ISSN 0973-8541, HUMANITIES AND DEVELOPMENT, VOL.20, No.4, Oct. –Dec., 2025/41

Status and Management of Water Resources (Especial Reference to India)

Anil Kumar Tiwari

https://doi.org/ 10.61410/had.v20i4.258

Abstract: Water is an invaluable natural resource and a life-giving element provide by the natutre. It is proved that the first life originated in water and from the earliest times human civilizations developed in the form of river valley civilizations on the banks of water sources. Water cycle is essential for the sustainable ecosystems of the earth, but over the decades, human greed for indiscriminate development, deforestation, rapid industrialization and urbanization, and consequent natural disasters have unbalanced the environment, leading to drastic changes in the global climate. Today climate change is not only a major global environmental problem but also a serious matter of concern for the third world countries like India. Since the last century, the Indian subcontinent has experienced trends of increasing temperature.

Climate change is directly related to water and having a serious impact on Indian water resources. Changes in the water cycle due to climate change are natural, leading to heavy rainfall, flooding in some areas and droughts in other areas. It is estimated that 12 percent of the total geographical area of the country is flood prone and 16 percent geographical area is drought prone respectively. Changes in land use, inter-basin transfers, uncontrolled and unscientific irrigation and drainage have changed the water cycle in most of river basins in India. However, most of India's water problems are related to groundwater and, we are the largest user of groundwater in the world. Overpopulation has led to a huge water demand. Water quantity and quality are affected because of inefficient water resource management.

Therefore, to insure the availability of water resources for next generations, there is a need for integrated and sustainable approaches of water resources management at every level, i.e., assessment of availability of water resources, managing variability for increasing demands and potential impacts of climate change. The paper is an attempt to present the availability and use of water resources in the specific context of India and recommend some measures of sustainable water management.

Key Words: Water Resources, Surface Water, Water crisis, Water Conservation and Management

- Assistant Professor of Geography, Kamla Devi Bajoria Degree College, Dubahar, Ballia- 277405 (U.P.)

Introduction: Water is an important natural resource as well as a life-giving element for all living things on this earth. The importance of water is increasing even more when water resources are used for drinking, irrigation, power generation, sewage disposal, cleaning, fishing, recreation, transportation and large-scale industrial processes. The distribution of rainfall in India is highly uneven both in terms of time and space. Water needs to be stored and used to meet the demands of different regions throughout the year. Sustainable development requires efficient management and optimum utilization of available water resources. Regional impacts in this regard are still uncertain, it is expected that global climate change causes an intensification of the hydrological cycle.

Global climate change is creating serious issues for India's fresh water resources and foodgrain production. Thus, rising surface temperature is enhanced the melting of snow and glaciers in the Himalayas and endangering the water supply on which millions of people depend. According to the IPCC analysis, India is likely to suffer from outright water stress with annual water availability of less than 1,465 cubic metres per capita by 2025 (The Hindu, 2019).

The politics of most of the countries of the world is focused on water conservation and supply, but, there are many disputes for the availability of safe and adequate water in the world. Many countries, states and communities can be seen fighting among themselves for the proper sharing of water. India's Indus Waters Treaty dispute with Pakistan and the Brahmaputra River water dispute with China are also the matters of international importance. The Cauvery river water sharing dispute between Tamil Nadu and Karnataka is pending even after involvement of Supreme Court. Although our country is getting enough water for our nutrition from rainwater, surface water and ground water, but in recent years problems are becoming serious in the western part of Rajasthan, southern states, Bundelkhand region, National Capital Region, some parts of Haryana and western Uttar Pradesh. The main reason for this type of problem is the high demand of water in above area due to the increase in population pressure and the intensity of development. Besides, the current socio-economic activities and excessive economic incentives are encouraging the improper use of water resources. The paper highlights the availability and use of water resources and the impact of climate change on water resources and recommend some measures of sustainable water management with special reference to India.

