Floods and Livelihoods: A Multi-dimensional Comparative Study of Territorial Space Planning Policies for Flood Detention Areas in China

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Abstract
Spatial planning integrates policies to enhance people's well-being globally, yet its effectiveness is constrained in China's flood detention areas (FDAs) balancing flood control and development. Vertically, policy priorities, synergies, and coherence deviate across planning levels. Horizontally, jurisdictional overlaps exist with other management systems. This study employs a comparative approach in China's Huaihe River Basin, analyzing territorial spatial plans across provincial, municipal, and county levels covering nine key FDAs, alongside multi-tiered construction management policies. In-depth fieldwork including resident interviews was conducted in one area. We scrutinize interactions between flood management and spatial planning systems, revealing policy framework characteristics and goal orientation similarities/differences. The research provides insights for optimizing spatial planning and improving well-being in these critical zones.

Keywords: Flood detention areas; Territorial spatial planning; Policy comparison; livelihood

1 Background

1.1 Flood detention areas in China

China's Flood Detention Areas (FDAs) are specialized low-lying zones within river basins designed to mitigate flood losses and redistribute floodwater temporospatial patterns (Yu et al., 2022). They serve dual roles in flood storage and residential livelihood. China's seven major river basins host 98 FDAs (National Revised Directory, 2010). Pre-2000, FDA management was fragmented, with inadequate flood-control infrastructure, emergency response, and post-disaster compensation. Since 2000, integrated policies on flood engineering, population control, and economic compensation have been implemented.

Nevertheless, FDA development faces persistent challenges, notably in the **Huaihe River Basin**. Constrained by frequent flooding and environmental limits, it is a "double-depression" in geographic and socioeconomic terms (Wang, 2018), exhibiting the highest economic/population density yet the lowest urbanization level among China's major basins (Song, 2023). Human-flood land competition is acute. Rural hollowing intensifies yearly, exacerbated by weak transport, substandard infrastructure, and low resource efficiency. These issues accelerate village hollowing, degrade public space resilience, and amplify social vulnerability through population loss. Targeted research and interventions for livelihood security in Huaihe's FDAs are urgently needed.

Spatial planning is a technical and policy instrument for coordinating spatial development and integrating objectives (Xu et al., 2017), functioning as a political governance process (Qian & Luo, 2011) and a mediator of human-environment relations (Zhao et al., 2024). China's spatial planning system, reformed through integrating multiple plans (e.g., land use, urban-rural), now adopts a "five-tier vertical structure (national to township) and three-category horizontal framework (master/specialized/detailed plans)" for territorial spatial planning (Li et al., 2025). This system coordinates socio-economic activities, ecological supervision, and cross-regional infrastructure.

Nevertheless, implementation challenges persist in vertical policy transmission and horizontal coordination, including fragmented departmental oversight, disconnected regulatory tools, and unaligned land-use control procedures (Li et al., 2025). FDAs in the Huaihe River Basin epitomize these issues. As critical flood regulation zones subject to dual planning systems (flood control and spatial planning) (Dong et al., 2016), FDAs bear dual mandates of disaster prevention and regional development, necessitating focused assessment of their planning objectives and outcomes.

1.3 Research focus

Existing studies on China's FDAs predominantly adopt engineering perspectives—covering hydraulic infrastructure, disaster compensation, resident relocation (Bi & Pan, 2024; Wang et al., 2020), land use patterns, social networks, and resilience assessments (Zhang, 2021; Du, 2023)—yet lack systematic analysis of territorial spatial planning. This study fills this gap through a comparative approach: vertically examining FDA management systems, and horizontally comparing multi-level spatial plans across 9 key FDAs in the Huaihe River Basin. The research analyzes similarities and differences in planning priorities, spatial structures, and policy instruments, integrating qualitative policy assessment with quantitative metrics. An in-depth case study of Mengwa FDA—the basin's primary flood buffer—evaluates policy implementation outcomes and resident interactions. Findings inform spatial planning optimizations for people's well-being in FDAs.

The study comprises four sections:

1) Vertical Analysis of the FDAs management system;
2) Horizontal Comparative Analysis of provincial, municipal, and county-level spatial plans for key FDAs;
3) In-depth Case Study of the Mengwa FDA integrating fieldwork findings;
4) Synthesis of Challenges in current management frameworks and proposed optimization strategies.

2.Research Methods

Data were sourced from official portals at multiple governmental levels, including policy documents, technical standards, spatial planning reports, and implementation records. Supplementary data came from interviews with water-resource officials and FDAs residents, focusing on policy implementation dynamics.

The policy analysis employed a comparative framework:

1)Vertically: Examining policy transmission characteristics across administrative tiers;
2)Horizontally: Contrasting goal alignment, priority focus, and content coherence among peer-level policies.

