

Chill Hours Record: A Sensitive Method for Climate Change Indication

Moshe Gophen, Moti Peres

Migal, Scientific Research Institute, Kiryat Shmone, Israel

Email: Gophen@Migal.org.il

How to cite this paper: Gophen, M. and Peres, M. (2026) Chill Hours Record: A Sensitive Method for Climate Change Indication. *Open Journal of Modern Hydrology*, **16**, 117-127.
<https://doi.org/10.4236/ojmh.2026.162008>

Received: October 19, 2025

Accepted: February 3, 2026

Published: February 6, 2026

Copyright © 2026 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

Global and regional climate change of which warming, supplied water availabilities, drought, floods, health and food safety, are mostly on top of present human society critical constrained concerns. That issue initiated scientific community mass mobilization aimed at case studies as well as forwarding mission achievement of mitigation. The indicated climate change foresee require sensitive early signs of which Chill Hours (CH) analysis is recommended. This paper presents an evaluation of temporal and spatial CH record from the Hula valley, a part of the Lake Kinneret drainage basin and discuss precautions of mild environmental exceptional warning of climate change sign factors. These retroactive warning notices included temperature increase, headwater yield reduction and changes of nutrients migration dynamics from the Hula valley into Lake Kinneret.

Keywords

Kinneret, Hula, Chill Hours, Climate Change, Temperature, Precipitation

1. Introduction

Three major headwater, flowing southward from the Hermon mountain rocky block, Dan, Hermon (Banyas) and Snir (Hazbany) rivers, join to form the Jordan river along 21 km crossing the Hula valley (177 km²) and the Korazim region into lake Kinneret. Before 1957 the south part of the Hula valley was covered by the old lake Hula and the northern part was covered by swampy wetlands. During the 1950's the Hula valley was drained and land use was converted into agricultural development. During the 1990's a Hula reclamation project was implemented, soil moisture was elevated and continuity of agricultural "green" crops cover was operated. Symptoms of climate change conditions were indicated in lake Kinneret and its watershed ecosystems: air and water temperature increase, decline in rain-

fall, and diminished river discharges accompanied by a reduction in epilimnetic lake nitrogen. The warming climate trend resulted intensification of zooplankton predation by fish and consequently crustacean biomass density and biodiversity index decline were documented [1]. Statistical evaluation of long-term (1946-2008) record of daily mean of air temperature in three meteorological stations (Dan, Dafna, Kfar Blum) in the Hula valley, confirmed a decline since the drainage of the hula valley (1957) whilst from mid 1980's, temperature elevation was documented. During the implementation of the Hula project management objectives (>1994), of which land green cover was verified, temperature increased. Those regional climate changes were probably induced by modifications of Albedo level: water covered land (before drainage) induced lowering Albedo whilst vegetation covered land (Hula project implementation) induced increased Albedo. Decline of Albedo resulted in higher sensitive heat flux, rising air temperature and vice versa [2]. Indications of climate change confirmed by air and lake water warming and consumption capacities policy in the drainage basin and lake water utilization were documented. After the decline of air temperature during 1940-1970's the trend was twisted towards elevation. Climate change caused a decline in rainfall, followed by a reduction of Jordan and other river discharges and underground flows, accompanied by a decline of Kinneret WL. With respect to climate change, water allocation for agricultural consumption was diminished [2]-[5].

Records of air temperatures in the drainage basin and in the Kinneret Epilimnion, precipitation and lake water level, and record of El-Niño/Southern oscillation (ENSO) were indicated as interrelated events. Moreover, Bleaks population size was enhanced whilst those of *Sarotherodon galilaeus* (SG) declined in correlation with El-nino/Southern Oscillation cycle. A contradicted impact of ENSO events on population size of Bleaks and SG in lake Kinneret was evaluated: Enhancement of reproduction of the winter spawner Bleaks and reduction of early summer spawner SG fingerlings recruitment. The ENSO event of winter extreme in Kinneret region is therefore negatively affecting Kinneret water quality [6]. Regional water balances confirmed enhancement of gravitating water loss in the Hula valley. The Hula valley soil properties of field capacity, bulk density and wilting point confirm the potential loss of gravitating water during periods of dryness due to climate change through preferential pathways [7]. Climate change symptoms of elevated water and air temperature and heat capacity combined with reduced precipitation accompanied by lake water level decline were indicated in lake Kinneret. Temperature of surface water increase accompanied by WL decline and decreased in deep layers during high WL were documented [8]. Significant changes, of temperature increase, decline in rainfall, causing a reduction in river discharges, and lake water inflows. These climatological changes were accompanied by a reduction in nitrogen and a slight increase in phosphorus in the lake epilimnion. The outcome was epilimnetic nitrogen deficiency and phosphorus sufficiency, which enhanced domination replacement of *Peridinium* spp. by Cyanobacteria. Climate change affected water quality deterioration in lake Kinneret

