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Bisleri

TRADING BLUE GOLD

A Blueprint for Water Credit Valuation in India

Nilanjan Ghosh • Soumya Bhowmick

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Abstract

This report explores the role of water credits to incentivise conservation, optimise allocation, and integrate sustainability into corporate and agricultural water use. Modelled after carbon credits, water credits incentivise stakeholders including agriculture, industry, services, and households—to offset consumption by investing in water conservation and efficiency measures. The study examines economic and ecological valuation models and pricing frameworks, proposing a real-world approach to valuing Green Water Credits (GWC) for farmers, drawing lessons from the beverage industry's water credit model. While India has taken steps towards promoting water credits, the absence of a valuation framework remains a critical gap. The report calls for integrated policies that expand water credit values to include ecosystem services, making conservation both an economic and environmental priority. Such a valuation framework can be replicated for various other sectors, including industry, households, and services.

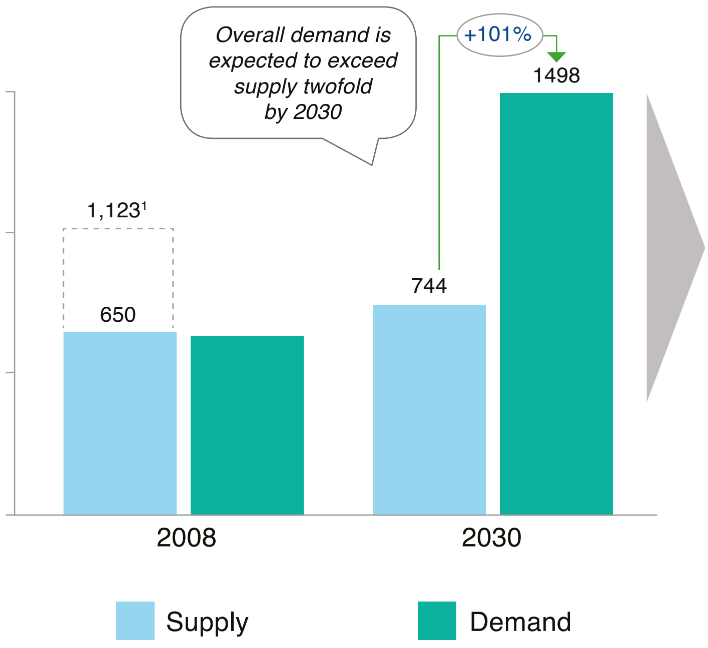
I.

Introduction

India faces an urgent water crisis as a result of population growth, rapid urbanisation, and climate change. The country's per capita water availability has decreased sharply, projected to drop from 1,486 cubic meters in 2021 to 1,367 cubic meters by 2031.[1] Regional and seasonal variability of water resources further complicates management and equitable distribution. With 55 percent of India's arable land dependent on monsoons, agricultural water availability remains highly susceptible to droughts, threatening productivity and food security.[2] Although recent droughts have been less severe than historical occurrences, they have still inflicted substantial damage on the agricultural sector and underscored critical vulnerabilities in India's water security framework.

Water scarcity is a growing global challenge, worsening even more for India. By 2025, 11 out of 15 major river basins in the country are expected to be water-constrained, and per capita annual water availability will fall below 1,700 cubic meters. As shown in Figure 1, water demand is expected to exceed supply twofold by 2030. This stems from groundwater overexploitation, insufficient rainwater harvesting, pollution of water bodies, and poor governance of water resources. This situation underscores the urgent need for innovative mechanisms like a system of water credits to incentivise conservation and ensure sustainable water management across sectors.

Figure 1: Forecast of Demand and Supply of Water in India: Without Intervention



Source: NITI Aayog[3]

India's water crisis is exacerbated by inefficient water use across sectors and the lack of an integrated national water management policy. While agriculture accounts for nearly 80 percent of freshwater withdrawals,[4] excessive reliance on groundwater and poor irrigation efficiency have led to the severe depletion of aquifers. Meanwhile, industrial expansion and rapid urbanisation have driven up water demand beyond local supply capabilities, intensifying sectoral competition for water resources. Poor wastewater management further compounds the issue—nearly 70 percent of India's freshwater supply is contaminated, making it unsafe for drinking and agricultural use.[5] The over-extraction of groundwater and inadequate infrastructure for rainwater harvesting further limit the country's ability to replenish and sustainably manage water resources. Climate change exacerbates extreme weather patterns, leading to more frequent droughts, erratic rainfall patterns, and declining water table levels, making conservation and efficient allocation more urgent. With approximately 87 percent of extracted groundwater used in agriculture—where wastage remains rampant[6]—improving water discipline is crucial for sustainability. While this report largely focuses on water management in agriculture, sectors such as manufacturing, energy production, and urban water management could also adopt innovative conservation technologies, optimising resource efficiency and reducing overall consumption.

In this context, markets can play an important role in managing water scarcity and its critical challenges. Modern industries, with their financial resources and business acumen, can contribute to market-driven solutions. While industrial water consumption competes with agricultural and domestic demands, often exacerbating resource constraints, industries have the potential to drive transformative change through mechanisms like water credits. These credits provide a structured framework for businesses to minimise their water footprint by investing in conservation, restoration, and efficiency-enhancing initiatives. Given India's distinct socio-economic and environmental complexities, integrating water credits can promote water sustainability within industrial operations while fostering responsible corporate water stewardship. Amidst growing regulatory imperatives, evolving international frameworks, and increasing consumer-driven sustainability expectations, industries are progressively aligning with water security initiatives that seek to harmonise business expansion with ecological responsibility.

Addressing India's water crisis requires innovative solutions beyond traditional conservation strategies. The concept of water credits offers a market-driven approach to incentivise efficient water use, restoration, and sustainable management across sectors. By creating a structured mechanism for offsetting water consumption, water credits align economic incentives with ecological responsibility. This analysis explores how water credits can bridge the gap between industrial demand, agricultural sustainability, and community needs, ensuring a balanced and accountable water governance framework.

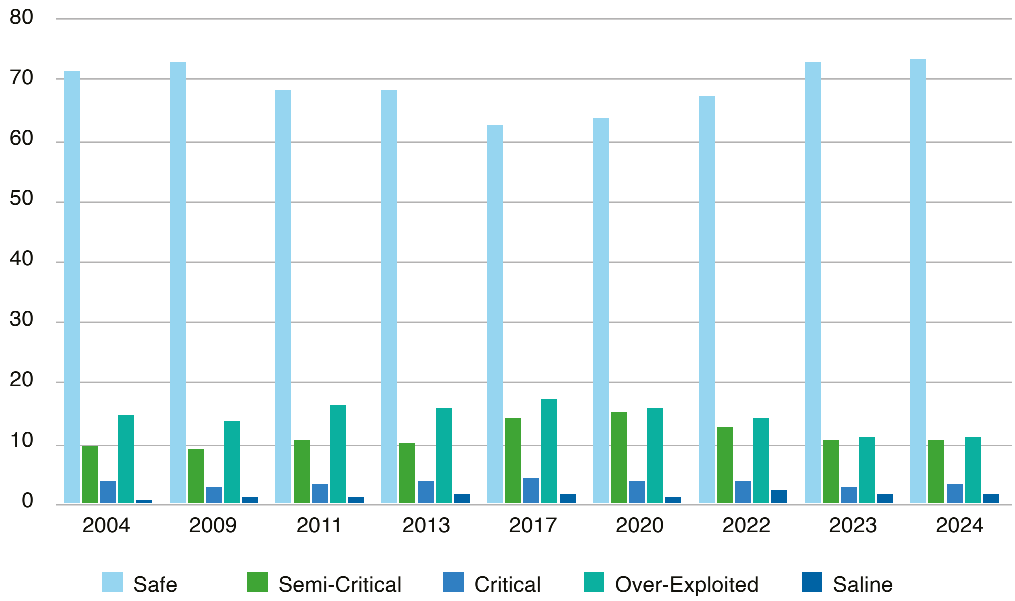
This study shows how water credits can be applied in India's agricultural sector, by drawing lessons from an industrial sector study as presented by the case of Bisleri. Discussing Green Water Credits in the agricultural sector, the report proposes a framework for credit valuation that has was not included in the case study. The report highlights water credits as an important market mechanism for sustainable water practices; outlines the concept of valuation of ecosystem services provided by water; and delves into pricing water rights or the credit mechanism from the market perspective. Learnings from Bisleri's case are applied to agriculture, emphasising the role of water-reliant industries, particularly beverages, in institutionalising GWCs. The report concludes by positioning GWCs embedded within Integrated Water Resources Management (IWRM) and offering policy recommendations for a water credit market.

