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# Unraveling the Productivity Paradigm in West Bengal's Agricultural Landscape

## A Study On Water Management Strategies Across Varied Agro-climatic Zones and Crop Potential in West Bengal

Founded in 2008, the Environment Conservation Society (ECS), also known as SwitchON Foundation, is a nonprofit organization dedicated to fostering equitable and sustainable development in India. Our vision is to build a sustainable and equitable India, focusing on Clean Energy, Clean Air, Sustainable Mobility, Climate Smart Agriculture, Conservation and Integrated Management of Natural Resources, Just Transition, Skilling, and Sustainable Cities. Our mission is to promote sustainable livelihoods and address environmental challenges through innovative business models and technologies, aiming to create opportunities for 10 million people at the bottom of the pyramid by 2030.

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# Executive Summary

West Bengal, an agrarian state with 71.23 lakh farm families, exhibits diverse agro-climatic zones that influence its agricultural practices. ***Effective water management is crucial for sustainable farming, given the state's varied topography, soil composition, and climate.*** This report provides an in-depth analysis of West Bengal's agro-climatic zones, detailing rainfall distribution, crop suitability, and water management practices.

***West Bengal spans six agro-climatic zones:*** Northern Hill, Terai-Teesta Alluvial, Gangetic Alluvial, Vindhyan Alluvial, Undulating Red Laterite, and Coastal Saline. These **zones receive varied rainfall,** from 1100 mm to 3500 mm, affecting crop selection and productivity. Major crops include paddy, wheat, maize, potato, jute, and vegetables. Despite ample water resources, with a total availability of 160.35 BCM (132.77 BCM from surface water and 27.58 BCM from groundwater), managing this resource is challenging.

Water management strategies vary by zone. The Northern Hill zone utilizes perennial streams and secondary water storage. The Terai-Teesta Alluvial zone relies on rainwater harvesting and shallow tube wells. The Gangetic and Vindhyan Alluvial zones employ groundwater tapping, river-lift irrigation, and draining-out techniques. The Undulating Red Laterite zone focuses on rainwater harvesting and secondary storage facilities, while the Coastal Saline zone uses raised bed technology and improved drainage systems.

Addressing water scarcity, waterlogging, and salinity issues is vital for West Bengal's agricultural sustainability. ***Strategic policies tailored to each zone's unique challenges are necessary to optimize crop yields and ensure long-term agricultural productivity.*** By implementing effective water management practices, West Bengal can enhance its agricultural output and support the livelihoods of its farming communities.

# 1.Introduction

West Bengal stands out as the most productive state in India. This predominantly agrarian state is home to 71.23 lakh farm families. The state's diverse Agro-climatic zones play a pivotal role in shaping the agricultural landscape, influencing crop suitability, and determining water availability for sustainable farming practices. Effective water management is crucial for stability and sustainability in agricultural production systems. This report presents an in-depth analysis of the various agro-climatic zones across West Bengal, detailing rainfall distribution and its direct impact on crop production. Additionally, it examines various water management systems employed in these zones, focusing on strategies designed to optimize irrigation, mitigate water scarcity, and enhance overall agricultural productivity. By exploring the dynamic interplay between water resources and agricultural practices, this report offers valuable insights into the challenges and opportunities present in West Bengal's different agro-climatic contexts.

# 2. Agro-climatic zones and rainfall in West Bengal

Agroclimatic zones significantly influence the agricultural landscape by determining the types of crops that can thrive in a region. These zones are defined by the interplay of climate, soil, and topography, which collectively affect agricultural activities. Among the various climatic factors, rainfall is paramount in influencing crop growth.