Review of Literature: A review of literatures on water resources and climate change discloses several specific influences on all the natural biotic and abiotic as well as

human civilisation. In this order, Nigel W. A., (1999) described an assessment of the consequences of climate change for comprehensive hydrological systems and water resources with the help of large-scale hydrological models. Mall, Rajesh and others (2006) explore the silent features of the potentials for sustainable development of surface water and groundwater with the limitations imposed by climate change. They have promoted that the broad scale intensive planning would be requisite for adaptation actions for the impact of climate change. Madhusoodhanan and Eldho (2016) explored the challenges for climate change impact assessment on the water resources of India. They presented the dynamic and comprehensive inventory and challenge of climate change and water resources. Johnson, T. and Others (2022) discussed resilience in the context of changes in climatic drivers, adaptability and water quality practices to meet long-term goals. Ciampittiello, M. and Others (2024) present an overview aims to achieve the kind of responses different governments are taking across countries, impact of different water management solutions on fields such as economy, society, and nature to find strategies and smarter solutions that consider also the cost–benefit ratio and environmental aspects, relevance of the main solutions on economy, society, and environment. Vahid Karimi and Others (2024) suggested the requirement, key mechanisms, and knowledge breaks of effective water authority and theorizes the relationship between water governance, climate adaptation, and sustainable development. Chivambo, J. M. F. and Other (2025) suggested that water authority remains a compound task, demanding association between researchers, officials and local inhabitants, as well as influential volume to address changes in water resources availability and related hazards.

Objectives and Data Sources: Objectives of this paper is assessment of availability and uses of water resources in the specific context of India and the impacts of climate change on water resources, future water related crises and some measures of water management are also discussed. This work is basically based on secondary data sources, personal observation and experiences.

The status of water resources in India: Water resources are not evenly distributed on the earth. A total of 361 million square kilometres of Earth's surface is covered by water followed by 149 million square kilometres of land area in the form of rivers, glaciers, lakes, swamps and groundwater (Jat, 2010). The details are as follows:

(A) Surface Water- India has a strong network of river systems, including the Himalayan river systems, besides the innumerable water bodies in the subcontinent, making it the second most water-resource-rich country in the world after South

America. Himalayan rivers are perennial sources of fresh water, although the flow decreases during the non-monsoon period. The primary sources of water in these rivers are either dry snow or rainwater. Despite many existing dams and canals, the capacity to draw the water from these rivers for various uses are fully achieved. However, the south peninsular rivers are charged by groundwater and their flow is strengthened by seasonal rainfall. Therefore, their flow becomes limited in the low summer season. Rivers like, Luni and Mahi, which flow through desert are completely flooded by the monsoon and cease to exist the rest of the year. Data shows that the Gangotri glacier is retreating by about 30 metres per year. Changed climatic conditions are expected to increase the rate of melting of glaciers, leading to increased heat flow in some river systems for a few decades, followed by decreased flow when the glaciers disappear (IPCC, 1998).

(B) Groundwater- Groundwater is the major source of drinking water in rural areas and about 85 percent of rural water supply in India is dependent on it. Unfortunately, due to large-scale extraction of subsurface water, the water table in many regions of the country has fallen significantly in recent decades, which threatening groundwater stability. Gujarat, Punjab, Haryana, Tamil Nadu and Rajasthan which have recorded groundwater deficit above the national average. In the lowland area, the aquifer never flows and become a deep aquifer. These artesian aquifers are filled with fresh water to a depth of about 2,500 meters (Chitale, 1992).

These deep aquifers are artesian and often produce water through wells without pumping. This helps to least reduce the direct operational cost and cost significantly less than surface irrigation projects for water supply in the same areas. Drinking water of deep aquifers is less likely to be contaminated with agrochemicals and other pollutants because of thick sediment column, which is the most effective filtering system. About 71 percent of the earth's surface is covered with water. But, only 03 percent of the water available in nature of pure water on the surface. Of this fresh water, 69 per cent is in the form of glaciers and ice caps, 30 percent as the under groundwater and less than 1 per cent in the form of ground water in lakes, rivers and swamps. The remaining 97 per cent is in the form of saltwater in the oceans.