II.

Water Credits: Rethinking Conservation Through Market Incentives

Almost 600 million people in India—a country with only 4 percent of the world's water resources—struggle with high to extreme water stress.[7] According to the *UN Sustainable Development Solutions Network's SDG Index Report 2019,* India ranks 115th out of 162 countries,[8] scoring 61.1 percent in SDG performance, below the average regional score of 65.7 percent for East and South Asia. Per capita groundwater availability has reduced sharply over the last 70 years, declining by almost a quarter.[9] A rapidly growing population, increasing food demand, and economic expansion continue to drive water consumption, while supply remains constrained by worsening pollution, frequent climate-induced droughts, and the lack of a uniform national water policy, leading to excessive groundwater depletion. These problems are aggravated by global warming, which poses a severe threat to future water availability in the region.

Figure 2: The Groundwater Situation: Percentage of Assessment Units Under Different Categories (2004-2024)



Source: Authors' own, using data from Central Ground Water Board.

Inadequate water management techniques and the absence of a monetised system hinder optimal water use and conservation efforts. For instance, chronically water-stressed regions with low and erratic rainfall struggle to implement conservation strategies, as water harvesting structures often fail to store sufficient volumes.[10] Moreover, the Composite Water Management Index (CWMI) by NITI Aayog indicates that 70 percent of India's water supply is contaminated, positioning it 120th among 122 countries in WaterAid's water quality index.[11] With agriculture being the largest water consumer, improving management practices in this sector is essential. Addressing the over-exploitation of groundwater resources and deteriorating water quality is imperative, as ineffective water-use efficiency in agriculture will undermine broader water conservation efforts.

Water credit policy serves as a strategic framework to optimise the management and allocation of water resources. Similar to carbon credits, water credits are market-based tools to foster water conservation and quality improvement, thereby addressing SDG 6 (access to clean water and sanitation). In this credit system, individuals or businesses implementing water-saving measures or quality enhancement projects earn water credits, which can later be traded to support replenishment initiatives elsewhere.[12] In other words, by assigning a quantifiable value to water savings, industries are encouraged to adopt efficient practices. Water credits help bridge the gap between need and access, ensuring fairer distribution across sectors while addressing financial barriers faced by marginalised communities. They also foster collaboration between industries and local communities by directing financial resources to water-efficient technologies, maintaining sustainable consumption levels, preserving ecosystems, and supporting the hydrological cycle.

However, with the rise in population and the degradation of natural environments, ensuring adequate and safe water supply for everyone is becoming increasingly challenging. India's acute water crisis is driven not just by resource scarcity but also by mismanagement. As the world's largest groundwater extractor, India withdraws over 253 billion cubic meters annually, depleting reserves and reducing per capita water availability. As a result, nearly 54 percent of assessment units are now classified as water stressed.[13]

The 2019 CWMI indicates that while Indian states have made progress in water management, substantial challenges remain. The complex interplay of social, political, economic, and environmental water risks demands immediate intervention.[14] Amidst escalating water challenges, water credits present a viable solution for efficient resource management. A robust water credit framework can balance industrial demand with ecological sustainability and social equity, ensuring resilience, scalability, and adaptability across sectors. By implementing the principles of IWRM, the framework can cater to ongoing water use while addressing broader community and environmental needs.

The Government of India provides financial assistance for water conservation projects through structured policy guidelines. As of September 2021, the financial assistance programme has been implemented across 23 states, disbursing over 3.4 million loans and benefiting more than 15 million people.[15] While state-level efforts have yielded notable results, there remains considerable scope for scaling up these initiatives to maximise their impact and ensure the equitable allocation of water resources.

While water credits provide a promising mechanism for optimising resource allocation, their effectiveness hinges on a clear understanding of the economic and ecological value of water. Without a well-defined valuation framework, water credits may become a mere compliance tool rather than a transformative force for sustainable water management.

III.

What is Water Worth? Valuation of Economic and Ecosystem Services

Water is crucial for providing ecosystem services, particularly in aquatic ecosystems like rivers, wetlands, estuaries, and near-coast marine environments, which offer a range of benefits—both goods and services—to people. Goods include clean drinking water and fish, while services encompass water purification, flood mitigation, and recreational opportunities.[16] Environmental flows, referring to the water flow regime needed to sustain ecosystems, are essential for their well-being.[17] The absence of these flows harms aquatic ecosystems and negatively impacts the communities and industries dependent on them. Over time, the lack of delineation of environmental flows jeopardises the existence of these ecosystems, affecting the lives, livelihoods, and security of dependent communities.

In recent years, economists have increasingly recognised the value of ecosystem services, regardless of their traditional economic values. While ecologists and professionals in the field have long identified these services, much work remains. However, the role of water in sustaining diverse natural ecosystems has often been underappreciated. A crucial yet often overlooked aspect is the need to balance water allocation for direct human use (such as agriculture, power generation, domestic supplies, and industry) with indirect human use (the maintenance of ecosystem goods and services) when providing environmental water allocation or flow requirements.

As water diversion from natural aquatic systems increases, balancing the needs of the aquatic environment with the demands for water diversion becomes critical in many river basins worldwide.[18] The Millennium Ecosystem Assessment underscores the importance of valuing ecosystem services related to water.[19] This document introduced a key classification of ecosystem services: provisioning services (e.g., food, fibre, energy), regulating services (e.g., carbon sequestration, microclimate regulation), supporting services (e.g., soil formation, primary production, essential for other services), and cultural services (e.g., tourism, spirituality). Despite these insights, water-related ecosystem services are often overlooked in reductionist policy-making approaches. However, policymakers in developed countries are gradually recognising the extensive value that these ecosystem services provide.

Water allocation challenges arise from the spatio-temporal differences in water availability. The conventional economic problem of "allocation of scarce resources among competing ends"[20] is evident in water management, leading to numerous studies on efficient allocation. However, institutional theory has not fully addressed this issue, failing to provide a comprehensive solution and remaining confined within theoretical limits. Institutionalists have explored the current state of water management, contributing to disputes and the economics of property rights. The failure of institutionalists to introduce any tangible instruments of water management has led to judicial control of water resources, resulting in inefficient and prejudiced utilisation of water. Given the global water crisis, introducing an efficient valuation technique is critical for water management and allocation. In cases where institutional economics has fallen short in resolving conflicts, developing a more impartial tool utilising emerging valuation techniques is essential.