**Table 1: Salient features of West Bengal on agricultural land**

| Sl.No | Salient features of West Bengal | Value |
|---|---|---|
| **1** | Total geographical area | 88.75 lakh ha |
| **2** | Agricultural land | 56.48 lakh ha |
| **3** | Net sown area | 52.43 lakh ha |
| **4** | Cropping intensity | 188.5% |
| **5** | Water availability (BCM) | |
| | Surface water | 132.905 |
| | Groundwater | 27.580 |
| | Total (BCM) | 160.485 |
| **6** | Area under micro-irrigation (ha) March 2019 | |
| | Drip irrigation | 964 |
| | Sprinkler irrigation | 65,723 |
| | Total | 66,687 |

*(Source: Mandal et al., 2022)*

Table 1 indicates that 64% of the land falls under the net sown area category, with a cropping intensity of 188.5%. West Bengal has a total water availability of 160.485 BCM, predominantly sourced from surface water. As of March 2019, 66,687 hectares were under micro-irrigation, with 65,723 hectares utilizing sprinkler irrigation.


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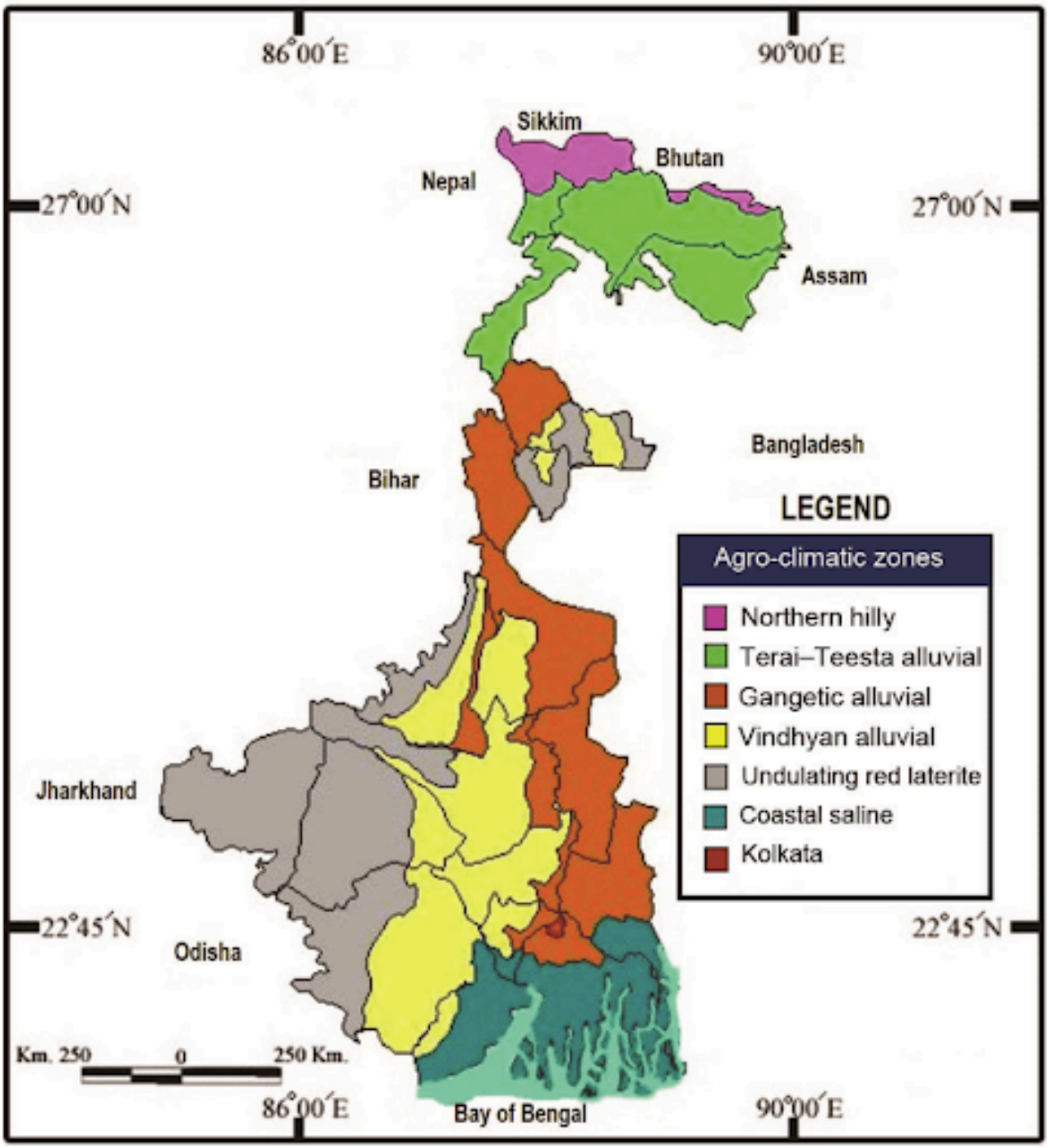


