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# Flood-Based Lotus Farming as a Nature-Based Solution in Climate-adaptive Agriculture in the Upper Vietnamese Mekong Delta: An Analytical Argument With Typical Cases

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**Abstract**

This article analyzes flood-based lotus farming as a nature-based solution (NbS) for climate-adaptive agriculture in Vietnam's upper Mekong Delta. The research design synthesizes secondary literature, using project reports from Láng Sen and Trà Sư as two core empirical cases; the study by Vo et al. (2021) in Đồng Tháp as an explanatory case to understand how lotus was shaped into an adaptive innovation; and a lotus value-chain report covering An Giang, Đồng Tháp, and former Long An, together with documents on lotus silk, to examine the conditions for value-chain upgrading and model scaling. The findings show that lotus broadly fits the NbS logic in three respects: (i) it generates hydrological–ecological co-benefits within floodplain environments; (ii) it creates agronomic co-benefits for the subsequent rice crop; and (iii) it opens opportunities for organizing a multi-layered value chain linked to processing, employment, and local branding. However, these benefits are not automatic. Evidence from the illustrative cases indicates that lotus performance depends closely on hydrological thresholds, cropping calendars, risk-management capacity, and the depth of market linkages. The article argues that lotus should not be treated as a standalone substitute crop but as a component of a flood-based livelihood system; accordingly, the sustainable future of the model must rest on three pillars: floodplain spatial planning, adaptive hydrological governance, and value-chain upgrading grounded in NbS logic.

**Keywords:** flood-based lotus; nature-based solutions; upper Mekong Delta; climate adaptation; floodplain agriculture; typical cases

## 1. Introduction

Over the past decade, development thinking in the Mekong Delta has gradually shifted from a hard water-control logic to an ecosystem-based adaptation logic. Government Resolution No. 120/NQ-CP marked a major turning point by affirming the principle of "working with nature," emphasizing the need to live proactively with floods, harness each subregion's ecological advantages, and reduce dependence on land–water use models that weaken the Delta's natural

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functions (Government of Vietnam, 2017). For the upper Delta, which continues to play a crucial role in receiving and regulating floodwaters for the entire deltaic system, agricultural transformation is not only a livelihood issue but also a matter of preserving floodplain space.

Studies of the upper Mekong Delta have shown that high-dike systems and triple-rice cultivation generate significant hydrological, ecological, and livelihood trade-offs. In An Giang, Tran et al. (2018) found that both farmers and experts rated flood-based options under low-dike systems more favorably when water retention, livelihood stability, and environmental sustainability were considered together. In other words, the key question is no longer how to eliminate floods, but rather which models can transform floodwaters into a productive resource within appropriate spatial settings.

In this context, Lotus has emerged as a noteworthy option. Lotus can grow under inundated conditions, and many parts of the plant can be used for food, medicine, cosmetics, handicrafts, tourism, and, more recently, lotus silk. However, the value of the lotus lies not merely in the number of products it can generate. According to Vo et al. (2021), lotus in the upper Mekong Delta has been reinterpreted as an adaptive technology, continuously shaped by interactions among farmers, local authorities, scientists, development organizations, and markets. It is precisely this "unfinished" or "not yet closed" character that makes lotus suitable for analysis not simply as a crop, but as a component of NbS-based transformation.

Nevertheless, most practical discussions of lotus still tend to fall into two extremes: either idealizing lotus as an automatically superior alternative to rice, or, conversely, assessing its performance only through the profit of a single lotus season. Neither perspective is sufficient to explain why lotus models generate clear co-benefits in some places, yet reveal substantial risks in others when floods arrive early, water levels rise rapidly, or markets are poorly organized. For this reason, this article adopts a typical-case approach, treating the results from Láng Sen, Trà Sư, Đồng Tháp, and the three-province cluster of An Giang–Đồng Tháp–former Long An as cases that help clarify the mechanisms, conditions, and limits of the model.

From this perspective, the article pursues three objectives. First, it establishes an analytical framework to examine whether flood-based lotus farming meets the logic of NbS. Second, it provides an in-depth analysis of three groups of typical cases concerning hydrological–ecological co-benefits, agronomic co-benefits, and conditions for value-chain upgrading. Third, it has implications for the sustainable future of lotus-based models in the upper Delta on an NbS foundation, rather than treating lotus merely as an alternative crop.