Although these tools are still nascent and their results considered as approximations, they can help assess the objective value of a resource based on its utility to various stakeholders, including individuals, communities, corporations, and national economies. Rationalising the use of valuation in water management and dispute resolution is crucial, as it provides a more objective instrument for decision-making. In some situations, valuation can offer a clearer foundation for prioritising decisions.[21]

Valuation contributes to both efficient and fair allocation of resources, promoting optimal social consumption and production. When formulating policies, it is important to consider the value derived from prioritising either equity or efficiency, or a combination of both. Similarly, when considering distribution, social planners must assess net social welfare to determine the most suitable distribution scheme. Additionally, optimisation exercises that account for constraints such as resource availability, infrastructure limitations, and economic factors are essential for optimising the overall economic welfare of a system.

These exercises yield shadow values, indicating the increase in welfare resulting from the relaxation of a specific constraint. Valuation plays a crucial role in legal proceedings by assisting in determining damages when one party has caused harm to another. The assessment of the economic value of the damages caused by negative externalities, such as pollution, helps establish compensation policies accurately. Valuation also facilitates the design of efficient management mechanisms, such as economic instruments and controls. By valuing damages resulting from pollution, various management options, including taxes, internalising externalities, governmental controls, and tradable permits, become available.

Moreover, the valuation of natural processes and resources enables the reconsideration of investment decisions, particularly in infrastructure development. By accounting for the ecological costs associated with projects, investment proposals can be revised to address potential harm to the natural environment. Valuation helps reduce the occurrence of market failures and contributes to market creation, especially for goods or resources that lack existing markets, such as certain environmental resources (e.g., air and water). Valuation helps establish market-clearing prices when such resources become scarce.

The valuation of water as a good in consumers' utility bundles has been approached through two broad methods: the stated preference approach and the revealed preference approach. The stated preference approach consists of a single component known as the Contingent Valuation Method (CVM), which involves creating a hypothetical market and surveying respondents about their willingness to pay for changes in their ambient environment, whether qualitative or quantitative. However, valuing irrigation water as a consumer good and using methods like CVM and travel cost methods are not common in research. These methods may not be suitable for valuing irrigation water, as it serves more as an input in the production process than as a consumption good.

The value of water can vary depending on factors such as rainfall patterns, scarcity levels, and economic deprivation. Determining its economic and ecological worth is just the first step toward rationalising its use. For a water credit system to be effective, pricing mechanisms must account for both scarcity and sustainability considerations. Water pricing has long been a contentious issue, requiring a balance between cost recovery, social equity, and conservation incentives.

IV.

Pricing Water Right: Balancing Cost, Conservation, and Equity

Assigning a price to water quantifies and clearly defines the value derived from it. Whether driven by government regulations or market forces, water pricing plays a crucial role in improving water allocations and promoting conservation, particularly once basic water needs are met for all individuals. The relative inelasticity of water demand concerning price signals necessitates that water prices be accompanied by additional effective social measures that can increase the responsiveness of water demand concerning price. The optimum price of water should encompass the costs incurred in service provision—operation and maintenance costs, capital costs, the resource cost reflecting its scarcity value, and pollution costs,[22] which account for the externalities generated by water use.

There are two primary factors involved in determining the pricing of water: equity and efficiency. Efficiency focuses on optimising the allocation of water resources to generate the maximum net benefit, using available technology and volumes.[23] It aims to equalise the marginal benefits across sectors to maximise overall social welfare.[24] Different situations and time horizons define efficiency, with first-best efficiency aiming to maximise net benefits over variable costs[25] in the absence of any distortionary constraints. When constraints or distortions are present, the allocation is termed second-best efficient. Equity in water allocation, however, ensures fairness among economically diverse groups in society. Equity objectives often conflict with efficiency goals, as fairness is subjective and challenging to measure objectively.

Approaches like Rawlsian fairness,[26] which prioritise the welfare of the least advantaged individuals in society, are used to assess equity. While water pricing mechanisms may not be highly effective in income redistribution,[27] governments may still subsidise certain sectors, such as agriculture, to increase water availability, leading to potential inefficiencies. Pricing can serve as a useful tool for promoting both equity and efficiency under specific conditions. Differential pricing based on volume, referred to as volumetric methods, aims to achieve vertical equity. Market-based pricing, on the other hand, tends to promote efficiency by allowing water to find its value in the market, reflecting its availability and scarcity. Higher market prices indicate greater effective demand for water and drive efficiency improvements. In cases where variations from equity and efficiency are considered, non-volumetric pricing methods, such as output pricing, may be applied. Output pricing assumes higher output correlates with higher water usage but disregards notions of resource-use efficiency and factor productivity, potentially leading to undeserved penalties for individuals who use the resource less extensively.

According to the Dublin Water Principles in 1992, water was introduced as an "economic good".[28] While this notion recognised water's economic value, it also highlighted its role as a public good, including its disposal. This recognition led to the establishment of heavily subsidised public water systems globally—except in France. Most countries still rely on traditional command-and-control methods for water management, requiring government involvement for monitoring and enforcement. Similarly, implementing water pricing policies demands substantial governmental oversight to address equity and public goods concerns effectively. Concerning the industrial sector, corporations emphasise water valuation to modify behaviour concerning water usage practices and investment decisions. The aim is to implement "true cost accounting", which fosters water conservation for future sustainability while incorporating social and environmental externalities into financial decision-making. This approach seeks to account for the true price of water, recognising the financial risks associated with higher water footprints and guiding investments in water-saving solutions. In the agricultural sector, water pricing should focus on social equity by ensuring access and affordability for all, particularly poor farmers and female agricultural workers. Moreover, sustainability should be prioritised to protect the long-term interests and livelihoods of these vulnerable groups.[29]

Economic theory has long explored how accurate pricing of both private and public goods can augment economic efficiency. However, this literature has typically assumed that raising prices—considering the usual price and income elasticities for water and prevailing income distributions—is regressive and, therefore, detrimental to equity. With growing populations, implementing some form of water allocation is the only sustainable pathway to ensuring universal access. Assigning value to water and developing appropriate tariff structures are becoming increasingly important for prioritising water resources for the most valuable purposes. These structures must be aligned with various social, political, and economic objectives based on specific circumstances. Consumers and water suppliers have unique expectations regarding water tariffs: consumers prioritise access to high-quality water at affordable and stable prices, while suppliers focus on covering costs and ensuring a consistent revenue stream.

The level and structure of water and wastewater charges have broader implications beyond these immediate priorities. Water fees can serve multiple purposes, such as generating revenue, improving the efficiency of water supply and service providers, managing demand, fostering economic growth, and advancing public welfare and equity. However, no single tariff structure can achieve all these goals simultaneously. Instead, utilities and communities must identify and prioritise the objectives that align closely with their specific needs and circumstances.

The optimum pricing of water should ensure the sustainability of service provision, universal access to high-quality water, and the conservation and preservation of water resources. However, implementation faces challenges. The long-run marginal cost approach, often regarded as an efficient pricing mechanism, depends on accurate information about fixed and variable costs over time. Uncertainty surrounding these forecasts casts doubt on how closely calculated prices align with the true long-term marginal cost.