**Figure 1: Agro-climatic zone of West Bengal**

*(Source: Mandal et al., 2022)*

West Bengal has six identified agro-climatic zones: the Northern Hill Zone, Terai-Teesta Alluvial, Gangetic Alluvial, Vindhyan Alluvial, Undulating Red Laterite, and Coastal Saline Zone (see Fig. 1). Table 2 provides a detailed discussion of each zone's regional and precipitation characteristics, as well as the major crops cultivated in each area.

**Table 2: Agroclimatic zone's characteristic table and rainfall variation**

| Agro-climatic zone | Total Area (lakh ha.) | Districts | Rainfall variation( mm) | Major crops |
|---|---|---|---|---|
| Northern hill zone | 2.428 | Darjeeling (except Siliguri sub-division), Kalimpong and the northern fringe of Jalpaiguri | 2500 - 3500 | Paddy, Oilseeds, Vegetables, Potatoes, Wheat, Pulses |
| Terai–Teesta alluvial zone | 2.149 | Siliguri sub-division of Darjeeling district, Jalpaiguri, Alipurduar, Coochbehar and North Dinajpur | 2000-3000 | Paddy, Tobacco, Jute, Oilseeds, Vegetables. |
| Gangetic alluvial zone | 15.304 | Northern and eastern parts of the River Ganga, comprising districts of South Dinajpur, Malda, Murshidabad, Nadia, North 24 Parganas, South 24 Parganas, Hooghly, Howrah, East Burdwan and parts of Birbhum. | 1350 - 1650 | Paddy, Jute, Sugarcane, Winter veg: Brinjal, Cauliflower,Cabbage,Tomato,Peacod,Fruit: Mango,Banana, jackfruit,Guava, papaya |
| Vindhyan alluvial zone | 17.537 | Western part of Murshidabad and Hooghly, South Dinajpur, eastern part of Birbhum and Bankura, East Midnapur, central part of Burdwan and the northern part of Howrah | 1300 - 1500 | Rice is the major crop; other important crops are potato, jute, sugarcane, pulses, oilseeds and vegetables. One of the best potato belts in the whole of India is located in this zone. |
| Undulating red laterite zone | 24.842 | South Dinajpur, Malda, Birbhum, West Burdwan, Purulia, Bankura, West Midnapur, Jhargram Birbhum, Burdwan, Bankura, Purulia and Midnapur | 1100 - 1300 | Wheat, rice and maize |
| Coastal saline zone | 14.569 | Southern parts of North 24 Parganas, South 24 Parganas, Howrah, East Midnapur | 1500 - 1800 | Paddy, Chillies, Watermelon, Sunflower, Groundnut, Sugarbeet and Vegetables |

*(Source: Krishi, 2023; Mandal et al., 2022; Dutta, 2018)*

Table 2 presents the essential rainfall rates and the major crops cultivated in each agroclimatic zone. In addition to rainfall, soil composition and water-holding capacity are crucial factors for successful cultivation.

# 3. West Bengal: Water Availability, Water Demand and Gap

The demand for water in agriculture is substantial, as it is essential for irrigating crops and supporting livestock. However, water resources are finite, and balancing water demand with availability presents a significant challenge to agricultural sustainability. In West Bengal, the primary surface water sources are the Himalayan and Northern Fan Rivers, Plateau and Western Fan Rivers, Ganga Delta Rivers, and coastal rivers and creeks. The total water availability is 160.35 billion cubic meters (BCM), with 132.77 BCM from surface water and 27.58 BCM from groundwater. Table 3 outlines the major water demand and gap scenarios for West Bengal.