[9]. Since the mid-1980s, significant changes in climate conditions have occurred, and trends of dryness in the Kinneret drainage basin have been documented, as well as temperature increase and precipitation decline. The precipitation decline, and consequently the reduction in river discharge, resulted in a decrease in Nitrogen flux into lake Kinneret. After the drainage of the Hula natural wetlands and old lake Hula (>1957), the ecological characteristics of the Hula valley were modified. The impacts of climate conditions (precipitation and discharge) on TP (total phosphorus) outsourcing through erosive action are significant: higher and lower discharge enhances and reduces TP load, respectively. The total TP flushing range from the Hula valley Peat soil through the subterranean medium is not precisely known but is probably outside lake Kinneret. Most runoff water with mediated TP originates from bedrock through erosive action. Long-term records of TP concentrations in headwaters and potential resources in the Hula valley confirmed the significant influence of climate conditions on the outsourcing of TP capacity. The impacts of agricultural development, external fertilizer loads and migratory Cranes in the winter are probably insignificant [10].

Climate change, specifically warmer temperatures and reduced rainfall, significantly alters Phosphorus dynamics in lake Kinneret by reducing river discharge, increasing evaporation, and leading to shifts in nutrient cycling, potentially boosting phosphorus in upper layers and fostering Cyanobacteria over desirable algae like *Peridinium*, highlighting climate's critical role in the lake's ecological health and water quality that were confirmed [11]. Earlier studies induced a courageous connection between climate change and Kinneret water quality. The conjugate of environmental conditions and water quality impacts within the ecosystem emphasized the impact role of fluctuated climate conditions on water quality in lake Kinneret. The objective of the present study is aimed at apply of implication improvement through the usage of Chill Hours (CH) model. Long term data record in earlier studies was evaluated through methods of averaged values whilst in the present CH research the Spatio-Temporal distributional aspects of evaluated absolute temperature measurements is emphasized. The paper does not represent comparative analysis of environmental data sets, therefore the ecological structure of timing, length and monitor stations are not precisely respected. Despite of record dissimilarities their relevance to the climate change issue is distinct. Headwater discharges, nutrient migrations, and regional warming trend are ecologically integrated and CH information are supportive.

2. Material and Methods

2.1. Chill Hours Model

The long-term (1988-2021) record of annual Chill Hours accumulation is based on a modification of the "Chill Days model" [12]-[14] and the "Utah model" as follows: air temperature ($^{\circ}\text{C}$) is continuously monitored and hourly averaged; Each hour with mean temperature below 7°C is valued as 1; Hourly temperature within the average range of 7.0°C - 10.0°C is valued as 0.5; mean range of 10.0°C

- 18.0°C is valued as 0 and higher than 18.0°C as -1; Each 24 h are totally summarized into one number. If the total summary is a positive number, it indicates the additional Chill Hours for those 24 h. A daily record of Chill Hours obviously reflects air temperature changes. A daily Chill Hours report is practically carried out as horticultural farmers's service during the winter season (November through April) and tentatively applied in this paper for sensitive method of climate warming trend development usage.

2.2. Data Source (Chill Hours Record)

The long term (1988-2021) annual record of air temperature utilized for the Chill Hours evaluation was provided by the Israeli meteorological service and agriculture service which is a supportive service to Grove crop managers. The computation of Chill Hours is based on a modification of the "Chill Days Model" [12] [13] and the "Utah model". If the total summary is a positive number which is indicating the additional Chill Hours for those 24 hours. Daily record of Chill Hours reflect obviously air temperature changes. Daily Chill Hours report is practically carried out during winter season (November through April). Long-term (1988-2021) record of daily Chill-Hours indicates annual atmospheric thermal fluctuations. The annual fluctuations of monthly means of air temperature is shown in **Figures 1-3**. Data shown in **Figures 1-3** confirm temporal (1988-2021) decline of the daily number of Chill Hours; shortening length (in days) of the seasonal chill hours and the longer time delay (in days) of the initiation of chill hours existence.

