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FROM FLOOD HAZARD TO PRODUCTIVE WATER RESOURCE: REFRAMING SEASONAL FLOODWATER FOR SUSTAINABLE IRRIGATION AND CLIMATE-RESILIENT DEVELOPMENT

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ABSTRACT

The floods resulting from the presence of seasonal floodwaters in arid and semi-arid regions have largely been considered a danger that needs management rather than considering it as a flow of renewable natural capital whose economic value depends on the capital it gets mixed with. This paper has formulated a new model referred to as Climate Resilient Seasonal Floodwater Economy (CRSFE). The seasonal floodwaters are considered as a flow and associated with climate resilient infrastructure, climate smart water governance, natural capital development, agricultural productivity enhancement, and rural economy transformation. The framework responds to an ongoing fragmentation within the literature whereby spate irrigation literature emphasizes water diversion and agricultural output; flood management literature stresses the importance of hazard mitigation; managed aquifer recharge literature concentrates on groundwater replenishment; and governance literature considers institutional coordination – literatures which have yet to consider pricing the value of floodwater relative to the contextual factors that determine whether it is captured or wasted. Methodologically, this study will employ a combination of a structured conceptual review, application of a case study (the Koh-e-Suleman Rod Kohi system, Pakistan), and a proposed empirical approach involving structural equation modelling and household level regression with propensity-score matching, being clear in its limitations regarding its inability to overcome the issue of unobserved confounders. The case study reveals four leverage points – stream gauging, customary/formal institution coordination, sediment aware infrastructure, and primary household surveys – while making the distinction between conceptual and tested claims clear throughout. The framework adds a testable capital-theoretic connection between water security and development economics; its policy implication is to consider floodwater investments as development portfolios rather than stand-alone flood control/irrigation initiatives.

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Introduction

Climate change is making the monsoonal and convective rains in dryland piedmont areas more variable and extreme, thus producing short and devastating flood events even where annual precipitation is still relatively low (Intergovernmental Panel on Climate Change [IPCC], 2022). The floods of August 2022 in Pakistan's Koh-e-Suleman hills exemplify this conundrum. In addition to causing record national economic and agricultural damage, satellite and remote sensing data reveal exceptionally heavy precipitation and hydrologic variability in the region (Cui et al., 2024; Ma et al., 2023; Nanditha et al., 2023). Among other things, the hill torrents in Koh-e-Suleman remain largely ungauged (Saleem et al., 2023). At the same time, the episodic flows are an essential source of irrigation for farmers in dryland South Asia and East Africa (Maru et al., 2023; Mume et al., 2023). Increasing variability and uncertainty in global water availability are revealed by other worldwide assessments, emphasizing the importance of information, storage and adaptive mechanisms alongside physical water resources (World Meteorological Organization, 2024). Multinational SDG studies also highlight that there is a relationship between how the environmental, economic, and institutional aspects are assessed simultaneously and the performance of indicators (Benedek et al., 2021; Wang et al., 2021). Hazard and asset are thus analytical constructs in addition to institutional ones because the same flow has the potential to destruct assets when uncontrolled but create assets when properly controlled and governed. The dual role of flows is the foundation for the development of CRSFE.

The issue of development economics, therefore, lies not just in water shortage but rather in the inability to make use of water availability to create durable productive resources. Floodwater, in this case, may be considered as renewable flow of natural capital, which value depends on the interaction between that flow and physical, institutional and ecological capital, in line with the concept of natural capital stock and the service flows created by them (Costanza & Daly, 1992; Costanza et al., 1997). Groundwater, soil fertility, vegetation and ecosystem services created by the flow of floodwater might bring about continuous benefits for agriculture and ecology, but in disaster management water benefits are seen from the perspective of reduction of damage. This separation of flood management, irrigation, groundwater, environment management, and rural development objectives hampers the identification of their combined welfare value. This is where SDGs are appropriately suited as a framework.