**Table 3:**
**Water availability, water demand, and water gap of West Bengal, India**

| Sl No. | Existing water availability during 2015 (BCM) | |
|---|---|---|
| 1 | Surface Water (BCM) | 132.77 |
| 2 | Ground Water (BCM) | 27.58 |
| 3 | Total available water (BCM) | 160.35 |
| 4 | Water Demand (BCM) | 90.54 |
| 5 | Water Gap (BCM) | 69.8 |

*(Source: Pal et al., 2023)*


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## 3.1. Water requirements for different types of crops

As indicated in Table 3, West Bengal had 160.35 billion cubic meters of available water in 2015. Of this, 132.77 billion cubic meters were sourced from surface water, while 27.58 billion cubic meters came from groundwater. The total water demand across all sectors was 90.54 BCM, resulting in a positive water gap in the agricultural sector.

**Table 4:**
**Water requirement table for different types of crops in West Bengal**

| Crops | Average Water requirement (mm) |
|---|---|
| Paddy (Kharif/Boro) | 1,300 - 1,500 |
| Wheat | 450 - 650 |
| Maize | 400 - 800 |
| Potato | 350 - 550 |
| Jute | 450 - 500 |
| Finger millet | 350 - 500 |

*(Source: Kapuria, & Banerjee, 2022; EAGRI, 2023)*

The water requirement varies based on different agro-climatic conditions and stages of cultivation. During the seedling stage, water needs are generally low. In paddy production, water requirements range from 1100 to 1250 mm in different parts of West Bengal (EAGRI, 2023). Cotton and pulses are also important crops in West Bengal, requiring 550–600 mm and 200–450 mm of water, respectively.

# 4. Effective water management for different Agro-climatic zones in West Bengal

## 4.1. Northern hill zone:

The northern part of West Bengal gets 2500-3500 mm rainfall but due to low water holding capacity proper water management practices must be adopted in the local irrigation process.

1. There are numerous perennial streams in North Bengal, referred to locally as 'Jhora', which act as primary water sources.
2. Create secondary water storage such as reservoirs, farm ponds, or tanks, and check dams.
3. With the help of Jhora and secondary water sources, a micro irrigation process constructed in the Northern hilly zone.
4. The northern hilly zone consists furrow irrigation system as a aletrnative.

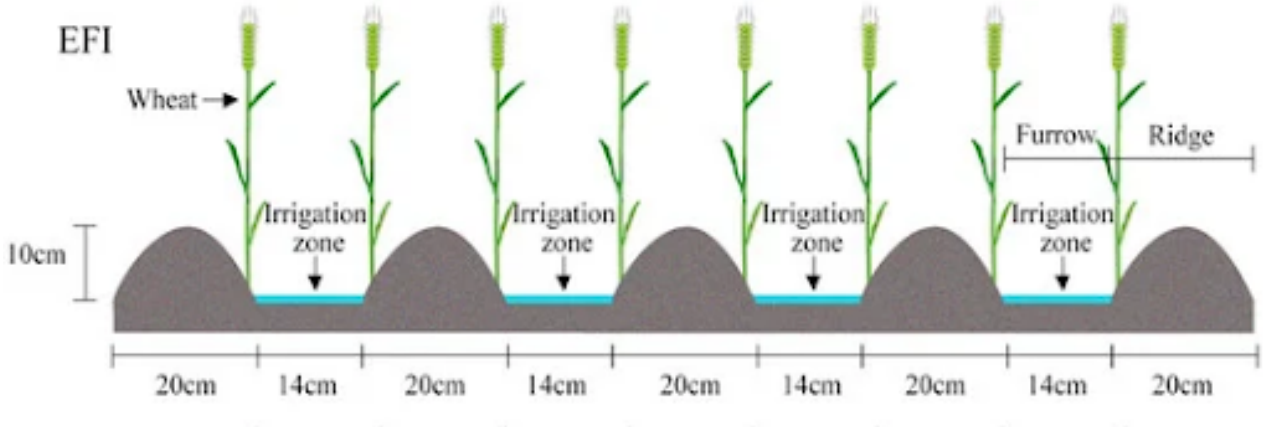


*Figure 2: A schematic diagram of the field layout of the AFI method (Source: Wu et al., 2023)*