The CH long-term (1989-2024) record maintain daily measurement of air

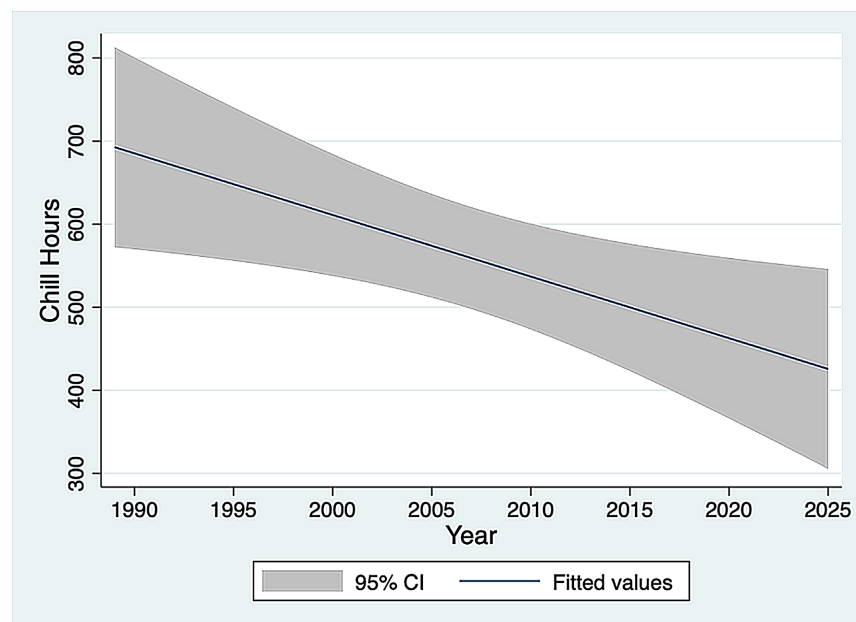


Figure 1. Linear regression of mean annual Chill Hours record of 3 stations located at 60 - 90 MASL Vs Year: $r^2 = 0.1637$; $p = 0.013$; Mean = 559; SD = 198; SE = 2.8; Coefficient = -7.4; $n = 37$; Evaluated Chill Hours Decline of 274 (40%). The total Mean is indicated.

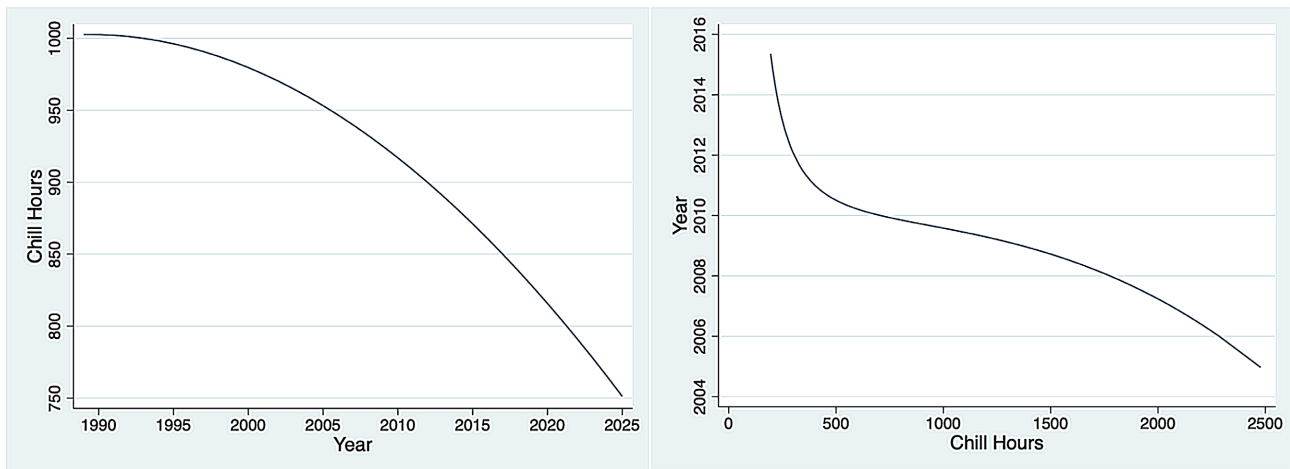


Figure 2. Two inverse plots of Fractional Polynomial regressions, Years Vs. Chill Hours (right panel) and Chill Hours Vs. Years (left panel), all stations, during winters of 1989-2025.