In the absence of market mechanisms to reflect resource scarcity and externalities, non-market valuation techniques are increasingly utilised. However, these methods are prohibitively expensive and highly location-specific, hindering their applicability elsewhere. Water pricing is further complicated by its dual nature as both a commodity and a fundamental human right, as pricing decisions often become politically sensitive, with governments intervening to keep prices low and pressure groups advocating for the same. Efforts to achieve multiple objectives, such as water conservation and equitable access across income groups, add further complexity to water pricing. As a result, water is frequently underpriced, leading to adverse outcomes such as low productivity, poor sanitation, increased disease prevalence, and inadequate investment in critical water infrastructure and technology, ultimately undermining long-term water security and development goals.

A multifaceted approach is crucial in designing tariffs for resource allocation. The primary objective is to optimise resource allocation to achieve efficiency, while also ensuring that users perceive the tariffs as fair. Equitable distribution of rates across different customer categories is vital to maintaining a just and balanced system. Financial sustainability is equally important, with tariffs needing to generate adequate revenue to support operations and ensure stability in net income. Transparency is critical, as the public must clearly understand the rate-setting process. Tariffs should also promote resource conservation, striking a balance between sustainability and affordability. The tariff-setting process should be carefully structured to avoid rate shocks, with forward-looking rates accounting for environmental costs and aligning with broader government policies. Water pricing must reflect supply characteristics, such as quality, reliability, and frequency, while being adaptable to measurable consumption patterns, including daily peaks and seasonal variations in water demand, to ensure a fair and efficient system for all stakeholders.

Effective water pricing is central to ensuring that water is allocated efficiently while maintaining social and environmental safeguards. However, translating pricing principles into actionable conservation strategies requires industry participation and sector-specific solutions. The beverage industry, a significant water consumer, has pioneered innovative water management approaches, demonstrating how water credits can be integrated into corporate sustainability models.

IV.

Water Credits in Practice: Insights from the Beverage Industry

In a pivotal action towards environmental stewardship, Bisleri's proposal of a water credit model for the beverage industry, aligned with the government's Green Credit Programme, launched in 2023, plays a crucial role in replenishing water use and fostering corporate sustainability within the sector.[30] The framework encourages responsible water use and accountability among beverage manufacturers, allowing companies to earn credits through conservation activities such as harvesting, efficient water use, wastewater treatment, and reuse. In collaboration with Teri School of Advanced Studies, the comprehensive study examines national and international practices related to water trading and credits while designing a robust framework for estimating the water footprint of a particular production unit.

The study tests and calculates the water footprint of two Bisleri production units located in distinct terrains, illustrating the need for a localised approach to water savings, considering variables such as rainfall consumption patterns at the watershed level and quality of ground water. However, implementation challenges exist. Heterogeneous water supplies, tariff structures, penalties for over-extraction of groundwater, compliance burdens for securing no-objection certificates, and fluctuating extraction charges complicate the operational landscape for the beverage industry. Given the scope and scale of a water unit, creating a baseline water footprint becomes difficult, especially with technological differences among companies. Additionally, validating long-term water conservation claims is challenging due to obstacles in monitoring and regulating consistent water usage, particularly when local environmental conditions and technology are constantly changing.[31]

The application of water credits in the beverage industry underscores the potential of market-based conservation mechanisms while also revealing operational challenges, like regulatory constraints and verification difficulties. Addressing these challenges requires a broader, more inclusive approach—one that extends beyond industrial water use to include agriculture and ecosystem preservation. Drawing lessons from this experiment, we propose a GWC framework for Indian agriculture. The GWC framework offers a scalable solution to incentivise farmers to adopt sustainable water management practices.

VI.

Towards Scalable Adoption of Green Water Credits

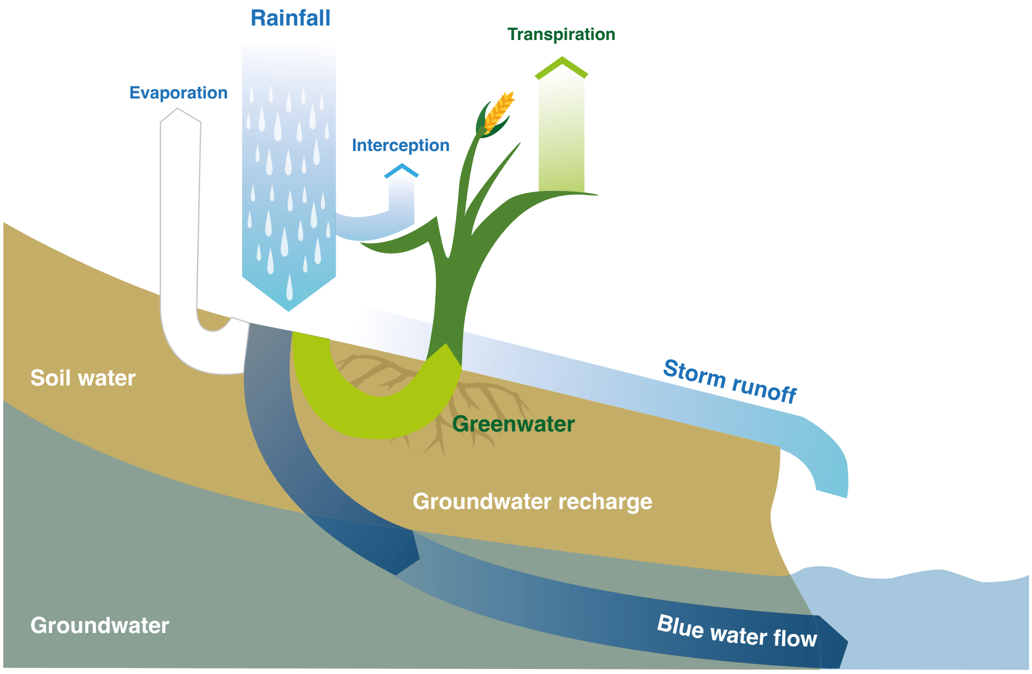
Green vs. Blue Water: Rethinking the Water Balance

Traditional water management strategies in Indian agriculture have primarily focused on blue water—encompassing surface and groundwater. However, this limited scope often neglects green water—freshwater stored in the soil and absorbed by plants, which is vital for rain-fed agriculture.[32] This oversight has resulted in inefficient water use, accelerated soil erosion, and declining productivity, highlighting the urgent need for innovative solutions, such as the Green Water Credit (GWC) framework.

Green water, or soil moisture utilised by plants, is indispensable for sustaining ecosystems, supporting human livelihoods, and ensuring agricultural productivity. It is fundamental to rain-fed agriculture, which forms a substantial proportion of global farming. Despite its importance, green water management has been largely overlooked, leading to practices that undermine environmental sustainability and economic resilience. Recognising the value of green water is crucial to addressing these challenges and promoting equitable and efficient resource use.

The concept of GWCs seeks to bridge this gap by offering financial incentives to farmers who adopt sustainable practices that optimise the use of green water. Drawing from the globally recognised Payments for Environmental Services (PES) framework,[33] GWCs encourage practices such as drip irrigation and land levelling, which enhance water retention, reduce soil erosion, and improve crop yields. These measures align private benefits, such as increased productivity, with public goods, like enhanced water availability, establishing a market-driven approach to conservation. By connecting upstream conservation efforts to downstream benefits for industries and municipalities, GWCs present a mutually beneficial solution to water scarcity.