## 4.2. Terai-Teesta alluvial zone:

The annual rainfall in this region ranges from 2000 to 3500 mm, and the land is prone to flooding. The majority of the land here is sandy to sandy loam, porous, and greyish-black. Although the productivity of the land is generally low, various water management practices assist in irrigation in this area. The following are the few significant characteristics of this zone:

1. Tapping of huge shallow groundwater and surface water.
2. Rainwater harvesting structures, through farm ponds, and integrated farming systems.
3. Shallow tube wells are used in rice cultivation, potato, mustard, and maize cultivation.
4. Drum seeders are used for jute in inter-cultivation periods.

## 4.3. Gangatic alluvial zone:

Most of the zone is characterized by neutral, greyish-colored soil and flat topography. The annual rainfall in this region ranges from 1300 to 1600 mm, which helps maintain the area's fertility. Various water management practices have been adopted to improve cultivation, including:

1. Apart from arsenic-polluted areas, groundwater tapping from unconfined aquifers in rabi and summer-season crops.
2. In rivers near farming land, the river-lift irrigation process is majorly used.
3. The draining-out technique is used in high-rainfall areas to avoid water congestion in short flooding periods.


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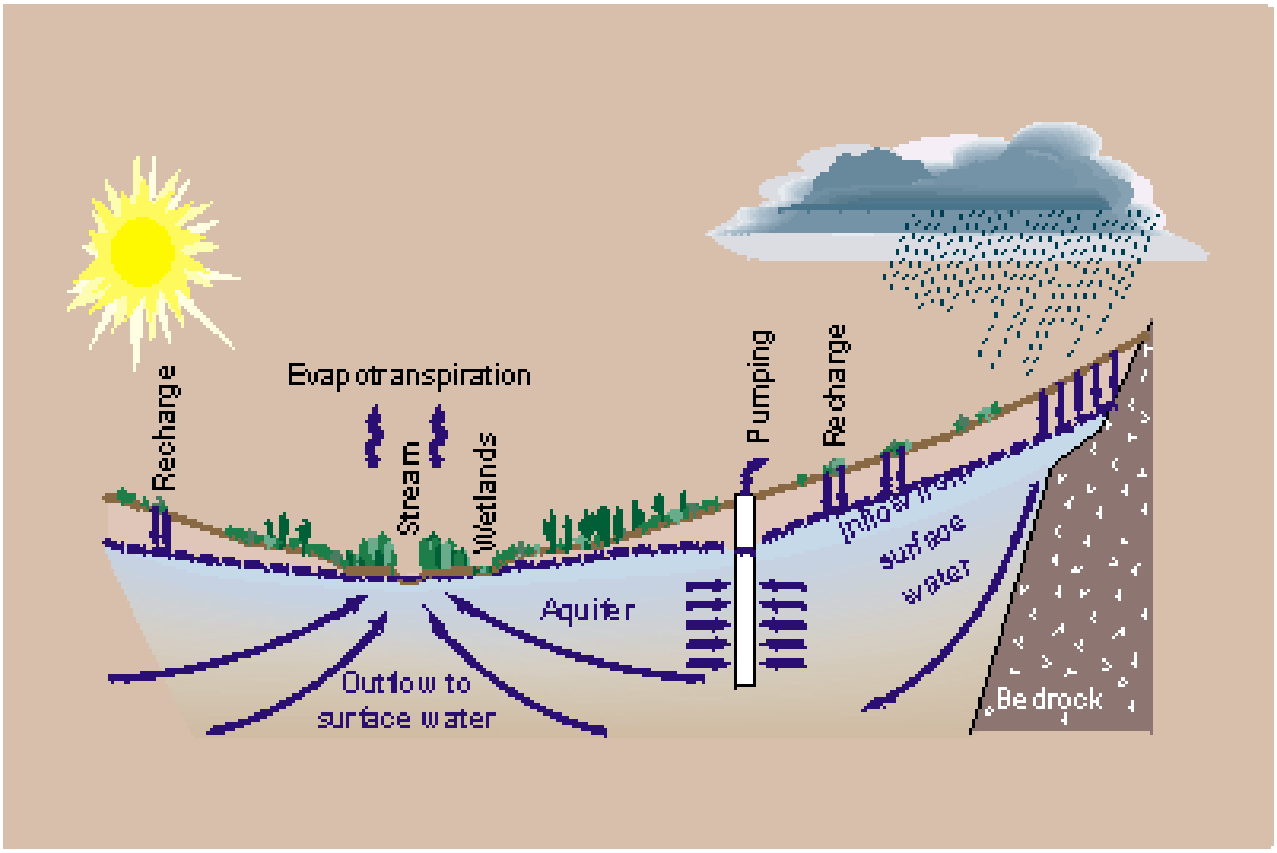


