modern standards like Israel, China needs to further deepen scientific research in key technological areas of water distribution in irrigation systems, judiciously exploit and utilize a wide range of water sources, including precipitation, groundwater, surface water, treated wastewater, desalinated water and impermeable treatment of reservoirs. This should be done with a sense of urgency first in arid and semi-arid regions with already established agricultural practices like northeast and northwest China. Furthermore, precedence should be given to farmers who have shown prior interest in water utilization efficiency practices and where water-saving agricultural development conditions are attainable with the incorporation of agronomy, agricultural engineering and advanced management.

Finally, Farmers should undergo serious technical training on sustainable use of agricultural water resources while being determined to accomplish water-efficient utilization outcomes and substantial economic as well as environmental benefits. Not only will scientific irrigation and integrated agricultural technical measures enhance water-efficient utilization, but also crop yield. Therefore, it is vital to promote and develop agricultural water-efficient utilization technological and non-technological phenomena and gather these in decidedly amalgamated and propagated use. Israel's agricultural water utilization efficiency and irrigation technological advance is truly a generous lesson for China's arid and semi-arid regions and other countries across the world facing water scarcity.

Acknowledgement
The author is grateful to the anonymous reviewers for providing constructive comments and corrections.

Funding: This work did not receive any funding.

Disclosure statement: No conflict of interest.

Key points

- The rise in population and the issue of climate change is likely to cause a further increase in demand for water due to its importance in agricultural food production.
- Israel's agriculture is a success story of a long, hard struggle against hostile ecological conditions and water scarcity.
- Israel's key innovations include; drip irrigation system, full use of limited natural precipitation, wastewater reuse, large scale brackish/seawater desalination, construction of a strong water policy and efficient management of an irrigation network.
- Demand for agricultural water in China's arid and semi-arid regions is higher than the supply and this has significantly affected crop yield. Enhancing water utilization rate and developing water-efficient agriculture like Israel's is the basic demand for modern agriculture and the essential means to address China's agricultural water scarcity.
- Commitments to water utilisation efficiency in China and everywhere have the potential to decrease groundwater abstraction rates, increase agricultural yields, and enhance food security by enlarging crop assortment while sustainably conserving water and the environment.

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