Figure 3: Green Water and Blue Water

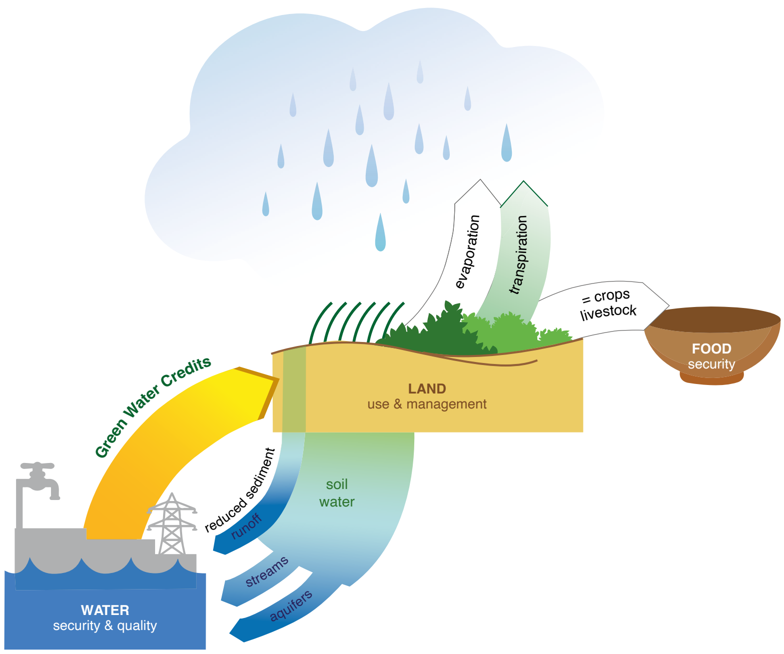


Source: ISRIC–World Soil Information "Green Water Credits (GWC)"[34]

The PES framework, widely applied in forest conservation and watershed management, has been adapted for green water management. Under this system, downstream users, such as municipalities and industries, financially support upstream farmers adopting sustainable practices. These payments reward farmers for their environmental services, fostering a symbiotic relationship that addresses water scarcity while boosting rural economies. The introduction of GWCs represents a crucial step in integrating green water management into broader sustainability strategies.

A distinctive aspect of the GWC framework is its method for quantifying the economic value of sustainable practices. It evaluates scenarios with and without the adoption of green water measures. Without these practices, crop yields depend on water requirements and other influencing factors, with limited productivity improvements. In contrast, adopting green water practices leads to measurable yield and efficiency gains. The difference between these scenarios forms the basis for calculating financial rewards for farmers. Farmers receive positive incentives when the gains from green water practices outweigh the status quo, encouraging widespread adoption.

Figure 4: Green Water Credits



Source: ISRIC–World Soil Information "Green Water Credits (GWC)"[35]

Implementing the GWC framework necessitates meticulous data collection on water usage, crop yields, and other pertinent parameters for baseline and treatment groups. Statistical analysis evaluates water savings and yield improvements, establishing credible baselines and benchmarks for the transparent issuance of credits. Farmers implementing green water practices earn credits based on measurable improvements, while downstream users fund these credits in exchange for enhanced water resources. Governments, NGOs, and independent agencies are pivotal in providing technical support, funding, and verifying outcomes to maintain accountability.

While green water's role in the hydrological cycle is crucial, practical implementation requires structured incentives, stakeholder engagement, and robust verification mechanisms. The GWC framework builds on existing environmental service models to create a structured, measurable system that rewards sustainable agricultural practices.

Theory to Practice: Operationalising GWCs

Successful GWC implementation requires a systematic, multi-stakeholder approach combining data-driven analysis, stakeholder collaboration, flexible market mechanisms, and robust monitoring systems. The following operational steps highlight stakeholder roles and the potential for trading credits among farmers.

Assessment of Water Savings and Yield Improvements:

The first step in implementing GWCs is a comprehensive assessment of water savings and the associated yield improvements from green water practices. This involves collecting robust data on water usage, crop yields, and related factors for both treatment (with green water practices) and control (without such practices) groups. Statistical and econometric techniques are used to estimate the marginal productivity of water, the elasticity of yield with respect to water use, and the overall water savings achieved. These calculations form the foundation for determining the incremental benefits of adopting green water practices and serve as a benchmark for issuing GWCs, ensuring credits accurately reflect measurable improvements in water management and agricultural productivity.

Stakeholder Collaboration:

The success of the GWC framework depends on effective collaboration among diverse stakeholders. Farmers are at the core of the framework as the primary implementers of green water practices and the sellers of GWCs. Downstream beneficiaries, such as industries, water utilities, municipalities, and agricultural corporations, act as the buyers of these credits. They benefit directly from improved water availability, reduced sedimentation, and enhanced ecosystem health. Governments, NGOs, and international organisations serve as facilitators, providing technical support, funding, and capacity-building programs to enable the smooth implementation of GWCs.

Issuance of GWCs and Trading:

GWCs are issued by independent third-party organisations, regulatory authorities, or certified government bodies responsible for verifying water savings and yield improvements. Farmers who meet or exceed the benchmarks set for green water practices receive GWCs, which they can either retain for compliance or trade in the market. A key innovation in the GWC framework is the potential for trading credits among farmers, allowing market dynamics to optimise water conservation efforts. Farmers who exceed their water-saving targets can sell their additional credits to other farmers or entities. This trading mechanism creates a dynamic market where the price of GWCs reflects supply and demand, driving efficiency and innovation in water management.

Monitoring and Verification:

Robust monitoring and verification systems are essential to maintaining the integrity of the GWC framework. Advanced technologies, such as IoT-based water management tools and on-ground inspections, are used to track compliance with green water practices and measure outcomes.

A well-designed credit system must be backed by empirical validation and quantifiable metrics to ensure its credibility and scalability. Developing a mathematical framework for GWC valuation enables policymakers and stakeholders to assess its impact systematically, ensuring that conservation incentives translate into tangible economic and environmental benefits.

Numbers Behind GWCs: A Mathematical Roadmap

The algebraic framework provides a structured method to evaluate the impact of sustainable water management practices on agricultural productivity and serves as a foundation for calculating Green Water Credits (GWC). This framework complements the earlier discussions on the significance of green water and the role of Payments for Environmental Services (PES) in incentivising sustainable practices. By mathematically distinguishing between the baseline (control) and improved (treatment) scenarios, the framework ensures that rewards for adopting water optimisation practices are both transparent and equitable. Here we present the methodology on the basis of which we estimate the difference in productivity between the blue and green water practices.

We propose the following framework with blue water practice as the control case, and green water practice as the treatment case. We assume that a representative farmer operates over two lands—one with blue water practice, and the other with green water practice. It is also assumed that the two lands are identically similar in terms of yield, and the same crop is produced but with two different practices. We present the following set of equations.

$$Y_C = \alpha_C \cdot \left(A_C \cdot \omega_C\right)^{\beta_C} \cdot \in_C \ldots (1)$$

$$W_C = A_C \cdot \omega_C \ldots (2)$$

Subscript c denotes the control case variables

Y_C denotes crop production under control case;

A_C denotes acerage under control case;

ω_C denotes crop – water requirement per unit area under control case;

$\in_C$ denotes vector of all other factors of production;

W_C denotes total water use as a product of crop — water requirement and acreage

By replacing (2) in (1) we obtain,

$$Y_C = \alpha_C \cdot (W_C)^{\beta_C} \cdot \in_C \ldots (3)$$

Taking natural log on both sides of (3),

$$\ln Y_C = \ln \alpha_C + \beta_C \cdot \ln W_C + \ln \in_C \ldots (4)$$

Partially differentiating (4) with respect to W_C, we obtain

$$\frac{\partial Y_C}{\partial W_C} \cdot \frac{W_C}{Y_C} = \beta_C \ldots (5)$$

β_C is interpreted as the elasticity of production with respect to water use.