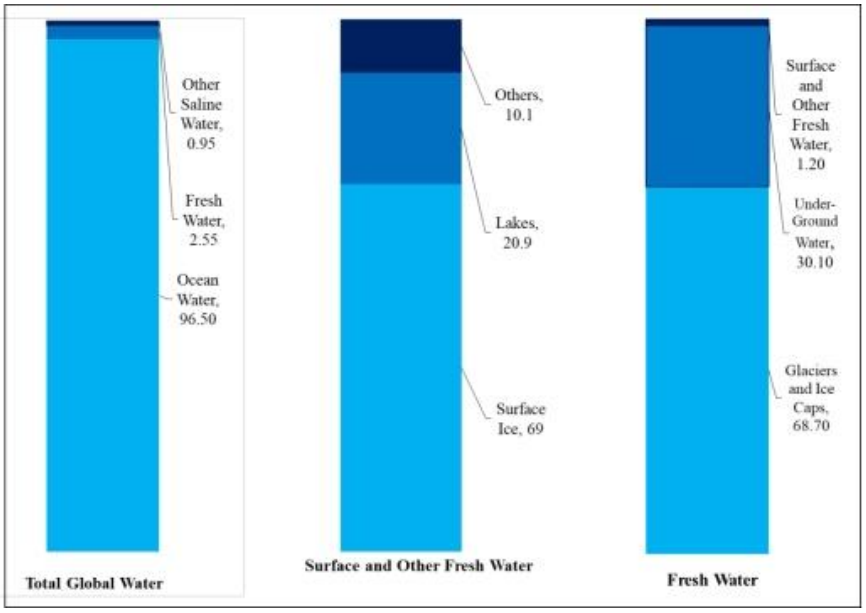

Figure- 01: Obtained from the United States Geological Survey, School of Hydrology, 2019

Figure- 01 shows that a relatively small portion is available to sustain human, plant and animal life. Most of this water is locked in ice, and the other 20.9 percent is found in lakes. Rivers make up 0.49 percent of the surface freshwater. Although, rivers has only account for a small amount of freshwater, this is where humans get a large portion of their water from (School of Hydrology, 2019). Only 1.20 percent of all fresh water is in direct use for humans, the remaining 98.8 percent of useful water is underground.

The two main sources of fresh water in our country are rainwater and rivers originating from the melting of Himalayan glaciers. There are about 5,000 glaciers in the Himalayas with an estimated snow cover of 43,000 square kms. It is believed that out of this, 10,000 square kilometres of snow cover falls in Indian regions (NEERI, 2019).

Impact of climate change on water resources: Water and climate change are inextricably interrelated. Climate change affects the water resources in complex ways, i.e., shrinking ice sheets, rising sea levels, floods and droughts etc. from unpredictable rainfall patterns (United Nations, 2023). Thus, climate change is exacerbating both water scarcity and water-related threats (floods and droughts), as rising temperatures disrupt rainfall patterns and the entire water cycle (UNICEF, 2023). Climate change

causes major changes in the water cycle, with some regions experiencing high and intense rainfall while others experiencing extreme drought (Mishra and Arunlal, 2022).

Temperature drives the water cycle and, affects it at every level, resulting in increased rates of evaporation and precipitation. In association with these processes, a shifting pattern of rainfall, runoff, can affect the spatial and temporal distribution of soils moisture, groundwater reserves, droughts, and floods. However, impact of climate change will be felt globally, but is likely to be severely felt in India with an agrarian economy. Increasing population, rapid urbanization and unplanned industrialization demand freshwater, food and energy will increase the extreme climate events due to changing climatic scenario and higher vulnerability.

The Union Ministry of Water Resources (2006) has estimated that the annual replenishable groundwater for the country was estimated at 432 billion cubic metres (BCM) as of March 2004. Sources of replenishment include rainfall (67 percent) and recharge (33 percent) due to source water conservation structures such as canal seepage, return flow from irrigation, seepage from water bodies and artificial recharges. There is a need to develop sustainable development and management plans, rational adaptation strategies to mitigate the adverse effects of climate change on water resources and to achieve it. There are three main signs of climate change: (i) Increase in global average temperature, (ii) Change in regional rainfall pattern, and (iii) Sea level rise.

Water Crisis: Water is being exploited in the race for development and, today, the water crisis will emerge as a disaster for the future. Water is being misused than it's used, a time will come when there will be a fight for fresh water. Along with the negligence of the people, governments are also guilty for lack of suitable and efficient plans for water conservation. It must to conserve water within time to avoid future disasters. Presently, half of the country is facing the water crisis every year from April to June (before the rains). Out of the 32 major cities of our country, 22 are currently facing a severe water crisis. Water level of more than four thousand underground water sources is continuously decreasing. About one billion people out of a population of 1.2 billion do not have access to quality drinking water (Srivastava, 2015). Central Water Commission has predicted that if population growth continues unabated, irrespective of climate change, per capita water availability will fall drastically by 2050 (Raje and Majumdar, 2010). Assessing the impact of climate change on water resources studies requires down-scaling rainfall and other variables such as

temperature, relative humidity, solar radiation, wind direction and wind speed from the global to regional levels.