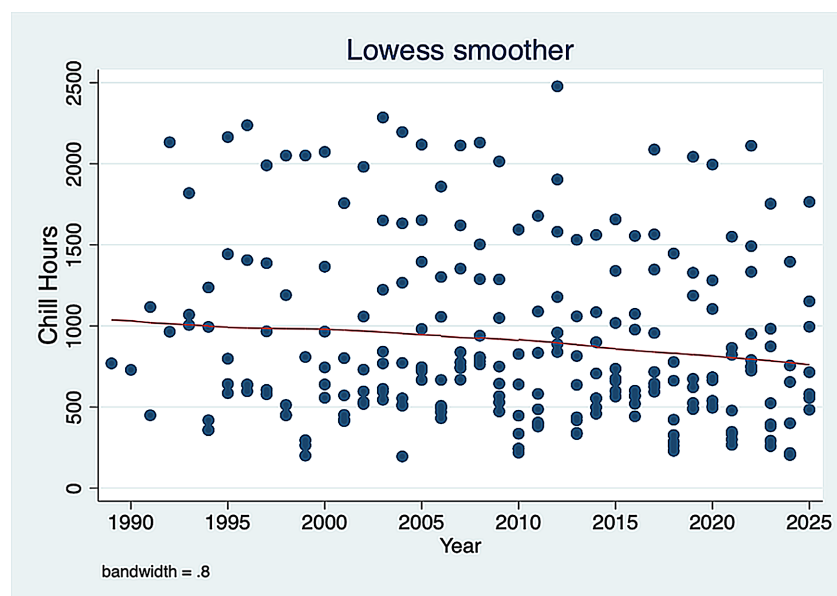


Figure 3. Lowess Smoother plot of Chill Hour record, all stations during winters 1989-2024.

temperature in 9 stations located at altitude range of 60 - 1090 MASL. Temporal fluctuations of CH were averaged and illustrated for 3 stations which are located in closely altitudes (60 - 90 MASL) to avoid altitude effect and local wind action disturbances.

3. Results

A graphical description of approximately 40% decline in the Hula valley of temporal (1989-2024) CH in the Hula valley is given in **Figures 1-3**.

The results given here of Chill Hours indicate a sensitive indications of regional climate change emphasized warming process trend. Nevertheless, as evaluated and shown in these figures the warming developed process is smoothly implemented but in “wavy” pattern: warming during 2004-2020 and relatively stable

later on.

The trend of Chill Hour decline in 3 stations located at an altitude ranged between 60 - 90 MASL, within the level range of the Hula valley, of app. 40% in the Hula valley was indicated.

The obvious correlation between CH and Altitude is given in **Figure 4**.

The temporal (1989-2024) decline of Jordan River discharge and consequently TN migration capacity are shown in (**Figure 5, Figure 6**).

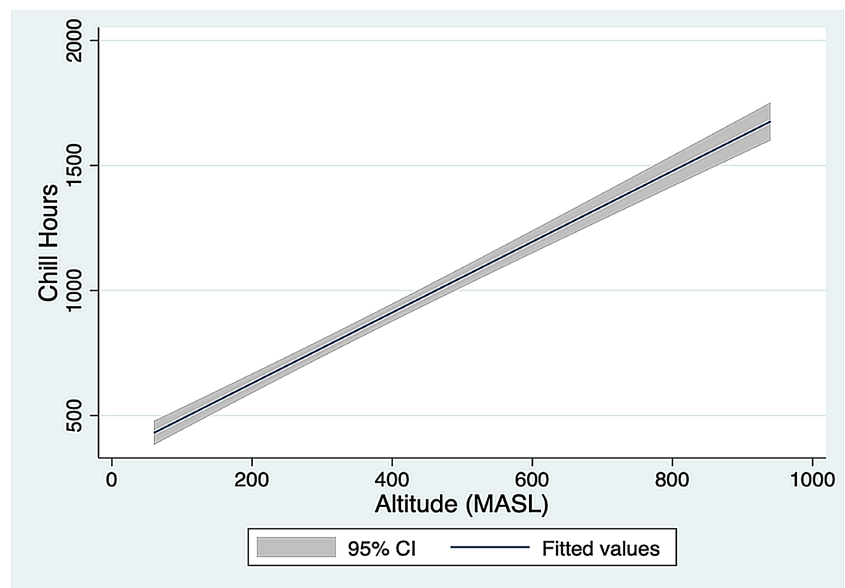


Figure 4. Linear Regression (95% CI) between annual (1989-2024) Chill Hours record and Altitude (masl) of monitor stations: $r^2 = 0.7264$; $p < 0.0001$; Coefficient = 1.41; $n = 230$; Mean = 835; SD = 530; SE = 0.06.