The literature identifies some key elements of the system but lacks analysis connecting those elements to each other. Research on spate and small-scale irrigation projects are adopting increasingly quasi-experimental methods and finding positive impacts on incomes, crop production, food security, and resilience in Ethiopia (Hussen & Hussen, 2024; Maru et al., 2023; Mume et al., 2023). Nevertheless, such research usually looks at specific irrigation projects without consideration of the hydrological, institutional, and natural capital system overall. On the other hand, Koh-e-Suleman researches offer unusually rich evidence from a number of disciplines: hydrological modelling reveals ungauged torrents and floods (Saleem et al., 2023); sediment research finds that torrent-sourced sediment is both fertility resource and infrastructure

management challenge (Zakir-Hassan et al., 2022); community research identifies institutional and infrastructural priorities (Zakir-Hassan et al., 2023); and provincial remote sensing highlights flaws in the rural water infrastructure (Urban Unit, 2022). The current research is highly isolated in nature and does not provide an economic valuation for the integrated water resources system as well as its welfare effects on households. The differences in methods used within this body of literature are highly significant; for example, while irrigation studies rely heavily on matching and treatment effects, the hydrology studies focus more on simulations and extreme event analysis. They serve different purposes and should not be mixed up.

Conversely, another set of literature deals with the floodwaters in relation to groundwater recharge. A thorough literature synthesis on the topic of MAR indicates that MAR is still an area with dominance of research related to hydrologic impacts, rather than socio-economic or food security impacts (Sinshaw et al., 2026). The example from the state of Gujarat shows that the MAR can simultaneously benefit groundwater availability, agriculture output, and socio-economic development (Alam et al., 2022), while the research on the other aspects of MAR is also ongoing (Hohne et al., 2025; Zheng et al., 2023). The research on governance brings the missing institutional perspective: polycentric governance may enhance coordination in complex water systems (Pahl-Wostl & Knieper, 2023), and the study of common-pool resources provides insights into how locally embedded rules may facilitate resource management in a collective manner without being necessarily based on privatization and/or centralization (Ostrom, 1990). However, the effectiveness of governance is also contingent upon the capacities of the state, preferences and interests of locals, and the balance of power (Kellner et al., 2024). Moreover, the theory of adaptive governance stresses learning and institutional adaptation in socio-ecological systems (Folke et al., 2005). The more recent research on implementation additionally demonstrates that institutionally weak governance could be a barrier to the integration of water-resources management (Lukat et al., 2022).

In all cases, these bodies of literature analyze the very same broad resource using different disciplinary lenses but do not have a common development-economic framework (see Table 1). Recent studies on irrigation provide evidence that irrigation increases crop income, productivity, and technology, yet the meta-regression analysis demonstrates significant heterogeneity in this impact, proving that availability of water is not enough to generate consistent gains (Gizaw et al., 2025; Zewdie et al., 2025). The problem that remains unanswered then is not about how to get additional water, but how to generate productive capacity out of the variable water resource under certain institutions, infrastructure, and ecology. CRSFE theory fills this void by analyzing the seasonal floodwater as natural capital within the development economic objective function and proposing the pathway from the floodwater capture to water security, natural capital, rural transformation, resilience, and sustainable development.

Research contributions: The study contributes in five ways. First, it develops the Climate-Resilient Seasonal Floodwater Economy (CRSFE), which represents a development-economics approach treating seasonal floodwater as renewable natural capital and not just as a risk factor. Second, it

identifies the complementarity between natural, physical, institutional and productive capitals defining the return to floodwater management. Third, it brings together hydrology, infrastructure, governance, livelihoods, and resilience literature usually studied separately. Fourth, it translates the approach into eight empirically testable propositions and an empirical strategy combining structural and household-level analysis. Fifth, it applies the framework exemplarily in Koh-e-Suleman, highlighting policy interventions without confusing conceptually derived insights with empirical validation. The goal is to build the CRSFE approach as a transferable framework for analysing floodwater as a development asset.

Table 1: Literature Gap and Current Study's Framework.