(5) may be rewritten as:

$$\frac{\partial Y_C}{\partial W_C} = \beta_C \cdot \frac{Y_C}{W_C} \ldots (6)$$

Equation (6) shows the relation between the marginal product of water $\frac{\partial Y_C}{\partial W_C}$ with the average product of water, i.e. $\frac{Y_C}{W_C}$, which is also a reflection of the yield.

Now, we consider the treatment case, i.e., GWP. These practices, such as land levelling, aim to enhance water productivity by minimising losses, improving distribution, or targeting water applications more efficiently. The yield and the production, in this case, is influenced by the total water applied and the same external factors as the control, but with the added benefit of optimisation techniques. This equation is critical for isolating the impact of these practices, providing a direct comparison with the baseline scenario to determine the improvements in water efficiency and yield. Here, we use the subscript t to denote the "treatment case" variables and propose equation (7) to estimate the marginal product of water in the treatment case.

$$\frac{\partial Y_t}{\partial W_t} = \beta_t \cdot \frac{Y_t}{W_t} \ldots (6)$$

This set of equations examines the marginal productivity of water—the additional production obtained from an incremental increase in water use. In the control case, marginal productivity reflects water use efficiency under conventional practices, often showing diminishing returns due to inefficiencies. In contrast, the treatment case demonstrates the improved marginal productivity achieved through optimised water management. Comparing these values allows the framework to quantify the specific contributions of sustainable practices to water efficiency, establishing the foundation for measuring the incremental benefits of green water management.

So, the increase in production under the treatment case can be given by

$$R = \int_0^{W_1} \frac{\partial Y_t}{\partial W_t} \mathrm{d}W_t - \int_0^{W_2} \frac{\partial Y_C}{\partial W_C} \mathrm{d}W_C \ldots (7)$$

Equation (7), which assumes water use is W_1 in the treatment case W_2 in the control case expresses automatically the reward R a farmer obtains by adopting green water practices. In the control case, elasticity highlights how responsive crop yields are to changes in water application under traditional methods, often revealing inefficiencies where additional water does not translate into proportional yield increases. In the treatment case, elasticity captures the improved responsiveness of yield to water use, demonstrating the effectiveness of practices like land levelling in maximising efficiency. This nuanced measure complements marginal productivity by providing insights into the scalability and sustainability of the benefits derived from water optimisation.

The overall water savings, W_S, while shifting to green water practice, in the process is: $W_S = (W_2 - W_1)$.

Since the farmer saves the water and has left the water flow instream or below the ground (in the case of groundwater), he may be given the credit certificate for the amount of water saved. The value of this credit (V_{Cr}) represents the marginal product of water, or the excess value of crop that he could have produced through the green water practice by using the traditional blue water practice, or,

$$V_{Cr} = \int_0^{W_S} \frac{\partial Y_C}{\partial W_C} \, dW_C$$

A mathematical framework for water savings is essential for designing an effective and transparent Green Water Credit system. However, the success of GWCs depends on their monetisation and tradability—ensuring conservation efforts yield financial incentives for farmers and industries. The next section examines the economic potential of GWCs, exploring how water savings can be converted into tradeable credits, facilitating wider adoption and long-term sustainability.

Savings to Credits: An Application of the Model on Monetising Water Conservation

To illustrate the impact of the GWC framework, a case example demonstrates how water savings translate into financial incentives for farmers. The following numerical application of the model uses a systematic approach to assess the economic value of sustainable water management practices and determine the credit valuation per unit of water conserved.

Land levelling is a widely recognised water conservation technique in agriculture, ensuring uniform water distribution across fields, and improving water-use efficiency. Beyond land levelling, integrating water-efficient crops and prudent irrigation methods can enhance water conservation efforts while improving per-acre productivity and farm earnings. Water-efficient crops, such as millets (e.g., sorghum and pearl millet), pulses (e.g., chickpeas and pigeon peas), and certain oilseeds (e.g., mustard), require less water than water-intensive staples like rice and sugarcane. In Rajasthan, for instance, switching from conventional wheat to drought-resistant millet varieties reduced water usage by 30 percent per acre while maintaining comparable yields.[36] Additionally, advanced irrigation techniques, such as drip irrigation and sprinkler systems, optimise water delivery by reducing evaporation and ensuring targeted hydration. A study in Maharashtra's sugarcane farms showed that drip irrigation reduces water consumption by up to 50 percent while increasing per-acre yield by approximately 25 percent.[37] These approaches improve water efficiency and raise farm incomes by reducing input costs and enhancing productivity.

In a controlled assessment using statistical random numbers (generated see appendices 1-4), adopting land levelling reduced total water usage by approximately 17,375 cubic meters per cultivation cycle, leading to water savings valued at an estimated INR 1.32 lakh per cycle. This financial valuation, based on the marginal productivity of water and the market price of sugarcane, demonstrates the tangible economic benefits of sustainable water management. A rigorous econometric approach is applied to establish a systematic and credible valuation mechanism for GWCs. The following methodology outlines the step-by-step calculation of the GWC value per 100 cubic meters of water saved.

The first step in valuing GWCs is standardising the dataset to maintain consistency across observations. The dependent variable (Y) represents total crop production (kilograms per cultivation cycle), while the independent variable (X) denotes total water usage (cubic meters per cultivation cycle). Ensuring uniformity in measurement units eliminates discrepancies in data interpretation and enhances the reliability of subsequent statistical analysis.

To accurately capture the relationship between water usage and crop production, a logarithmic transformation is applied to both Y and X to linearise their relationship.

A regression of log(Y) on log(X) is conducted separately for the treatment group (with land levelling) and the control group (without land levelling). This step estimates the elasticity of production with respect to water usage, represented as the beta coefficient (β). A statistically β confirms the robustness of the estimated relationship, ensuring reliable results for further calculations.

Once the regression model is established, the Average Productivity (AP) of water is calculated for each data point using the formula AP = Y/X, quantifying the output per unit of water used. The Marginal Productivity (MP) of water is then derived by multiplying AP by the estimated β coefficient, giving the additional production contribution of the last unit of water used. MP values are computed for all data points within both the treatment and control groups.

To establish a comprehensive valuation, the Average Marginal Productivity (AMP) of water is determined by averaging MP values across all data points in each group, quantifying the productivity gains from water conservation measures. The economic value of water savings is computed by multiplying the average water savings (in cubic meters) by the AMP of water (in kg per cubic meter) and the market price of sugarcane (in INR per kg). This calculation yields the total economic value of water conserved per cultivation cycle.

Once the total economic value of water savings is established, the unitary method determines the GWC value per 100 cubic meters of water saved. Assuming that one GWC corresponds to 100 cubic meters of conserved water, the final GWC value (in INR) is computed accordingly. For the land levelling case, the derived GWC value per 100 cubic meters of water saved is estimated at INR 759. This valuation demonstrates how monetising water conservation efforts can incentivise sustainable agricultural practices and promote a market-driven approach to environmental sustainability.