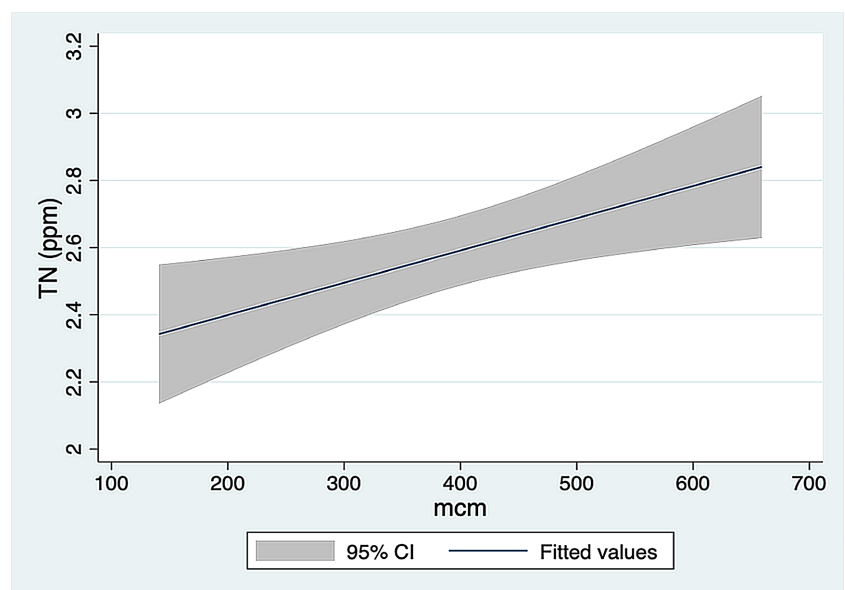


Figure 5. Linear Regression (95% CI) plot between annual mean of TN concentration (ppm) in river Jordan discharge and its capacity, (mcm:10⁶ m³/year), statistical parameters are: $r^2 = 0.1297$; $p = 0.011$; SE = 4.9; Coefficient = 12.9.

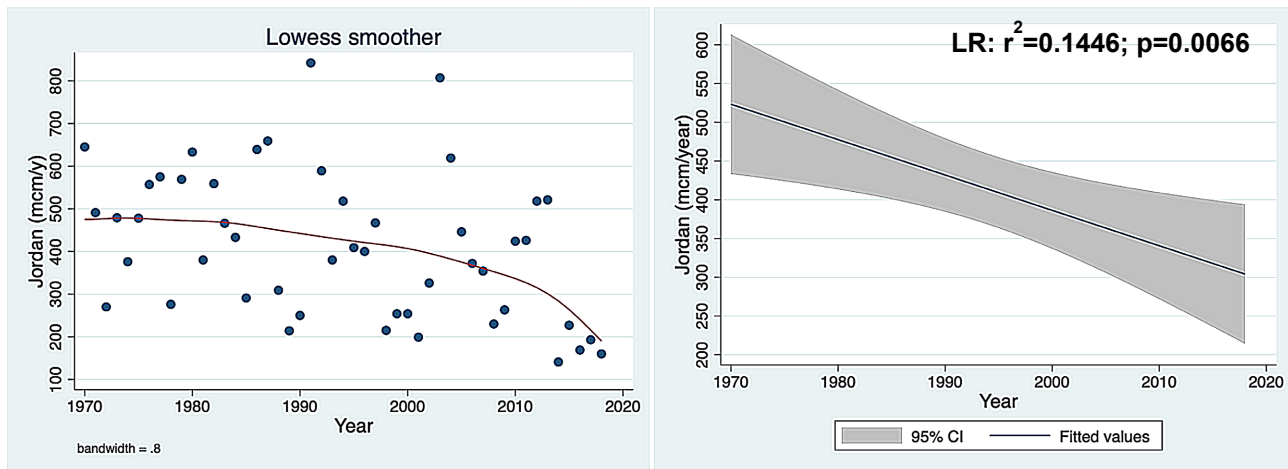


Figure 6. Lowess Smoother (left) and Linear Regression (right) plots of the temporal (1970-2018) changes of Jordan discharge (mcm:10⁶ m³/year) and Year. Statistical parameters of the Linear Regression are: $r^2 = 0.1466$; $p = 0.0066$; Coefficient = -4.6; Mean = 414; SD = 170; SE = 1.61.

4. Discussion

A brief survey of actual (2019-2023) literature confirms the importance given by the scientific communities to the climate change issue. Global and regional climate change, emphasizing warming, is presently a crucial issue of human society. Scientists, political nation leaders, economists, water management managers, future model expertise ecologists, and other worriers about predicted significant future impact of risky climate changes. The prediction of extreme events of droughts and floods, starvation, health difficulties, economical disturbances and more were thoroughly discussed in scientific conferences. Ecosystems respond to climate change, ecosystem resilience enhancement and addressing of a changing climate [15]. The belief about climate change is upward when experiencing unusual warmer temperature whilst other climate condition consequences are ignored [16]. Global and regional warming is a symptom of climate change which is indicated also by CH of which air temperature elevation, rainfall and river discharge, decline accompanied by reduction of nutrient migrations are included here.