Stream of literature	Issue addressed effectively	Issues yet to be addressed	Proposed approach in CRSFE
Spate/ flood-based irrigation	Floods, farm production, and impacts on livelihoods	Little integration between natural capital, governance, and economy-wide resilience	Connecting floods to infrastructure, institutions, productivity, and resilience
Flood and hill-torrent management	Runoff, hazard vulnerability, sediment risk, and infrastructure	Approach tends to consider water either as a hazard or engineering flow	Contributes productivity and natural capital perspective to hazard assessment
Aquifer recharge	recharge, storage of ground water, and drought management	Recharge can be disconnected from demand, governance, and welfare of households	Recharge is considered in a wider framework of productive investments
Water governance	Coordination, institutional fit, and collective action	No direct link between governance and productivity/natural capital perspectives	Governance treated as determinant of investment return
Rural development and irrigation economics	Incomes, productivity, food security, and livelihoods	Little consideration of water access as endogenous outcome	Contributes hydrological, institutional, and natural capital perspectives

Materials and Methods

The present study employs a methodology involving both the development of a theoretical framework and an exemplification through a single case analysis coupled with an outlined empirical testing approach. The choice of Koh-e-Suleman is due to the existence of relatively

new evidence concerning the hydrology, sedimentation, infrastructure, governance, and flooding of this very hill-torrent system in secondary sources (Nanditha et al., 2023; Saleem et al., 2023; Urban Unit, 2022; Zakir-Hassan et al., 2022, 2023). This makes the current case suitable for analytical synthesis but not for representing any statistical population. The study does not estimate causal effects or structural coefficients. Instead, the goal of the study is to develop a sound theoretical framework based on the evidence base. The criteria for selecting the evidence are explicitly conservative: all the evidence that is specific to the case at hand is kept intact in order to make the analysis geographically relevant, while the more general causal claims have to be backed up by peer-reviewed comparative evidence. Thus, the illustrative case will never be treated as an impact evaluation study due to representativeness.

The methodology flows from the research question. It would be inappropriate to use a single-equation regression in describing a structure where multiple dimensions function simultaneously, entail latent variables, and produce reciprocal feedback effects. CRSFE arranges seven dimensions – season floodwaters, climate resilient infrastructure, climate smart governance, natural capital enhancement, rural economic transformation, climate resilience, and sustainable development – in an expected causal chain with two feedback mechanisms (Figure 1). The ordering corresponds to the theoretical process, in which water is captured and managed by infrastructure and governance; this affects the natural capital and the productive potential; productive activities lead to higher levels of resilience and sustainable development; and good ecological and resilience results return to governance and infrastructure decisions. CRSFE thus treats infrastructure and governance as complementary rather than independent treatments. This is supported by previous studies demonstrating that coordination during the policy cycle impacts implementation results in river basin systems (Schütze et al., 2022). These seven dimensions are not taken as additive. Their expected value is based on complementarity, such as better information about water can increase the efficiency of infrastructure; infrastructure improves water productivity; governance dictates access and maintenance; and natural capital enhances future productivity.

This structure is meant to be used for further structural equation modeling (SEM). In the measurement model, each latent variable is defined through its observable measures:

$$x_{ij} = \lambda_{ij}\eta_i + \varepsilon_{ij}, j = 1, ..., k_i, \quad \text{..... (1)}$$

where λ_{ij} is the factor loading of measure j of construct i and ε_{ij} is the measurement error. The structural model is based on the path suggested:

