Irrigation expansion in the face of war and climate change

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1 author:

Di Tian
Auburn University

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Climate change and Russian invasion threaten Ukraine's crop production. Data-informed climate adaptations and water management for sustainable irrigation expansion are recommended for post-invasion recovery in Ukraine and global food security.

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Global food security is threatened by climate change due to increasing temperatures, changing rainfall patterns, more frequent extreme events, as well as instability ranging from social unrest to violent conflict[1]. Ukraine, known as both Europe's and the world's breadbasket, has been severely disrupted by both climate change and conflicts, posing a great risk to global food security.

Writing in *Nature Food*, Rosa et al.[2] present a quantitative assessment of the effects of climate change and the Russian invasion that commenced in 2022 on Ukraine's irrigated agriculture. Using remote sensing analysis verified by census data, Rosa et al. estimated that between 2017 and 2021, prior to the Russian invasion, irrigated lands yielded about twice the productivity of rain-fed agriculture, despite only a small portion of croplands in Ukraine being constantly irrigated. However, in 2022 the irrigated lands were notably reduced, primarily attributed to them being outside government control or affected by ongoing hostilities, whereas the regions away from the invasion zone did not experience any decrease in irrigated areas. The complete destruction of the Kakhovka reservoir dam in 2023, a primary water source for major irrigation systems in south Ukraine, will adversely affect around 67% of Ukraine's pre-invasion irrigated area, based on the estimation of Rosa et al.

Climate change poses an ongoing threat to Ukraine's agricultural systems. Rosa et al. estimate that under climate change alone, 10% of the rain-fed croplands in Ukraine will face green water scarcity (that is, insufficient rain for optimal crop growth) under a baseline climate (1996–2005), while the numbers increase to 41% and 77% of total croplands under 1.5 °C and 3 °C warming scenarios, respectively. Irrigation is an effective climate adaptation measure to increase agricultural resilience under water scarcity. Irrigation expansion can also boost the economy by increasing agricultural productivity as irrigated agriculture has greater productivity than rain-fed agriculture in Ukraine[2]. However, irrigation expansion should be achieved sustainably by ensuring that water consumption does not exceed renewable water resources and does not harm ecosystem health. Using data from climate and hydrological models, Rosa et al. identified croplands over Ukraine where potential irrigation needs can or cannot be met using local renewable water resources under the baseline, 1.5 °C or 3 °C climate warming scenarios. Effective water management strategies are particularly needed to address the unsustainable irrigation expansion in prioritized regions where irrigation needs exceed renewable water resources. Given the destruction caused by the invasion and the increasing water scarcity caused by climate change, the authors highlight the pressing need for rehabilitating and modernizing Ukraine's irrigation systems.

Due to limited renewable water resources, sustainable irrigation expansion requires effective water management and ensuring the most efficient use of water for food production while maintaining ecosystem health. Rosa et al. recommend upgrading water infrastructure, expanding water supply, reforming irrigation systems and improving irrigation efficiency to address the future water scarcity challenge in Ukraine. Improving water use efficiency requires more efficient irrigation, which can be achieved by precise, accurate terrestrial hydroclimate monitoring (for example, for precipitation, soil moisture and evapotranspiration (ET)) and skillful weather or subseasonal-to-seasonal forecasts through innovative land surface modelling, satellite remote sensing, and improved weather or subseasonal-to-seasonal forecast models.

Climate adaptation strategies for sustainable irrigation expansion require data-informed climate impact assessment to identify the areas of need and understand the risks and the development potentials in the future. Rosa et al. used ET, precipitation and total run-off outputs from global climate models and hydrological models, and a crop water model alongside ET and precipitation inputs to assess future green water stress and sustainable irrigation expansion potential. However, global climate or Earth system models still suffer from inherent biases in simulations of hydroclimate processes[3]. Addressing this requires process-informed downscaling and bias corrections[4] or improved representations or sub-grid processes and parameterizations[5], which still need more research but could be achieved by, for example, leveraging deep learning[6]. Even though the authors may have used the best data currently available in Ukraine, the study still has limitations due to the inherent model biases and uncertainties.

Global warming would amplify the difference between water availability in water-poor and water-rich regions[7]. For example, in the United States irrigation use has substantially expanded in the traditionally rain-fed eastern states from 1997 to 2017, presumably due to increasing droughts[8]. Besides the warming climate, the continued management intensification to improve agricultural productivity, such as increasing planting density, has synergistically increased crop water needs[9], which drives additional irrigation use.

Locally and across the globe, sustainable irrigation expansion requires data-informed climate adaptation strategies and water management, presenting the need for high-quality, accessible terrestrial hydroclimate data and information, such as precipitation, ET and soil moisture. For instance, precision water management requires accurate ET data at high spatial and temporal resolutions. A daily, 30-m resolution satellite-based ET data platform has recently been developed over the western United States for land and water resource-management applications[10]. Such a platform is based on public satellite data available across the quasi-globe and can be extended to other crop production regions, while still having much room for improvement. Future efforts are needed to improve terrestrial hydroclimate projections and impact modelling to better inform long-term climate adaptations, and to improve terrestrial hydroclimate monitoring and forecasting to better support effective water management, locally and across the globe. These efforts will help to build climate resilience in agriculture to sustain food production and healthy ecosystems in the future.

Di Tian
Department of Crop, Soil, and Environmental Sciences, Auburn University, Auburn, AL, USA.
e-mail: tiandi@auburn.edu

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References

1. WFP USA. *Winning the Peace: Hunger and Instability* (World Food Program USA, 2017).
2. Rosa, L. et al. *Nat. Food* https://doi.org/10.1038/s43016-024-01017-7 (2024).
3. IPCC *Climate Change 2021: The Physical Science Basis* (eds Masson-Delmotte, V. P. et al.) (Cambridge Univ. Press, 2021).
4. Maraun, D. et al. *Nat. Clim. Change* **7**, 764–773 (2017).
5. Rasp, S., Pritchard, M. S. & Gentine, P. *Proc. Natl Acad. Sci. USA* **115**, 9684–9689 (2018).
6. Reichstein, M. et al. *Nature* **566**, 195–204 (2019).
7. Manabe, S. & Broccoli, A. J. *Beyond Global Warming: How Numerical Models Revealed the Secrets of Climate Change* 1st edn (Princeton Univ. Press, 2020).
8. Hrozencik, R. A. & Aillery, M. *Trends in US Irrigated Agriculture: Increasing Resilience Under Water Supply Scarcity*. Report No. EIB-229 (US Department of Agriculture Economic Research Service, 2021).
9. Medina, H. & Tian, D. *Environ. Res. Lett.* **18**, 024020 (2023).
10. Volk, J. M. et al. *Nat. Water* **2**, 193–205 (2024).

Competing interests

The author declares no competing interests.