The Central Water Commission (A sub-committee of the Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India) has assessed the requirement of water for various uses in Environment Statistics. In 2010, total water demand of human activities was 793 billion cubic metres in India, in which maximum portion 84.24 percent water need for irrigation followed by 7.06 percent for drinking uses and only 1.51 percent used for industrial purposes. It has been estimated that for 2050 water demand will be just double of 2010 (1447 billion cubic metre) because of explosion of population and increase the per capita capacity of water consumption (Table-01 and Figure-02). The progressively deteriorating population and demand for water and the depleting and polluted water sources are further indications of the dangerous future of mankind.

Water Conservation and Management: Over the century, two significant changes have recorded in our country regarding water conservation. First, we have shifted the responsibility of water management almost entirely to the states, and the states have poorly managed the water projects, which require repair and maintenance. Furthermore, due to the lack of interest of public in the careful uses of water, the sustainability of water resources has become precarious. Consequently, the government's drinking water supply schemes are facing serious problems, and despite the government's best efforts, the problems appear to be unresolved.

Table- 01: Sectorwise Demand of Water in India

Sectors of Demand	Demand of Water in Year (Billion Cubic Meters- BCM)					
	2010		2025		2050	
	BCM	Percent	BCM	Percent	BCM	Percent
Irrigation	668	84.24	910	83.26	1072	74.08
Potable Water	56	7.06	73	6.68	102	7.05
Industry	12	1.51	23	2.10	63	4.35
Energy	5	0.63	15	1.37	130	8.98
Others	52	6.56	72	6.59	80	5.53
Total	793	100	1093	100	1447	100

Source: Environment Statistics, 2018 (2025 and 2050 Projected)

Second, instead of many simple and traditional indigenous techniques of rainwater harvesting, exploitation of rivers and groundwater through dams and tube wells has become the primary source of water. Enormous demand of water and current state of our water resources, alternatives must be developed to supplement existing freshwater reserves and reduce over-exploitation, to ensuring sustainable water extraction systems. Micro-watershed development is a viable and sustainable way to use water more expeditiously, and, it is must to develop an approach for land and water conservation that utilizes natural and human resources to ensure food, fodder, fuel, fruits, and fiber. Watershed planning is based on the principle of utilizing of land to its potential and water availability (Smyle, et. al., 2014).

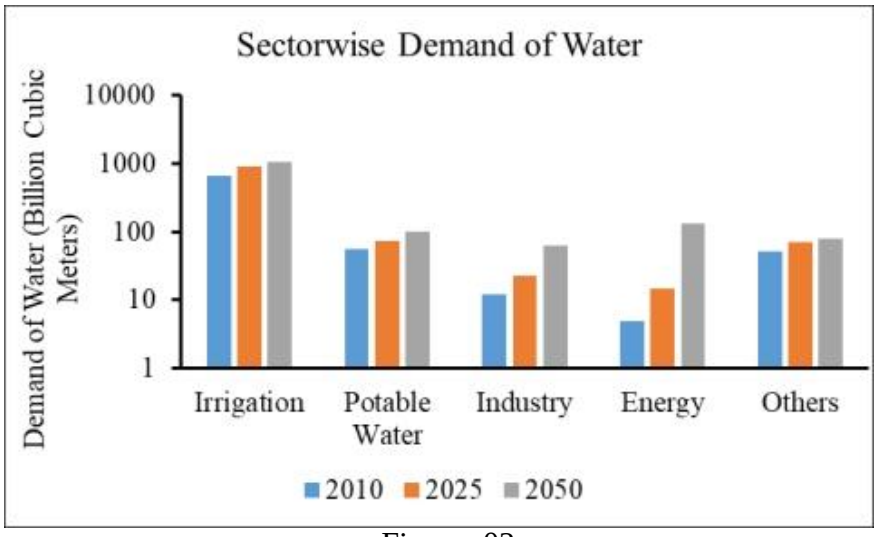

Figure- 02

To sustain the available water resources in an area, the following key factors should be taken into account (Jha and Sinha, 2009):

1. Water availability,
2. Favourable topography and slope,
3. Physical and hydro-geophysical infrastructure,
4. Water infiltration and its repairable characteristics,
5. watersheds efficiency
6. Techno-economic feasibility of water management.
7. Options for groundwater recharge