A two-day field campaign in the Mengwa FDA involved structured workshops and semi-structured interviews with local officials and 30 residents. Interview protocols and questionnaires were designed a priori, with follow-up interviews conducted for data triangulation and depth validation.

3. Institutional Framework for FDAs in China

China's FDAs cluster in low-lying plains of seven major river basins. Their management follows a three-tier vertical hierarchy: national - basin/provincial - municipal/county levels, operating through government-led, ministry-coordinated, multi-agency collaboration. Flood control infrastructure is planned, constructed, and managed via categorized, zoned, and tiered approaches under legal statutes and specialized planning instruments (Figure 1).

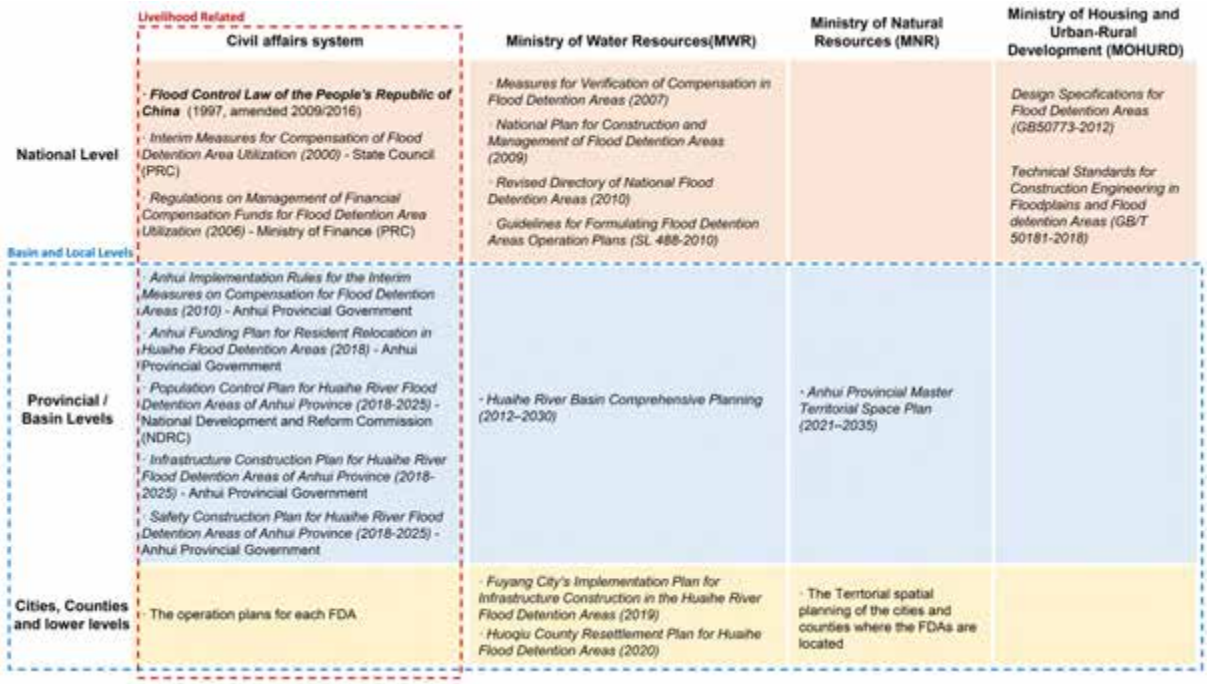

Fig.1 Institutional framework for FDAs in China (Anhui section of the Huaihe River Basin)

3.1 National Policy Framework by Agencies

3.1.1 Supreme Legislation

The Flood Control Law of the People's Republic of China (1997, amended 2009/2016) establishes a three-tier flood planning system (major river basins/other basins or regions/urban flood control), mandating safety infrastructure planning, population growth control, and organized resettlement in FDAs.

3.1.2 Ministry of Water Resources (MWR)

1) National Plan for Construction and Management of Flood Detention Areas (2009): Synthesizes basin-level and provincial plans, with thematic studies on safety construction models, economic development frameworks, and management systems; systematically evaluates flood risk objectives.
2) Guidelines for Formulating Flood Detention Area Operation Plans (SL 488-2010): Specifies requirements for organizational safeguards, early-warning systems, evacuation protocols, and engineering operations.
3) Measures for Verification of Compensation in Flood Detention Areas (2007): Audits compensation procedure compliance, loss data authenticity, and compensation standard rationality.
4) Revised Directory of National Flood Detention Areas (2010): Designates 98 FDAs based on flood risk assessment.