## 2. NbS Analytical Framework and Research Methods

### *2.1. Analytical framework: flood-based lotus as a nature-based solution*

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NbS is understood according to the IUCN definition as actions to protect, sustainably manage, or restore natural or modified ecosystems in ways that address societal challenges effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits (Cohen-Shacham et al., 2016). This definition is particularly relevant to the upper Mekong Delta, where the challenge is not only to reduce climate risks but also to restore ecological functions that have been weakened under closed intensive farming systems.

According to this definition, a lotus can be considered an NbS only if it satisfies all four analytical conditions simultaneously. First, the model must help address a core societal challenge, here understood as adapting to fluctuating floods, sustaining livelihoods, and reducing climate vulnerability. Second, it must generate observable ecological co-benefits rather than merely replacing one crop with another. Third, it must be strongly localized, meaning that it depends on specific floodplain conditions, crop calendars, water governance, and livelihood structures. Fourth, it must be capable of long-term maintenance through appropriate social and market institutions.

This framework helps avoid a common misunderstanding: not every production system located in floodwater areas automatically qualifies as an NbS. A system becomes an NbS only when ecological, livelihood, and governance benefits are effectively interconnected. For this reason, the article does not treat lotus as a purely technical object, but rather as a hybrid system at the intersection of ecology, production, and institutions.

*2.2. Research design and selection of typical cases*

The study uses an explanatory secondary-data synthesis approach. The evidence base is built from five groups of sources: (i) the CRxN Mekong project completion report in Láng Sen; (ii) the technical–economic report on flood-based livelihood models in Trà Sư; (iii) the peer-reviewed article by Vo et al. (2021) on the emergence of lotus as an adaptive innovation in Đồng Tháp; (iv) the 2025 lotus value-chain analysis report for An Giang, Đồng Tháp, and former Long An; and (v) documents on lotus silk development linked to the Mekong Delta flood-retention strategy by IUCN/Eco-Eco. To ensure spatial consistency, the article deliberately excludes studies from Central Vietnam that appeared in earlier drafts, because the ecological, hydrological, and institutional conditions there are not directly comparable to the research question for the upper Mekong Delta.

The selected cases are not intended to be statistically representative of the whole region. Rather, they are used to illuminate different layers of mechanism in the lotus model. Láng Sen is selected as a landscape-scale case in which lotus is embedded in the logic of flood retention, emissions reduction, sediment deposition, and biodiversity restoration. Trà Sư is a system- and household-scale case, where deeper data are available on inputs, profits, hydrological risk, and spillover effects to the subsequent rice crop. Đồng Tháp, through the work of Vo et al. (2021), serves as an explanatory case of the formation of lotus as an adaptive innovation under the lens of the social construction of technology. Finally, the three-province cluster of An Giang–Đồng Tháp–former

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Long An, together with the lotus silk case, is used to analyze the conditions for value-chain upgrading and scaling under NbS logic.

This design enables the article to connect two levels of analysis: from quantitative, empirical evidence at specific project sites to broader arguments about the sustainability conditions of the lotus as a flood-based livelihood system. It also helps avoid over-generalizing from a single pilot site to the entire upper Delta.

Table 1. Typical cases and their analytical significance

| **Case** | **Scale/space** | **Main evidence** | **Significance under the NbS framework** |
|---|---|---|---|
| Láng Sen (CRxN Mekong) | Wetland buffer zone, landscape scale | 40.6 ha; 8 households; water retention; emission reduction; sediment deposition; biodiversity | Clarifies the hydrological–ecological co-benefits of lotus within floodplain space |
| Trà Sư (Mekong NbS) | Melaleuca forest buffer zone, farming-system and household scale | Reduced inputs for the subsequent rice crop; differentiated profits; rapid flood-rise risk | Clarifies inter-season agronomic co-benefits and the conditional nature of NbS under hydrological thresholds |
| Đồng Tháp (Vo et al., 2021) | Plain of Reeds, innovation–institutional scale | Historical development of the model; actor interactions; multifunctionality | Explains lotus as an adaptive innovation co-constructed by society |
| An Giang–Đồng Tháp–former Long An and lotus silk | Commodity-chain/regional scale | 3,629 ha in 2024; value-chain bottlenecks; product, process, and institutional upgrading | Identifies market and organizational conditions for NbS to move beyond pilot demonstrations and scale up |

The article interprets these cases as typical analytical cases. Therefore, the findings are read in terms of conditions and mechanisms rather than as statistically representative results for the entire upper Delta.