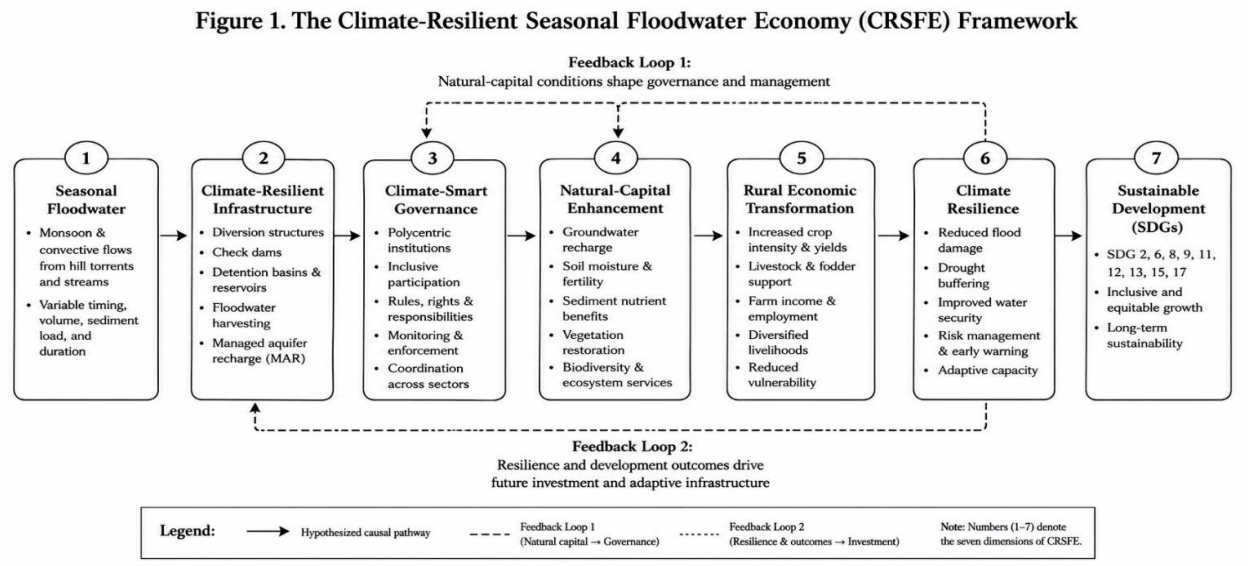


Figure 1. Climate Resilient Seasonal Flood Water Economy (CRSFE): Investment-to-Transformation Pathway and Feedback.

$$\eta_2 = \gamma_{21}\eta_1 + \zeta_2; \eta_3 = \gamma_{31}\eta_1 + \zeta_3; \eta_4 = \beta_{42}\eta_2 + \beta_{43}\eta_3 + \zeta_4; \eta_5 = \beta_{54}\eta_4 + \beta_{53}\eta_3 + \zeta_5; \eta_6 = \beta_{65}\eta_5 + \beta_{63}\eta_3 + \zeta_6; \eta_7 = \beta_{76}\eta_6 + \beta_{75}\eta_5 + \zeta_7, \quad (2)$$

Where γ and β are structural path coefficients and ζ indicates disturbance terms. The presence of two feedback loops (D4→D3; D6→D2) makes the system non-recursive, which means that future estimation needs to use a method that can cope with reciprocal paths instead of a straightforward recursive path model. The final estimation method – covariance-based SEM or PLS-SEM – must be chosen after the indicator set-up, sample size, distribution characteristics and measurement model are defined (Kline, 2023). The suggested modeling approach takes into account the fact that although feedback loops have theoretical sense, their empirical identification is quite complicated. Therefore, if in the end there are no enough data to define reciprocal paths, the model must be reduced and not overestimated. Estimation must consider alternative estimations and mediations, not just focus on statistical significance.

A household-level reduced-form test for the livelihood's linkages among infrastructure, governance, and rural development may therefore proceed as follows:

$$HLS_i = \alpha + \beta_1 INFRA_i + \beta_2 GOV_i + \beta_3 LAND_i + \beta_4 LU_i + \beta_5 LIVESTOCK_i + \beta_6 CREDIT_i + \beta_7 LOC_i + \varepsilon_i, \quad (3)$$

where HLS_i denotes a household living-standards index including income, durable consumption, education, health, and housing variables; $INFRA_i$ denotes household exposure to resilient infrastructure against floods; GOV_i denotes participation in governance or governance quality;