A review of physical and other lake features response to climate change and discussion of recent and expected lake responses and future prediction of research opportunities in lake monitoring and modelling management are concluded [17]. A world encountered 315 cases of natural disasters during 2018, which are mainly related to climate condition changes. Food production, water supply, safe health conditions have been identified as vulnerable under climate disasters. Geoengineering techniques are considered to stabilize or reduce global warming [18]. The impacts of climate change on soil microorganisms in different climate-sensitive soil ecosystems [19], as well as potential ways that soil microorganisms can be harnessed to help mitigate the negative consequences of climate change are explored was documented [20]. A reviewed perspective summary of surface and atmosphere climate change indicators is documented by

[20]. Nevertheless, Chill Hours changes induced by climate condition change was not considered.

A global and regional well known dependency of crop production, especially non-irrigated agriculture rely on rainfall and surface temperature modifications [21]. The impact of climate change on ten sectors of human society, water, water desalination, energy, renewable energy supply, health, industry, built environment is discussed [22].

Finding accurate indications to detect climate change at the earliest possible stages is a desirable objective of human society supported by scientists and engineers mostly emphasized in development or desert countries. Thought, regional climate change modelling over a world-wide geographical zone [23]-[26] of which northern and southern river Jordan ecosystems was intensively explored [27]-[31]. The improvement of REGCM3 model as useful tool for climate studies was documented by [23]. For example, a focus on techniques applied to downscale large-scale climate model simulations to the spatial scale required by local response models (hydrological, agricultural, soil) was documented, specifically on the middle east, appropriate for input into a local watershed model of hydrological model for Karst environment (HYMKE) [27]. The effect of future climate change on the precipitation (rain or snow) capacities and its effect on streamflow in the Jordan river. A global perspective study example [23] has indicated regional climate model version 3 (REGCM3) is an important research tools available to scientists around the world, including developing countries [23]. Results from REGCM3 serves as benchmark simulations applied over economically developing nations (EDNS) and is useful for climate studies. The chill hours model represents a newly developed tool for the study of regional climate change. monitored evaluation of air temperature record support discrete spot heat distribution whilst CH model represent spatial (aerial) and temporal distribution of heat energy. The CH methodology described here probably contributes to the indication of climate change at early stages. The presentation of long-term record of Jordan discharge and consequently nutrient migrations (TN, TP) is therefore included here supporting indication of climate change at a respective periodical season of the CH record. Despite of CH methodology differ it is a valuable contributed confirmation of climate change trend.

Linear regression (95% CI) plot between CH monitored at 9 stations located at an altitude range of 60 - 940 MASL during 1989-2024, and Year indicating the temporal distribution is shown in **Figure 1**. Results indicate 40% reduction of CH in the Hula valley during 35 years which means a mild warming trend.

A differ statistical method, Fractional Polynomial, is utilized in **Figure 2** (CH Vs Year plot) confirm the results given in **Figure 1**. Nevertheless, an inverse plot of Year Vs CH confirm CH decline (i.e. warming trend) during 2004-2010 and thermal stability (un-changed CH) later on reflecting continuity of warmer conditions. A summarized overview of CH decline in the Hula Valley is presented in **Figure 3** as Lowess Smoother plot. The obvious topographical correlation between

Altitude (MASL) range and temperature is given in **Figure 4**. Despite of topographic position which create colder conditions a fixed altitude was maintain for each station during monitor period.

Climate change, dryness and warming, headwater discharges decline and consequently diminishment of nutrient migrations from the Hula valley into lake Kinneret is exemplified in **Figure 5** for the Nitrogen case. Thought, despite of the obvious water quantity mediated nutrients erosion force parameter should be considered. Lower discharge (**Figure 6**), and current velocity diminish friction effect and erosive force and consequently migrated nutrients capacities.

Chill Hours record (1989-2024) monitored in 9 stations located at altitude range of 60 - 940 MASL in the Hula valley, part of the Lake Kinneret drainage basin during the winters of 1989-2024 confirmed climate change development. Temperature elevation, headwater discharges decline, reduction of nitrogen migration from the Hula valley into lake Kinneret were documented. The awareness of climate change in response to CH signal is concluded.

The concept of the CH methodology is different from other commonly evaluated methodological paradigms, [17]-[26]. The features of CH method presented here highlight the importance of its usage. The uniqueness of a different new method, the CH, is suggested. Climate change induces environmental effects of which soil fertilization through micro-organisms activity as well as socio-economic consequences such as food safety which (quality and quantity) is typical to development and desert countries [21].