## 3. Results

### *3.1. Flood-based lotus fits the NbS logic because it simultaneously generates livelihood,* hydrological, and ecological value

The combined evidence from project reports, peer-reviewed studies, and value-chain analyses suggests that lotus should not be viewed narrowly as a crop-substitution option. Rather, it is better understood as a multifunctional land–water use configuration in floodplain environments.

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The value of the lotus lies not merely in providing an additional income for farming households, but in the way it operates across multiple functional layers of the agro-ecological system.

At the production level, lotus has a notable advantage because almost the entire plant can be utilized for different purposes, from seeds, rhizomes, tubers, leaves, and flowers to stems, thereby expanding the product portfolio from fresh food, medicinal and cosmetic uses, and handicrafts to raw materials for deep processing and experiential tourism. This multi-output character gives Lotus the potential to generate higher value-added than single-product systems and opens opportunities to disperse market risk across households and value-chain actors.

At the hydrological level, lotus is especially important because it helps maintain and utilize flood-season water surfaces, rather than treating floods as something to be completely removed from agricultural land. This creates a fundamental contrast with intensive rice farming under high-dike systems, which depends on strict water control and increasingly separates production from the natural rhythm of flooding. Lotus, by contrast, allows agricultural space to remain connected to flood-season water regimes, thereby supporting water retention, sediment reception, and the ecological regulatory functions of the floodplain. In other words, lotus is not merely a production activity that occurs "during the flood season," but a form of livelihood organization based on floods.

At the ecological level, lotus creates more favorable conditions for natural processes that have been severely weakened in closed farming systems. Maintaining water surfaces and receiving floodwater enhance opportunities for sediment deposition, improve habitat for aquatic species, and provide a basis for integrated models such as lotus–fish, lotus–ecotourism, or lotus linked to wetland conservation. More importantly, in many cases, the lotus is associated with reduced reliance on high levels of chemical inputs, especially when embedded in rotation systems or "working with nature" models that incorporate sound water and seasonal management. Therefore, the value of lotus cannot be adequately assessed by looking only at direct revenue or profits from a single lotus season; it must also include the ecological and systemic co-benefits it generates for subsequent crops, household livelihoods, and the wider floodplain landscape.

This argument is consistent with Vo et al. (2021), who interpret lotus as a form of flood-based farming characterized by multifunctionality. In that perspective, lotus is not simply a crop adapted to inundated conditions, but a "livelihood technology" shaped by multiple actors and multiple objectives simultaneously: production, climate adaptation, water retention, supplementary livelihoods, service development, and the restructuring of relations between agriculture and floodplain ecology. Precisely because of this multifunctional character, lotus cannot be evaluated using the conventional criteria of intensive agriculture alone, such as biomass yield or net profit from a single season. Instead, lotus must be understood at the system level, where its effectiveness depends on interactions among hydrology, cultivation techniques, value-chain structure, product diversification, market linkages, and long-term ecological benefits. This is also why an NbS-oriented assessment of lotus requires moving from the

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question “How profitable is one hectare of lotus?” to the broader question: “How does lotus contribute to resilience, floodplain ecological functions, and the sustainability of the wider rural livelihood system?”