$LAND_i$, LU_i, $LIVESTOCK_i$, and $CREDIT_i$ denote productive assets and finance; LOC_i denotes spatial exposure; and ε_i is the error term. While exposure should ideally be measured using observable proximity or service measures and not an assumption that there is a binary treatment, a simple OLS regression with heteroskedasticity-robust errors is a transparent starting point, whereas propensity score matching or quasi-experimental approaches could control for observable selection biases when treatments and comparison groups exist. As a result, the treatment variable should be identified ex ante on the basis of measurable exposure to the service, whereas outcome variables need to be measured both pre- and post-intervention whenever feasible. Propensity score matching is appropriate only if overlap and balance are proven, or else a quasi-experiment should be conducted. Research findings on irrigation uptake demonstrate the importance of these identification techniques (Ebrahim & Toy, 2024; Zewdie et al., 2025). For future use, outcome variables should be measured ex ante to treatment exposure, and spatial dependence needs to be accounted for, as households exposed to the same torrent, facilities, markets, or underground water source may not be independent.

The eight propositions articulate these links in empirical form (Table 2): P1, floodwater management enhances water security via infrastructure and governance; P2, climate-resilient infrastructure enhances agricultural productivity; P3, water security enhances rural economic resilience; P4, natural capital intermediates the floodwater-productivity link; P5, governance intermediates the floodwater-water security link; P6, rural economic resilience enhances sustainable development; P7, climate resilience intermediates the water security-sustainable development link; and P8, co-ordinated CRSFE dimensions enhance multi-SDG progress. The empirical study program will involve household surveys, georeferenced infrastructure exposure, hydrological measurements, groundwater monitoring, remote sensing, and development indicators. No further statistical constructs are specified here beyond those already mentioned in the cited literature.

Table 2. CRSFE propositions and their empirical interpretation

Proposition	Core Relationship	Suggested Evidence
P1	Floodwater management -> infrastructure and governance -> water security	Flow reliability, water storage/groundwater recharge, allocation
P2	Climate-resilient infrastructure -> agricultural production	Yield, cropping intensity, agricultural income, water productivity
P3	Water security -> rural economic resilience	Income stability, asset security, livelihood diversification
P4	Natural capital -> Floodwater -> productivity	Groundwater, soil moisture/fertility, vegetation, NDVI
P5	Governance -> Floodwater -> water security	Legal/regulatory rules, participation, conflict resolution, maintenance
P6	Rural economic resilience ->	Income, employment, food security, well-

	sustainable development	being
P7	Climate resilience -> water security -> sustainable development	Vulnerability to shocks, ability to recover from shocks, adaptive capacities
P8	CRSFE dimensions jointly -> multi-SDG sustainable development	SDG indicators and composite development at district level

Results and Discussion

Results are purely conceptual and interpretative since the current analysis does not estimate any models and the application of Koh-e-Suleman is based on secondary data. However, the key finding is common for all previous literature: seasonally occurring water flows can become sources of development only if physical infrastructure, governance, and ecosystem services complement each other as capital. This fact justifies the poor performance of infrastructure only. Literature about Gujarat suggests that integrated recharge can help to increase groundwater supply and food productivity, while Ethiopian literature suggests that benefits of irrigation depend on having productive and institutional capital (Alam et al., 2022; Hussen & Hussen, 2024; Maru et al., 2023; Mume et al., 2023). In addition, the meta-regression findings support heterogeneous irrigation returns, confirming CRSFE's focus on complementary factors over water availability alone (Gizaw et al., 2025). This interpretation is in line with the irrigation literature in general, where positive effects on livelihoods have been found overall, but context matters a lot; in essence, infrastructure should not be looked at as a stand-alone technology that works with a set return everywhere. In this regard, the interpretation addresses mechanism consistency, not effect magnitude. Not a single coefficient can be drawn from the comparative research, and no specific welfare gain for any given place is claimed by CRSFE. This distinction makes the framework even more relevant.