Acknowledgements

Thanks to Mekorot-National Water Company for River Jordan discharge and Nutrient compositions and Meteorological Service and Shoham-Agriculture Service for Air temperature data.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Gophen, M. (2020) The Impact of Climate Change on Zooplankton Biodiversity Index (ZBDI) in Lake Kinneret, Israel. *Open Journal of Ecology*, **10**, 822-828. <https://doi.org/10.4236/oje.2020.1012050>
- [2] Gophen, M. (2014) Land-Use, Albedo and Air Temperature Changes in the Hula Valley (Israel) during 1946-2008. *Open Journal of Modern Hydrology*, **4**, 101-111. <https://doi.org/10.4236/ojmh.2014.44010>
- [3] Gophen, M. (2020) Climate and Water Balance Changes in the Kinneret Watershed: A Review. *Open Journal of Modern Hydrology*, **10**, 21-29. <https://doi.org/10.4236/ojmh.2020.102002>
- [4] Gophen, M. (2023) Land Use-Land Cover and Climate Change in the Hula Valley. In: Gophen, M., Ed., *Agriculture, Recreation, Water Quality and Nature Protection in the Hula Valley, Israel*, Springer, 89-111. https://doi.org/10.1007/978-3-031-23412-5_6

- [5] Gophen, M., Meron, M., Levin-Orlov, V., Tsipris, Y. and Peres, M. (2020) Climate Change, Regional Water Balance and Land Use Policy, in the Watershed of Lake Kinneret (Israel). *Open Journal of Ecology*, **10**, 200-224. <https://doi.org/10.4236/oje.2020.104014>
- [6] Gophen, M. (2016) The Impact of El-Nino/Southern Oscillation (ENSO) on Fishery and Water Quality in Lake Kinneret (Israel). *Open Journal of Modern Hydrology*, **06**, 43-50. <https://doi.org/10.4236/ojmh.2016.62005>
- [7] Gophen, M. (2019) Climate Change and Water Loss in the Kinneret Drainage Basin. *Land Use Policy*, **80**, 424-429. <https://doi.org/10.1016/j.landusepol.2018.03.008>
- [8] Gophen, M. (2019) The Ecological Outcome of Climate Change in Lake Kinneret—Thermal Pollution. *Open Journal of Modern Hydrology*, **9**, 89-102. <https://doi.org/10.4236/ojmh.2019.93005>
- [9] Gophen, M. (2021) Climate Change-Enhanced Cyanobacteria Domination in Lake Kinneret: A Retrospective Overview. *Water*, **13**, Article 163. <https://doi.org/10.3390/w13020163>
- [10] Gophen, M. (2021) Effects of Climate Conditions on TP Outsourcing in Lake Kinneret (Israel). *Climate*, **9**, Article 142. <https://doi.org/10.3390/cli9090142>
- [11] Gophen, M. (2021) Short Commentary Phosphorus Outsourcing to Lake Kinneret (Israel) Is Significantly Affected by Climate Conditions. *Geology, Earth and Marine Science*, **3**, 1-2. <https://doi.org/10.31038/GEMS.2021342>
- [12] Byrne, D.H. and Bacon, T. (1992) Chilling Accumulation and Its Importance and Estimation. *The Texas Horticulturist*, **18**, 8-9.
- [13] Cesaraccio, C., Spano, D., Snyder, R.L. and Duce, P. (2004) Chilling and Forcing Model to Predict Bud-Burst of Crop and Forest Species. *Agricultural and Forest Meteorology*, **126**, 1-13. <https://doi.org/10.1016/j.agrformet.2004.03.002>
- [14] Gophen, M. (2024) Lake Kinneret and Hula Valley Ecosystems under Climate Change and Anthropogenic Involvement. *Climate*, **12**, Article 72. <https://doi.org/10.3390/cli12050072>
- [15] Malhi, Y., Franklin, J., Seddon, N., Solan, M., Turner, M.G., Field, C.B., *et al.* (2020) Climate Change and Ecosystems: Threats, Opportunities and Solutions. *Philosophical Transactions of the Royal Society B: Biological Sciences*, **375**, Article ID: 20190104. <https://doi.org/10.1098/rstb.2019.0104>
- [16] Choi, D., Gao, Z. and Jiang, W. (2020) Attention to Global Warming. *The Review of Financial Studies*, **33**, 1112-1145. <https://doi.org/10.1093/rfs/hhz086>
- [17] Woolway, R.I., Kraemer, B.M., Lenters, J.D., Merchant, C.J., O'Reilly, C.M. and Sharma, S. (2020) Global Lake Responses to Climate Change. *Nature Reviews Earth & Environment*, **1**, 388-403. <https://doi.org/10.1038/s43017-020-0067-5>
- [18] Fawzy, S., Osman, A.I., Doran, J. and Rooney, D.W. (2020) Strategies for Mitigation of Climate Change: A Review. *Environmental Chemistry Letters*, **18**, 2069-2094. <https://doi.org/10.1007/s10311-020-01059-w>
- [19] Jansson, J.K. and Hofmockel, K.S. (2019) Soil Microbiomes and Climate Change. *Nature Reviews Microbiology*, **18**, 35-46. <https://doi.org/10.1038/s41579-019-0265-7>
- [20] Zhai, P., *et al.* (2023) Indicators of Global Climate Change 2023: Annual Update of Large-Scale Indicators of the State of the Climate System and Human Influence. Volume 16, 2625-2658.
- [21] Yila, K.M., Gboku, M.L.S., Lebbie, M.S. and Kamara, L.I. (2023) Changes in Rainfall and Temperature and Its Impact on Crop Production in Moyamba District, Southern