### *3.2. Typical case 1: Láng Sen shows that lotus can generate hydrological–ecological co-benefits at the landscape scale*

The Láng Sen case provides the strongest evidence that lotus can be interpreted as an NbS at the landscape scale. According to the CRxN Mekong project completion report, the flood-season lotus model was implemented on 40.6 ha with 8 participating households, supported by technical assistance, early-season input support, and research and workshop activities on the lotus value chain in the Mekong Delta. More importantly, the report records that the two-rice-one-lotus flood-season model reduced greenhouse gas emissions by 46.33%, equivalent to 18.51 tons CO2eq/ha/year compared with triple-rice cultivation; average water retention reached 4,905 $m^3$/ha/day in 2024 and a maximum of 19,917 $m^3$/ha/day in 2025; sediment deposition reached 17.2 tons/ha, equivalent to about 698 tons across the whole model area; and the system recorded 86 plant species, 73 waterbird species, and 51 fish species.

These figures support two conclusions. First, the lotus in Láng Sen does not merely produce an agricultural commodity; it also serves functions of water retention, sediment retention, and habitat maintenance. Second, the model's benefits emerge at a scale much larger than that of the individual plot. Therefore, an assessment of lotus based only on household profit would miss the most important part of its value.

From an NbS perspective, Láng Sen is a typical case because it demonstrates that lotus can simultaneously address three societal challenges: maintaining livelihoods during the flood season, supporting floodplain restoration strategies, and reducing the farming system's environmental footprint. This is precisely why Láng Sen should be read as a landscape case rather than simply a technical case of lotus cultivation.

### *3.3. Typical case 2: Trà Sư shows that the value of lotus lies in inter-season co-benefits, but NbS only works when hydrological thresholds are managed*

If Láng Sen demonstrates landscape-scale benefits, Trà Sư is a typical case at the farming-system scale. The Mekong NbS report records that after lotus, the following Winter–Spring rice crop reduced nitrogen by about 47%, phosphorus by 26%, and potassium by 27%; fertilizer costs fell by about 20%, from VND 8.63 million to VND 6.93 million per hectare; while rice yield increased from 8.269 to 8.698 tons/ha, equivalent to an increase of about 5%. This finding is particularly important because it shows that the lotus should not be assessed in isolation as a production season, but rather as part of a two-rice-plus-flood-season livelihood system that can generate inter-season co-benefits.

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Economically, Trà Sư shows that lotus cultivation can be profitable, but not linearly or stably. For the group of households with observed income data in 2024, the model reached a benefit–cost ratio of about 1.43 with an average profit of about VND 13.66 million/ha. By 2025, lotus stem production had fallen to a benefit–cost ratio of about 1.31 and a profit of about VND 3.13 million, while lotus seed-head production generated higher absolute profit, about VND 19.50 million, with a benefit–cost ratio of about 1.45 and an ROI of about 45.40%, but required greater investment and higher risk-management capacity. Thus, lotus can be profitable, but financial performance depends strongly on product structure, harvest windows, and the degree of alignment between the crop calendar and flood dynamics.

The most analytically valuable point in Trà Sư is the model's hydrological boundary. The report emphasizes that the greatest risk is concentrated in the period when floodwater rises rapidly after the sluice opening on 15 September. When water levels rise quickly, lotus cannot grow upward in time, while strong waves and currents break leaves, reduce photosynthesis, and lead to severe weakening or mass mortality. The project's technical guidance therefore recommends that lotus for stem harvesting be planted early, ideally before 10 July, to ensure sufficient harvest time before the strong flood rise begins.

From an NbS perspective, Trà Sư teaches a crucial lesson: lotus is not a model that tolerates inundation unconditionally. NbS does not mean "letting nature take care of everything." Rather, it requires an adaptive governance structure in which water-level monitoring, close tracking of sluice operations, and careful seasonal timing are conditions for ensuring that ecological benefits are not overwhelmed by hydrological shocks.

*3.4. Typical case 3: Đồng Tháp and the three-province cluster show that lotus can only move from adaptive innovation to a sustainable model when upgraded into a value ecosystem*

Vo et al. (2021) is especially valuable because it does not describe lotus as a finished technology, but rather as a technological artifact gradually shaped through social negotiation. Lotus initially emerged in response to natural conditions unfavorable to rice; it was then reinterpreted as a more attractive livelihood, and later it was continuously redefined by different actors—farmers, local authorities, scientists, and development organizations—according to their own interests and expectations. This reading is highly relevant to the NbS framework because it shows that the adaptive character of the lotus lies not only in the plant's biology but also in the social system's capacity to redesign the model in response to real-world conditions continuously.