The Koh-e-Suleman example highlights the real-world significance of such complementarity. Hydrological evaluation recognizes ten major hill torrents and significant flood generation capacity notwithstanding a lack of gauging (Saleem et al., 2023). The 2022 floods highlight the price paid when flows are left ungoverned, while national and satellite data support the exceptional intensity and disruption in precipitation (Cui et al., 2024; Ma et al., 2023; Nanditha et al., 2023). The implication is that investments in infrastructure are proceeding with a considerable amount of information uncertainty. Gauging streams are more than mere sensors; they are valuable information assets that can optimize the infrastructure. The governance constraint is the second one. Evidence from the Koh-e-Suleman community confirms the persistence of water sharing using customary and negotiated means, while institutional coordination emerges as an area of importance besides infrastructure development (Zakir-Hassan et al., 2023). This finding is in line with the finding that inter-level coordination may be conducive for better water governance (Pahl-Wostl & Knieper, 2023); however, institutional coordination efforts have been known to fall apart in case there is no consideration of the fit between institutions, the strength of the state, or the power dynamics (Kellner et al., 2024; Lukat et al., 2022).

Another example of the framework's integral logic comes from sediment. Sediment carried by torrent flows could reduce the capacity of the channel and infrastructure systems while simultaneously contributing to soil replenishment on farms (Zakir-Hassan et al., 2022). A single-purpose flood control analysis, then, would be understating the importance of one aspect while overstating that of another. In CRSFE, sediment flows have to be designed within the context of an infrastructure-natural capital system. The same is true for MAR research (Hohne et al., 2025; Sinshaw et al., 2026; Zheng et al., 2023).

The livelihood and SDG impacts appear realistic, although site-estimates are currently unavailable. Studies related to irrigation identify an association between reliable water supply and income, food security, assets, and resilience (Hussen & Hussen, 2024; Maru et al., 2023; Mume et al., 2023), whereas research conducted in Pakistan confirms the importance of human, social and financial capital in relation to household well-being, social mobilization and livelihood institutions (Janjua & Sakhani, 2014; Rehman et al., 2026; Sakhani et al., 2021, 2025, 2026). Thus, CRSFE identifies associations between water security and achievement of SDGs based on underlying processes rather than just mapping targets. Productive water leads to food security and income; infrastructure to innovation and resilience; ecosystem functions to natural capital; and accountable institutions to implementation coordination (IPCC, 2022; United Nations, 2015; Wang et al., 2021). The same approach can be used for assessment of SDG progress. Progress should be measured using welfare, productivity, resilience and ecological indicators rather than stating that the intervention leads to achieving several SDGs (Benedek et al., 2021; Wang et al., 2021).

Four leverage points become evident: installation of stream gauging and integration of hydrologic, precipitation, groundwater, and remote sensing data; establishment of accountable polycentric coordination without undermining local institutions; design of water diversion and storage systems with clear sediment pathways; and collection of household panel data for measuring impacts on productivity, well-being, and resilience. Comparing examples of flood-based irrigation in Ethiopia, MAR in Gujarat, and MAR in South Africa reveals that the problem of integration is not unique to Pakistan (Alam et al., 2022; Hohne et al., 2025; Hussen & Hussen, 2024; Maru et al., 2023; Mume et al., 2023). The example of Koh-e-Suleman represents analytical convergence on hydrology, sedimentation, governance, and development evidence while being illustrative and not causally validated application. This gives rise to implications for leverage sequencing: information infrastructure should come before any major expansion; institutional coordination should accompany design and maintenance; and household measurement should precede implementation so that impacts could be measured. Thus, the proposed framework translates a comprehensive policy agenda into a measurable investment and does so through proper sequencing of actions which is in line with the idea that information, institutions, and physical assets are jointly productive.

Table 3. Koh-e-Suleman leverage points identified through the CRSFE diagnostic

Leverage points	Problem	Proposed Economic Mechanism	Priority Intervention
Hydrological Information	The many ungauged hill torrents	Uncertainty reduction and expected return on investment for infrastructure investments	Maintain flow gauges and combine with rain and remote sensing data
Institutional Coordination	Customary institutions coexist with formal institutions, and agencies have unclear jurisdictions	Lowers transaction costs and improves resource allocation and maintenance	Establish accountable polycentric coordination
Sediment management	Sediment is damaging infrastructure but useful for soil fertility	Minimize maintenance cost while increasing benefit to agriculture	Explicitly incorporate sediment pathways into diversion and storage
Household evidence	Households do not have site-specific welfare benefits	Enables causality estimation of welfare gains due to productivity	Establish panel household survey that incorporates infrastructure exposure