- Sierra Leone. *Atmospheric and Climate Sciences*, **13**, 19-43.
<https://doi.org/10.4236/acs.2023.131003>
- [22] Alnaser, N.W., Flanagan, R., Kazmerski, L., Sayigh, A.A., Nayfeh, M.H. and Alnaser, W.E. (2022) Worrying about Climate Change. *Atmospheric and Climate Sciences*, **12**, 441-461. <https://doi.org/10.4236/acs.2022.122026>
- [23] Pal, J.S., Giorgi, F., Bi, X., Elguindi, N., Solmon, F., Gao, X., *et al.* (2007) Regional Climate Modeling for the Developing World: The ICTP RegCM3 and RegCNET. *Bulletin of the American Meteorological Society*, **88**, 1395-1410.
<https://doi.org/10.1175/bams-88-9-1395>
- [24] Parry, M.L., Canziani, O.F., Palutikof, J.P., Van der Linden, P.J. and Hanson, C.E. (2007) *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Cambridge University Press, 976 p.
- [25] Vicuna, S. and Dracup, J.A. (2007) The Evolution of Climate Change Impact Studies on Hydrology and Water Resources in California. *Climatic Change*, **82**, 327-350.
<https://doi.org/10.1007/s10584-006-9207-2>
- [26] Viney, N.R. and Sivapalan, M. (1996) The Hydrological Response of Catchments to Simulated Changes in Climate. *Ecological Modelling*, **86**, 189-193.
[https://doi.org/10.1016/0304-3800\(95\)00050-x](https://doi.org/10.1016/0304-3800(95)00050-x)
- [27] Samuels, R., Rimmer, A., Hartmann, A., Krichak, S. and Alpert, P. (2010) Climate Change Impacts on Jordan River Flow: Downscaling Application from a Regional Climate Model. *Journal of Hydrometeorology*, **11**, 860-879.
<https://doi.org/10.1175/2010jhm1177.1>
- [28] Alpert, P., Krichak, S.O., Shafir, H., Haim, D. and Osetinsky, I. (2008) Climatic Trends to Extremes Employing Regional Modeling and Statistical Interpretation over the E. Mediterranean. *Global and Planetary Change*, **63**, 163-170.
<https://doi.org/10.1016/j.gloplacha.2008.03.003>
- [29] Krichak, S.O., Alpert, P. and Kunin, P. (2009) Projections of Climate Change over Non-Boreal East Europe during First Half of Twenty-First Century According to Results of a Transient RCM Experiment. In: Groisman, P.Y. and Ivanov, S.V., Eds., *Regional Aspects of Climate-Terrestrial-Hydrologic Interactions in Non-Boreal Eastern Europe*, Springer, 55-61. https://doi.org/10.1007/978-90-481-2283-7_7
- [30] Kunstmann, H., Suppan, P., Heckl, A. and Rimmer, A. (2007) Regional Climate Change in the Middle East and Impact on Hydrology in the Upper Jordan Catchment. In Boegh, E., *et al.*, Eds., *Quantification and Reduction of Predictive Uncertainty for Sustainable Water Resources Management*, IAHS publ. 313, 141-149.
- [31] Rimmer, A. (2007) Systems Hydrology Models for the Upper Catchments of the Jordan River and Lake Kinneret, Israel. *Israel Journal of Earth Sciences*, **56**, 1-17.
<https://doi.org/10.1560/ijes.56.1.1>