The GWC framework introduces a market-based instrument that allows farmers to conserve water while monetising their conservation efforts. Beyond earning credits for sustainable water use, farmers can trade surplus GWCs with other farmers or industries that require offsets. This introduces flexibility in water conservation targets, ensuring that efficiency gains occur where they are most cost-effective.

Governments, NGOs, and regulatory bodies play a critical role in ensuring fair pricing, compliance, and the long-term sustainability of the system. The framework is designed for scalability, extending beyond individual farms to watershed-level conservation initiatives. By integrating ecosystem services into water management, the GWC framework aligns private incentives with broader social and environmental benefits, making it a promising solution to the growing challenge of water scarcity.

This illustrative example highlights the practical applicability of GWCs in real-world scenarios. By integrating scientific valuation techniques with economic incentives, the framework tackles water scarcity while providing farmers with tangible financial benefits for adopting sustainable practices. Moving forward, refining ecosystem services valuation and expanding financial support mechanisms will be crucial for mainstreaming GWCs into national and international water management strategies.

Despite its advantages, the current GWC framework focuses primarily on private rewards, such as increased yields and incomes, while broader ecosystem services remain undervalued. Groundwater recharge, flood control, and biodiversity preservation are not adequately compensated. Integrating the valuation of these ecosystem services into the GWC framework is vital for ensuring equitable and comprehensive rewards for all contributions to environmental conservation.

To ensure long-term sustainability and scalability, integrating a structured trading platform for GWCs—similar to carbon credit exchanges—would enhance water conservation by creating a market-driven mechanism for incentivising sustainable practices. A GWC trading exchange would enable industries, municipalities, and agribusinesses to offset water consumption by purchasing credits from water-efficient stakeholders, such as farmers implementing drip irrigation, recharging groundwater, or practicing sustainable land management. This would monetise conservation efforts, attract private-sector investment, and establish water as an economic asset within a regulated framework.

To operationalise this, a centralised administrative and regulatory mechanism is required to oversee credit issuance, trading, and compliance. This could be managed by a dedicated body under India's National Water Mission, launched in 2011 in collaboration with state water authorities and environmental finance institutions. A robust governance framework should ensure transparency, accuracy, and efficiency in credit trading. Key control mechanisms would include independent verification of water savings, digital monitoring using IoT sensors and blockchain, and a dynamic pricing model reflecting regional water scarcity and conservation needs. Establishing a legal mandate for credit ownership, trading rights, and compliance is crucial to prevent market manipulation and ensure equitable participation.

By integrating a well-regulated trading platform and governance structure, GWCs can transition from a localised incentive model to a nationally scalable financial instrument. This would generate financial rewards for water-efficient stakeholders while driving systemic improvements in water resource management by aligning economic incentives with conservation priorities. A dual payment system could also be proposed, rewarding farmers for both private benefits and public goods. Funding could come from downstream industries, municipalities, governments, and international organisations. By broadening the scope of rewards, the GWC framework incentivises sustainable practices and align individual actions with collective sustainability objectives.

By linking financial incentives with sustainable water management, the GWC framework introduces a market-driven mechanism that benefits multiple stakeholders. However, for long-term impact, GWCs must evolve beyond private incentives to include ecosystem services, ensuring holistic conservation. A dual-payment model—rewarding both individual conservation efforts and broader environmental benefits—could provide a more equitable and effective approach.

VII.

The Role of a Water-Reliant Beverage Industry

The question that arises is: What role can industries, especially those dealing with water (e.g. beverage industry) play, given their wherewithal and the bandwidth to play an important role in institutionalising agricultural water credits?

First, the beverage industry can initiate demand-driven incentivisation. Beverage companies, particularly those producing soft drinks, bottled water, juices, and alcoholic beverages, being significant consumers of water, apart from agriculture can integrate GWC frameworks into their corporate water stewardship programmes. While creating a market-driven mechanism to incentivise farmers to adopt sustainable water conservation practices, these companies can commit to purchasing water credits generated through agricultural conservation efforts, ensuring a steady demand for these credits.

Second, they can be initiators and key players in supporting Public-Private Partnerships (PPP) for Sustainable Water Management. The industry can collaborate with governments, NGOs, and financial institutions to create structured water credit programmes that farmers can access. Partnerships with development financial institutions at national levels like the National Bank for Agriculture and Rural Development (NABARD) and multilateral institutions like the World Bank and Food and Agriculture Organization (FAO) can help create enabling policy frameworks for supporting water credit markets.

Third, beverage companies can play an important role through supply chain integration. Many beverage companies source their raw materials such as sugarcane, barley, coffee, and tea, all of which are water-intensive crops. These firms can mandate sustainable water practices as part of their supplier agreements, linking farm-level conservation to market-based incentives.

Fourth, the framework can also work from Carbon-Water Nexus & (Environmental, Social, and Governance) ESG Investments in the beverage industry. With the increasing significance and mainstreaming of ESG reporting, beverage companies can leverage water credits as an offset mechanism similar to carbon credits. This aligns with corporate sustainability goals and global frameworks such as CDP (Carbon Disclosure Project) Water Security and the Alliance for Water Stewardship (AWS). This makes them direct participants in the Green Water Credit market, thereby helping in deepening the market and infusing liquidity.

Fifth, there is an urgent need for funding and financial support to facilitate the adoption of green water practices. Beverage corporations can play a pivotal role by investing in capacity-building, farmer training programs, and technology adoption. Optimising key operational processes, such as raw material and packaging material sourcing, upstream transportation networks, energy sources, processing efficiencies, and cost-effective overhead management, can enhance sustainability across the supply chain. Additionally, targeted investments can help farmers optimise water consumption through advanced irrigation techniques such as drip irrigation and land levelling. Direct monetary incentives or subsidies for water-efficient practices can further accelerate the institutionalisation of water credits.

Sixth, given their reach and access to the policy research think-tank, advocacy groups and policy-making communities, the industry can work with policymakers to establish standardised measurement criteria for water credits.

By participating in water governance frameworks, they can advocate for the regulatory recognition of agricultural water credits. Overall, the beverage industry is well-positioned to institutionalise agricultural water credits through market mechanisms, supply chain integration, financial investment, and policy advocacy. By aligning business interests with sustainable water management, beverage companies can create a scalable and sustainable model that benefits both agriculture and industry while addressing global water challenges.

VIII.

Conclusion

India's escalating water crisis demands a paradigm shift in how water resources are valued, allocated, and conserved. Traditional water management approaches focused on supply augmentation have proven inadequate in the face of increasing demand, unsustainable extraction, and ecosystem degradation. The introduction of market-based mechanisms like water credits presents a transformative opportunity to align economic incentives with sustainable water use. By integrating financial accountability with conservation efforts, water credits not only encourage industries to offset their water footprint but also empower communities to participate in structured water stewardship.

A well-calibrated water credit system has the potential to redefine water governance in India, fostering greater efficiency in allocation, strengthening corporate responsibility, and enhancing regional water security. However, realising its full potential requires robust policy frameworks, scientific valuation methods, and mechanisms for transparent implementation. Clear regulatory guidelines, supported by data-driven monitoring, will be essential to ensure that water credits do not merely serve as compliance instruments but become genuine tools for replenishing water ecosystems and enabling equitable access.