Conclusion and Policy Recommendations

The research finds that floodwater in drylands must not be regarded merely as a risk factor to control. The Climate-Resilient Seasonal Floodwater Economy (CRSFE) paradigm considers floodwater in drylands as natural capital whose economic value is contingent upon the presence of complementary physical capital and climate-resilient governance systems. Its basic idea is that water availability alone does not produce sustainable benefits; rather, the synergy of natural capital, physical capital, institutional capital, human capital, and financial capital is required to harness flood pulses for agricultural production, livelihood diversification, ecosystem services, and climate resilience. The Koh-e-Suleman example confirms the applicability of such a comprehensive approach, but it is only illustrative.

The key role of the framework is in linking hydrology, infrastructure, governance and rural development literatures, which are often studied independently. Seven interrelated dimensions of the framework include: seasonal flood water, climate resilient infrastructure, climate smart governance, enhancement of natural capital, rural transformation, climate resilience, and sustainable development, with a specified interaction between them constituting an empirical development pathway. The literature is extended through treating the productive use of seasonal floodwater as a problem of complementary investments where infrastructure generates capacity, institutions allocate and maintain infrastructure, and natural capital processes generate

persistence of benefits. Consequently, the policy may shift from spending on individual flood control to managing flood water as an asset. Firstly, governments should set up gauging stations and hydrology monitoring facilities in order to base investments in diversion, storage, recharge, and warning on the observation of flood behaviour, instead of relying on limited information (Saleem et al., 2023). Secondly, governments should build infrastructure which is able to address both sedimentation and soil replenishment, as floods not only damage infrastructure through their sedimentation but also add value to agriculture through their sedimentation (Zakir-Hassan et al., 2022).

In addition, financing systems should take into account the multiple outputs possible in floodwater seasonal management schemes. The recharge facility may serve at once to build drought resilience, mitigate floods, increase agricultural production, and improve the groundwater situation, whereas sediments-related facilities will help safeguard physical capital and preserve soil ecosystem services. Benefit matrices which distinguish between financial gains, non-financial gains, ecosystem services, and distribution effects will decrease the likelihood of discounting such integrated projects. It is especially relevant in cases of limited fiscal space for climate finance. The distributional evaluation would have to highlight the winners and losers of both upstream and downstream communities, thereby ensuring that integration does not repeat the pattern of existing inequality and shifts risks between communities.

The governance transformation needs to concentrate on coordination and accountability, rather than institutional multiplicity. The customary Rod Kohi institutions need to be part of the polycentric system linking the local knowledge to the formal administrative and technical systems, while ensuring transparency, representation, and accountability (Kellner et al., 2024; Pahl-Wostl & Knieper, 2023; Zakir-Hassan et al., 2023). The agricultural policy will have to go alongside water investment because the availability of water creates welfare benefits only when the farmers can also access seed, extension, credit, markets, livestock services, and information. Research on the welfare and income diversification of small farms also confirms that complementary household assets and finance are necessary to create welfare from production (Sakhani et al., 2021, 2025).

The first important issue from an empirical standpoint is that of shifting from validation to causation. Future studies should combine household surveys with georeferencing infrastructure exposures, hydrological measurements, water table data, remote sensing of vegetation and land cover and district-level development indicators. SEM analysis could be used to test the internal logic of CRSFE, whereas matching or quasi-experimental techniques can help identify household-level impacts. However, as matching does not solve the problem of unobservable bias, researchers may consider using panel or difference-in-differences techniques where possible. It should also be noted that the current framework must be viewed more as a transferable and empirically testable research agenda than as a completed impact assessment exercise. The overall contribution of the approach under discussion here lies in moving beyond the false dichotomy of flood control vs. water management and illustrating how seasonal floodwaters can serve both as a

hazard, production factor, recharging mechanism, sediment conveyor and basis for climate-proof rural development.

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