Although the effectiveness of above options is subject to the uncertainty and vagaries of climatic conditions, and poor monsoons can severely affect their efficiency, the above strategies remain important in regional water management. The country's growing demand for water and its retrograding availability are a growing national concern. Predictions of water crises for future are rapidly becoming reality. Major governmental initiatives are needed to plan and implement water conservation programs. The significant impacts of global warming on water resources, it is must that government develop some appropriate integrated guidelines and action plans for sustainable water conservation. These attempts require an integrated approach with considering the following facts:

1. Healthy aquatic ecosystems (mangroves, seagrass beds, marshes, and wetlands) and improved water management can protect living organisms from climate change and its threats by reducing greenhouse gas emissions. (Christophersen, 2022).
2. Early warning systems for floods, droughts, and other water-related hazards provide more than a tenfold return on investment and can significantly reduce disaster risk, *i.e.,* 24-hour warning of an impending storm can reduce ensuing losses by 30 percent (WMO, 2022).
3. Water supply and sanitation systems that can withstand climate change could save the huge lives of infants (Guterres, 2018).
4. Improvements in drilling technology (pumping sets) over the past few decades have led to over-exploitation of groundwater. FAO estimated that 10 percent of global grain harvests are being produced from depleted groundwater (UNEP, 2022). Climate-smart agriculture can help reduce demand on freshwater supplies by using drip irrigation and other water resources more efficiently.

Conclusion: Rainwater, surface water, and groundwater resources have collectively provided adequate and sufficient water for the average Indian population. Increasing demand and development pressures are changing the water availability situation in India (Geography and You, 2010). Currently, the level of groundwater exploitation in the country is 63.33 percent, possibly the highest in the world. Approximately 67 percent of groundwater is recharged by rainfall, which is insufficient (Saxena, 2022). Thus, groundwater reserves are depleting, and surface water resources have become so polluted that they are no longer suitable for lives. Water management is the only

option to maintain the relationship between water and life. The Government of India's Jal Shakti Abhiyan, Jal Jeevan Mission, Atal Groundwater Project, Amrit Sarovar Yojana, and the concept of local-level Pani Panchayats are important steps in this direction (Kurukshetra, 2022). India can avert future water crises by using and managing its water more judiciously. This requires publishing water resource data and setting standards for water use, which must be strictly followed to ensure adequate, clean water is available to everyone. Water development projects should be multipurpose, achieving maximum human well-being in the shortest possible time, energy consumption, budget, and environmental damage.

References

1- António Guterres (2018), Remarks at launch of the New Climate Economy report, 05 September 2018, available on: https://www.un.org/sg/en/content/ sg/speeches/2018-09-05/new-climateeconomy-report-remarks-launch#:~: text=Climate%2 Dresilient %20water%20 supply%20and, vast%20benefits%20 for%20public%20health, accessed on 29.05.2023.

2- Chitale, M. A. (1992). Water Resource Management in India — Achievements and Perspectives, World Bank Technical Paper No. 175.

3- Chivambo, J. M. F., Bonde, F., Chichava, I., Abuchir, J., Cuinica, S. and Muhala, V. (2025), Effect of climate change on water resources management: a review of the literature. Urban, Planning and Transport Research, 13 (1), Availabe at: https://doi.org/10.1080/21650020.2025.2504488.

4- Christophersen Tim (2023), Nature for Climate Action, United Nations Environment Programme, available at: https://wedocs.unep.org/ xmlui/bitstream /handle/20.500.11822/35360/NatClim.pdf.

5- Ciampittiello, M., Marchetto, A., and Boggero, A. (2024), Water Resources Management under Climate Change: A Review, Sustainability, Vol. 16 (9), 3590, Availabe at: https://doi.org/10.3390/su16093590.14

6- Environmental Statistics (2018), Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India, New Delhi.

7- Geography and You, January 2010, Volume 9, Number 1, Page 17.

8- IPCC (1998), The Regional Impacts of Climate Change: An Assessment of Vulnerability. A Special Report of IPCC (Intergovernmental Panel for Climate

Change) Working Group II [Watson, R. T., M. C. Zinyowera and R. H. Moss (eds.)] and WMO/ UNEP. Cambridge: Cambridge University Press.

9- Jat, B.C. (2010), Water Management, Geography and You, Volume 9, Number 1, January 2010, Pages 42-48.