Moreover, as demonstrated through data application, successful water credit systems require localised adaptation, accounting for hydrological variations, industry-specific challenges, and socio-economic disparities. Scaling these initiatives will necessitate greater synergy between government policies, private sector engagement, and community participation. Incentivising conservation through tradable credits, fostering public-private partnerships, and leveraging digital technologies for monitoring can improve water use efficiency across sectors.

While water pricing reforms and efficiency measures help curb wastage, they must be accompanied by mechanisms that recognise the ecological value of water. GWCs offer an innovative way to integrate environmental services into water management, rewarding conservation efforts that benefit entire watersheds. Expanding water credits to include ecosystem services—such as groundwater recharge, soil moisture retention, and pollution control—will ensure conservation is both financially viable and ecologically comprehensive.

One limitation of this framework is that it relies on random numbers, whereas real-life experiments are needed to validate its outcomes. However, given the nature of the production function and the impact of green water practices observed so far, the results are expected to follow a similar trend.

A second limitation pertains to the framework itself. While farmers are compensated based on the base value of the GWC, this valuation is derived from the opportunity cost of conserving water rather than engaging in blue water practices. However, this compensatory value does not fully capture the broader benefits of retaining water within the ecosystem. Every unit of conserved water performs ecosystem functions, including groundwater recharge, biodiversity support, and climate regulation, all of which provide direct and indirect benefits to human communities. By explicitly acknowledging and incorporating the value of these additional ecosystem services, a more comprehensive and accurate valuation of GWCs can be established.

Therefore, what this report intends to propose is that the broader implication of such water credit markets is embedded in the framework of Integrated Water Resources Management (IWRM) that talks of integrating land, water and ecosystems and promote the three Es – two human dependent ones (social equity and economic efficiency) and one related to ecosystem (environmental sustainability) .

Understanding the GWC fit within this framework requires examining key tenets of IWRM and their connection to the guiding principles of this emerging paradigm.

A. **Water is not a stock of material resource to be stored for human use only, but an integral component of the global hydrological cycle:** By creating a reward system for water released back into the ecosystem, GWC acknowledges the water's role beyond short-term human use.

B. **Water and food do not necessarily share a linear, positive relation, rather food security solutions need to be sought through better water, soil and crop management practices:** GWC institutionalisation challenges the traditional "more food, more water" mindset by promoting sustainable agricultural practices.

C. **The multidimensionality of water demand along with those of the natural ecosystems needs to be acknowledged. The emerging transdisciplinary paradigm of IWRM talks of the existing trade-off prioritisation between the two classes of competing water needs:** those of the natural ecosystem and those of the human society, while there are competing demands within the human socio-economy: GWC enhances the understanding of the trade-offs between the natural ecosystem and human demand and helps in the prioritisation of water needs without compromising with the fundamental food security goals.

D. **Objective analyses are needed for an integrated and comprehensive approach to assessing interventions on hydrological flows by considering the integrity of the hydrological cycle:** With an enhancement of the proposed framework to including ecosystem services of water savings and enhanced flow regimes, the GWC valuation can help in an integrated evaluation of such institutional interventions in the broader hydrological cycle.

E. **Newer and holistic economic instruments and institutions should be developed for the assessment of projects and efficient, equitable, and sustainable utilisation of water resources as well as for the reduction of damage to their quality from pollution:** Water credits help in discovering the prices and reflect the scarcity value of water. Such values can even help in project evaluation and monitoring, apart from signalling the existing state of the resource in terms of its physical availability and quality.

In conclusion, water credits must not be viewed as an isolated policy instrument but as a critical component of a larger shift towards sustainable water governance. The importance of Green Water Credits does not only lie in the context of agricultural waters, but in the context water in the framework of a river basin. The water technocracy and the policy-making community needs to appreciate that.

Further, if such a market is to be developed, it will need a strong regulator with proper understanding of not only hydrology or hydrogeology, but also various market mechanisms including financial instruments, regulatory instruments, and the steps to curb possible market cornering tendencies by various players. Again, the market needs to be broad-based with heterogeneous players other than farmers. It will require players like municipal corporations, energy companies, local governments, the beverage industry, and hospitality and other agro-based industries who have sufficient exposure to the water sector. Even financial institutions like banks, as well as insurance and reinsurance companies—which are exposed to the risk of failing agricultural loans due to the unavailability of water—need to be part of such a market framework.

The success of such a market depends on the participation of industries, and farm communities, and the willingness of policymakers and communities to collaborate in rethinking the governance of water. Such broad-based and heterogenous participation will help in deepening the market and also in infusing the much-needed liquidity. By embedding water credits within a holistic framework that prioritises resilience, accountability, and environmental sustainability, India can move towards a future where economic growth and water security are not mutually exclusive goals.

Appendices

Appendix 1: Raw Data (Treatment and Control Groups)

	Treatment Group		Control Group	
	Total Production (kgs per cultivation cycle) (Y)	Total Water Used (cubic meters per cultivation cycle) (X)	Total Production (kgs per cultivation cycle) (Y)	Total Water Used (cubic meters per cultivation cycle) (X)
Mean	158.19	65.37	114.63	48.41
Median	105.00	45.72	60.00	32.66
Mode	120.00	52.25	30.00	26.13
	Water Applied: 2756 cubic meters per irrigation per acre.			
	Water Requirement Proportion (Land Levelled): 0.79.			
	Price (INR per kg): 3.15 (Source: Cabinet Committee on Economic Affairs).[39]			

Appendix 2: Regression Output (Treatment Group)

Regression Statistics						
Multiple R	0.95					
R Square	0.90					
Adjusted R Square	0.90					
Standard Error	0.26					
Observations	226.00					
ANOVA						
	df	SS	MS	F	Significance F	
Regression	1.00	140.94	140.94	2081.35	0.00	
Residual	224.00	15.17	0.07			
Total	225.00	156.10				
	Coefficients	**Standard Error**	**t Stat**	**P-value**		
Intercept	0.96	0.23	4.11	0.00		
LN X	0.99	0.02	45.62	0.00		

Appendix 3: Regression Output (Control Group)

Regression Statistics					
Multiple R	0.93				
R Square	0.86				
Adjusted R Square	0.86				
Standard Error	0.34				
Observations	211.00				
ANOVA					
	df	SS	MS	F	Significance F
Regression	1.00	146.25	146.25	1288.48	0.00
Residual	209.00	23.72	0.11		
Total	210.00	169.97			
	Coefficients	**Standard Error**	**t Stat**	**P-value**	
Intercept	-0.23	0.32	-0.73	0.46	
LN X	1.09	0.03	35.90	0.00	

Appendix 4: Green Water Credit Valuation

Indicator	Treatment (Land Levelling)	Control (No Land Levelling)	Difference (Treatment - Control)
Average Marginal Productivity (MP) of Water (in kgs per m³)	2.42	2.39	0.03
Water Savings (m³ per cultivation cycle)			173,75.55

Land levelling enhances water distribution efficiency, reducing water usage by 17,375.55 cubic meters per cultivation cycle. The economic value of this water savings is calculated by multiplying the saved water volume by the Average Marginal Productivity (MP) of the treatment group (2.42 kg per m³) and the sugarcane price (Rs. 3.15 per kg), yielding a total value of Rs. 1.32 lakh per cultivation cycle. Based on this, the value per Green Water Credit (GWC) is derived as (Rs. 1.32 lakh / 17,375.55 m³) × 100 m³ = Rs. 0.00759688 lakh per GWC, or approximately Rs. 759.69 per GWC, assuming 1 unit of GWC corresponds to 100 cubic meters of water saved.

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