*Figure 3: Availability of an adequate supply of freshwater (Source: USGS, 2017)*

## 4.4. Vindhyan alluvial zone:

This zone encompasses approximately 1.7537 million hectares and receives an average annual rainfall of 1300 to 1500 mm. The water management technologies employed in this region are largely similar to those used in the Gangetic Alluvial Zone. Characteristics of irrigation in this zone include the following.

1. Groundwater tapping, river-lifting, draining-out technique.
2. In post rainy season drip and sprinkler irrigation methods are used for post monsoon crops.

## 4.5. Undulating red laterite zone:

This zone covers approximately 2.4842 million hectares and is characterized by laterite and red alluvial soils. The region experiences annual rainfall ranging from 1100 to 1300 mm, with approximately 80% of this rainfall occurring between June and September. Due to the limited rainfall, farmers in this area have implemented various water management practices. The following are the few significant characteristics of this zone:

1. Use of rainwater harvesting by dug wells and ponds for conservation and utilization of rainwater.
2. Utilization of secondary water storage facilities, such as ponds and canals, serves the dual purpose of conserving both soil and water resources.
3. Alternate wetting and drying (AWD) methods used for rice cultivation.
4. In post rainy season drip and sprinkler irrigation methods are used for post monsoon crops.

## 4.6. Coastal saline zone:

The southern part of West Bengal receives 1500 to 1800 mm of rainfall, but the presence of salinity poses significant challenges to agriculture. Approximately 1.4569 million hectares of this area have soils that are predominantly silty clay, rich in magnesium, and of fine texture. Effective water management practices can facilitate the development of mono-cropping in this region. The following matters are noticed in the agricultural landscaper of this region.

1. Raised and sunken bed technology is used for agriculture and aquaculture in this region.
2. Improved excess rainwater storage and the drainage system.
3. Adopted the Dapog method and Alternate wetting and drying (AWD) method for rice cultivation

# 5. Conclusion

West Bengal's diverse landscape, encompassing varied topography, soil composition, and climatic conditions, positions the region with significant agricultural potential. However, the state grapples with a spectrum of water-related challenges, including water stress, waterlogging, and salinity. Persistent water scarcity is a prevalent issue in many regions across the state.

As per the average water requirement table, it can be understood that most water-required crops are paddy, sugarcane, wheat, and maize. At this present time, finger and kodo millet are cultivated in an undulating red laterite zone, which is predominantly marked as the water scarcity region of West Bengal. Secondary water storage and the river lifting process are most common in various agro-climatic zones. In Gangatic and Vindhyan alluvial zones, groundwater tapping is primarily used to utilize prominent groundwater presence. Alternate wetting and drying (AWD) methods are mostly shown in undulating red laterite zones and coastal saline zones for rice cultivation. Specifically, the northern zone employs water drainage systems to mitigate waterlogging on agricultural lands.

Given these complexities, strategic policy decisions are essential, addressing water extraction and sustainable energy usage across different parts of Bengal. The implementation of zone-specific water management strategies is recommended to empower farmers in cultivating optimal crop yields amid varied water challenges.

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