10- Jha, B. and Sinha, S. (2009), Towards Better Management of Ground Water Resources in India. Water and Energy International. 67.

11- Johnson, T., Butcher, J., Santell, S., Schwartz, S., Julius, S., and LeDuc, S. (2022), A review of climate change effects on practices for mitigating water quality impacts. Journal of water and climate change, 13, 1684–1705, https://doi.org/ 10.2166/wcc.2022.363.

12- Kurukshetra, July 2022, Editorial

13- Madhusoodhanan, C. G., Sreeja, K. G., and Eldho, T. I. (2016), Climate change impact assessments on the water resources of India under extensive human interventions, Ambio, 45 (6), pp. 725– 741, https://doi.org/10.1007/s13280-016-0784-7.

14- Mall, Rajesh, Gupta, Akhilesh, Singh, Ranjeet, Singh, R and Rathore, L. (2006), Water Resources and Climate Change: An Indian Perspective. CURRENT SCIENCE, Vol. 90, No. 12, Published on 25 June 2006, available at:https://www.researchgate.net/publication /235916232_Water_resources_and_ climate _ change_An_Indian_perspective.

15- Mishra, Avinash and Arunlal, K. (2022), Sustainable Management of Water Resources, Kurukshetra, July 2022, Pages 5-9.

16- NEERI (2019), Guideline Document On Rainwater Harvesting Edition I, Compiled By CSIR-NEERI, Nagpur, P. 5

17- Nigel W. A. (1999), Climate change and global water resources, Global Environmental Change, Vol. 9, No. 1, Pages S31-S49, available at: https://www. sciencedirect.com/ science/article /pii/S0959378099000175.

18- Raje, D. and P.P. Mujumdar (2010), Reservoir Performance under Uncertainty in Hydrologic Impacts of Climate Change, Advances in Water Resources, Vol. 33, No. 3, pp. 312–26.

19- Saxena, Jagdeep, (2022), Water Management in Agriculture, Kurukshetra, July 2022, pp. 14-20.

20- Smyle, Jim and Others (2014), Watershed Development In India: An Approach Evolving through Experience. 10.13140/RG.2.1.1120.2164.15.

21- Srivastava, Kamal Kishore (2015), Future Disaster: Water Crisis, available on: https://hindi.indiawaterportal.org/articles/ bhavaisaya-kai-apadaa-j ala-sankata, accessed on 22.05.2023.

22- The Hindu (2019), India's per capita water availability to decline further: ICAR, Economy, Agribusiness, September 05, 2019, New Delhi, available on: https://www.thehindubusinessline. com /economy/agri-business /indias- per-capita-wateravailability- to-decline-further-icar/article 29342714.ece, accessed on: 24.05.2023.

23- UNICEF (2023), Water and the global climate crisis: 10 things you should know, available on: https://www.unicef.org/stories/water-and -climate-change-10-things-you-should-know, accessed on: 24.05.2023.

24- Union Ministry of Water Resources (2006), Dynamic Groundwater Resources of India, Central Groundwater Board, Ministry of Water Resources, Government of India.

25- United Nations (2023), Water – at the center of the climate crisis, Climate Action, available on: https://www.un.org/en/climatechange/science/climate-issues/water, accessed on: 24.05.2023.

26- United Nations Environment Programme (2022), Five Threats to Water That Sustains Our Farms, available at: https://www.unep.org/news-and-stories/story/five-threats-water-sustains-ourfarms, dated- 31.05.2023.

27- Vahid Karimi, Esmail Karamidehkordi and Yan, Tan (2024), Water governance, climate change adaptation, and sustainable development: A future perspective, in Suhaib A. B. and F. A. Malla (eds) Current Directions in Water Scarcity Research, Elsevier, Volume 8, Pages 219- 232, https://doi.org/10.1016/B978-0-443-23631-0.00015-7.

28- Water Science School (2019), The distribution of water on, in, and above the Earth, posted on October 25, 2019, available at: https://www.usgs.gov/media/ images/distribution-waterand-above-earth#:~:text= About%2071%20percent %20of%20the ,in%20you%20and% 20your%20dog, accessed on : 29.05.2023.

29- WMO (2022), Press Release on Early Warning systems must protect everyone within five years, published on: Published 23 March 2022, available on: https://public.wmo.int/en/media/pressrelease/%E2%80%8Bearly-warning-systems- must-protect-everyone-within-fiv