However, this process of shaping can only become sustainable when Lotus is connected to a sufficiently deep value ecosystem. The 2025 Lotus Avalue-Chain analysis Report shows that the three provinces of former Long An, Đồng Tháp, and An Giang together had about 3,629 ha of lotus in 2024, of which seed-head lotus accounted for 63%, lotus stem 34%, and lotus tuber 3%. Despite this relatively large scale, the lotus value chain remains fragmented, small-scale, and weakly integrated between farmers, cooperatives, and processing enterprises. The report

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identifies three major pillars for upgrading: restructuring the production organization, modernizing harvesting–processing–storage technology, and developing market, branding, traceability, and product-standardization strategies.

The economic data in the value-chain report also reveals another aspect of sustainability conditions. At the farm level, estimated profit per hectare per season for lotus seed-head, stem, and tuber can all be attractive; however, harvesting costs account for a very high share of total cost, about 50% for seed-head lotus, 67% for lotus stem, and 45% for lotus tuber. This shows that the lotus can generate income for agricultural labor, especially female labor, but is simultaneously constrained by low mechanization, which makes cost reduction difficult without technological innovation.

The lotus silk case further clarifies this direction. Documents from IUCN and Eco-Eco show that lotus stems—normally little used in conventional lotus cultivation—have been experimentally processed into fibers and woven into lotus silk products in support of the Mekong Delta flood-retention strategy. The initiative aimed to develop a sustainable lotus silk value chain during 2021–2025, with around 1,000 direct and indirect beneficiaries. In this sense, lotus silk is not merely a high-value handicraft product; it illustrates the possibility of transforming a by-product of flood-based farming into a new value-adding segment.

Taken together, these pieces of evidence suggest that lotus only becomes a sustainable pathway when it passes beyond the threshold of being merely a “lotus cultivation model” and becomes a “lotus value ecosystem.” This is a process in which production, collection, processing, traceability, local branding, and benefit-sharing mechanisms must be reorganized together.

## 4. Discussion

The typical cases examined in this article allow the discussion to move away from the simplified question “Is lotus good or not?” toward a more analytical one: under what conditions does lotus actually function as a nature-based solution? This is an important methodological shift. If lotus is approached only as a crop-substitution option under a seasonal profitability logic, evaluation easily falls into two extremes: excessive optimism in years with favorable hydrological conditions, or excessive pessimism in years of abnormal floods, weak markets, or thin value-chain organization. By contrast, the NbS framework requires a broader and more rigorous evaluative standard: lotus only becomes genuinely adaptive when it simultaneously generates livelihood benefits for producers, maintains or restores at least part of the ecological functions of floodplain space, and is supported by institutional and market conditions capable of converting potential benefits into sustainable outcomes.

In this sense, Láng Sen is a case that shows that the lotus can be understood as a form of soft ecological infrastructure at the landscape scale. The value of the model lies not only in the products derived from the lotus plant but also in the lotus's role in mechanisms of water and sediment retention, in maintaining flood-season water surfaces, and in supporting wetland

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ecological functions. In other words, at Láng Sen, lotus is no longer a single crop but a component of the floodplain structure, where production, hydrology, and conservation are inseparable. This layer of evidence shows that lotus can contribute to climate adaptation not by resisting floods, but by reorganizing livelihoods to function with floods.

Trà Sư adds a different and more nuanced analytical dimension: the benefits of lotus do not appear only within the lotus season, but also at the inter-season and inter-system levels. When lotus improves the following rice crop through lower input use and better soil–water conditions, the model reveals a characteristic feature of NbS: value is not concentrated in a single immediate output but distributed across multiple ecological and production cycles. However, Trà Sư also clearly exposes the model's boundary when hydrological conditions exceed the lotus's tolerance threshold. At that point, a model previously considered adaptive can rapidly shift into a vulnerable state. This reminds us that lotus is not a default ecological solution, but a configuration highly dependent on alignment between crop timing, water operations, inundation depth, the rate of water-level rise, and the mechanical impacts of waves and currents. It is precisely here that Trà Sư enables the article to move beyond a one-dimensional success narrative and to pose a more important scientific question about the model's adaptive thresholds.
Meanwhile, Đồng Tháp and the three-province cluster of An Giang–Đồng Tháp–former Long An reveal a lesson for value chains and development institutions. Even if lotus is ecologically well adapted to inundated environments, the model can still stagnate, fragment, or become vulnerable in the absence of appropriate value-chain institutions. In other words, ecological adaptation does not automatically translate into economic sustainability. A lotus model may perform well at the field scale but still fail at the livelihood scale without standardized seed systems, organized raw-material zones, procurement linkages, processing capacity, branding, and market segmentation. Thus, the value-chain case adds an important conclusion to the hydrological–ecological cases: NbS is not only a matter of "the right crop in the right water," but also of "the right chain and the right institutions."

The combination of these three layers of cases supports a stronger central conclusion: the adaptive value of the lotus is real but conditional. The conditions are not merely natural but a combination of three groups: suitable floodplain space, hydrological Governance via thresholds, and institutional–market conditions that can absorb changes, risk, and upgrading value. When one of these three groups of conditions is absent, lotus may persist as a production model, but it is unlikely to reach the full meaning of an NbS. Conversely, when these three groups of conditions converge, lotus can become not just an adaptive crop but a means of restructuring the relationship among agriculture, water, and livelihoods in the upper Delta.

On that basis, the article proposes three important shifts in policy and project-development approaches. First, there is a need to move from the idea of a "lotus model" to the idea of "lotus space within the floodplain." This means the lotus should not be expanded through campaign-style replication or along simple administrative boundaries, but rather be planned in spaces capable of retaining floodwaters, receiving sediment, and controlling key hydrological risk

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thresholds. Second, there is a need to move from "encouraging planting" toward "governing hydrological thresholds." In this approach, crop calendars, sluice-operation information, flood forecasting, and measures to reduce local waves and currents are no longer external support factors, but integral parts of model design. Third, there is a need to move from a "fresh agricultural product" mindset toward "upgrading a value ecosystem." Lotus can only realize its multifunctional advantages when embedded in a broader value system that includes seed systems, raw-material zones, traceability, branding, deep processing, niche markets, and market segmentation.

At the scientific level, these analyses also point to a research direction different from more familiar approaches. The issue is no longer to keep proving, in general terms, that Lotus is "beneficial" or "profitable," but rather to more clearly quantify the thresholds that cause the model to shift from an adaptive state to a vulnerable one. This is a critical research gap if the NbS framework is to move from a conceptual description to an actual decision-making tool. These thresholds include the daily rate of water-level rise, inundation depth across different growth stages, the degree of damage caused by waves and currents, recovery capacity after hydrological shocks, and the minimum level of market linkage required to absorb risks associated with output and price fluctuations. Only when these thresholds are clearly identified can lotus be planned, supported, and scaled as an NbS on a scientific basis, rather than merely as a promising model in discourse.

## 5. Conclusion

This article contends that flood-based lotus farming can be recognized as a nature-based solution for climate-adaptive agriculture in the upper Vietnamese Mekong Delta. However, this benefit is not inherent to the lotus plant alone. The NbS advantages of lotus emerge only when the model concurrently provides livelihoods and hydrological–ecological benefits, supported by suitable governance and market structures.

The typical cases clearly reveal these three layers of conditions. Láng Sen shows that lotus can contribute to water retention, sediment deposition, emission reduction, and habitat maintenance. Trà Sư shows that lotus can reduce inputs for the subsequent rice crop and generate profit, but is also extremely sensitive to hydrological thresholds and crop timing. Đồng Tháp, together with the three-province cluster, shows that lotus can only become a sustainable transition pathway when organized as a value ecosystem rather than merely as a standalone cropping model.

Accordingly, the sustainable future of lotus does not lie in mechanically expanding the planted area, but in connecting three pillars: floodplain spatial planning, adaptive hydrological governance, and value-chain upgrading grounded in NbS logic. In this sense, lotus is not the sole answer for the upper Delta, but it is one of the most feasible foundations for shifting from "flood-control agriculture" to "flood-based agriculture" under climate change.

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