3.1.3 State Council & Ministry of Finance (MOF)

1) State Council: Interim Measures for Compensation of Flood Detention Area Utilization (2000): Defines compensation recipients, scope, and criteria; announces first 97 national Flood Detention Areas.
2) MOF: Regulations on Management of Financial Compensation Funds for Flood Detention Area Utilization (2006): Standardizes fund usage targets, coverage, criteria, and application/approval procedures.

3.1.4 Ministry of Housing and Urban-Rural Development (MOHURD)

1) Design Code for Flood Detention Areas (GB 50773-2012): Requires flood-control works to comply with integrated basin planning and flood control plans, with designs categorized by FDA types and risk levels.

2) Technical Standard for Buildings in Floodplains and Flood Detention Areas (GB/T 50181-2018): Regulates technical requirements for foundations, masonry structures, and reinforced concrete frame buildings.

3.2 Provincial Policy Framework (Anhui Section of the Huaihe River Basin)

3.2.1 Ministry of Water Resources

Huaihe River Basin Comprehensive Planning (2012–2030): Coordinates flood regulation, development governance, and environmental protection to guide construction and management of basin-scale flood control projects.

3.2.2 Civil affairs system

1) Anhui Implementation Rules for the Interim Measures on Compensation for Flood Detention Areas (2010): Issued by Anhui Provincial Government, refines compliance audits, loss verification, and fund supervision procedures for compensation disbursement.
2) Anhui Funding Plan for Resident Relocation in Huaihe Flood Detention Areas (2018): Issued by Anhui Provincial Government, establishes diversified funding mechanisms and implementation pathways for resettlement initiatives.
3) Population Control Plan for Huaihe River Flood Detention Areas of Anhui Province (2018-2025): Issued by National Development and Reform Commission (NDRC), implements population management, resettlement programs, diversified relocation, and supporting infrastructure in 16 designated FDAs along the Huaihe River.
4) Infrastructure Construction Plan for Huaihe River Flood Detention Areas of Anhui Province (2018-2025): Issued by Anhui Provincial Government, standardizes construction tasks, technical criteria, funding allocation, and implementation responsibilities for transportation, power grids, potable water, and telecommunications systems.
5) Safety Construction Plan for Huaihe River Flood Detention Areas of Anhui Province (2018-2025): Issued by Anhui Provincial Government, specifies technical requirements for resident relocation, flood-resistant shelter construction, relocation subsidies, and operational modifications of detention basins.

3.2.3 Provincial Department of Natural Resources

Anhui Provincial Territorial Space Master Plan (2021–2035): Mandates spatial control measures for FDAs within urban-rural coordination frameworks, emphasizing disaster resilience and ecological conservation.

3.3 Local Implementation

Operational plans for FDAs are developed by city/county water resources departments with multi-level government input. Natural resources bureaus formulate territorial spatial plans for localized land-use control. Selected governments enact resettlement plans, e.g.: Fuyang City's Implementation Plan for Infrastructure Construction in the Huaihe River Flood Detention Areas (2019), Huoqiu County Resettlement Plan for Huaihe FDAs (2020), specifying relocation principles, scope, and compensation.

3.4 Systemic Challenges in Flood Detention Governance

China's flood management centers on the Flood Control Law of the People's Republic of China, with national policies coordinating standards and compensation. Local implementations exhibit critical gaps:

1) Regulatory Hierarchy Deficits
The Flood Control Law establishes statutory principles for area operation and safety.
Supplementary regulations (e.g., Interim Measures) lack binding force (Wang et al., 2022).
Poor articulation between basin and spatial plans persists.
2) Fragmented Management Conflicts
Divergent departmental objectives lead to Interest conflicts; Cross-sectoral/regional complexities lead to Coordination failures; Disparate low relocation standards across basins (Table 1).

Table 1 Management Responsibilities and Departments

Management Responsibility	Responsible Authority
Engineering Planning	Basin Agencies + Water Administrators
Flood Operation & Safety Plans	Flood Control Headquarters + Governments
Socioeconomic Management	Local Governments
Spatial Planning	Natural Resources Bureaus + Local Governments

4. Comparative Study of Territorial Spatial Planning

The Huaihe River Basin's 9 critical FDAs are all located in Anhui Province (selected from its 16 total basins), spanning 5 cities and 9 counties (Figure 2 and Figure 3). Divergent planning objectives and priorities emerge from geographical, resource, and disaster exposure variations. This study conducts a comparative analysis of municipal/county plans (Table 2), examining key aspects including livelihood security, disaster resilience, "Three Zones and Three Lines," and agricultural/ecological layouts to identify systemic challenges in spatial planning frameworks and propose targeted optimization strategies.

Fig.2 The 9 key FDAs in the Huaihe River Basin within Anhui Province

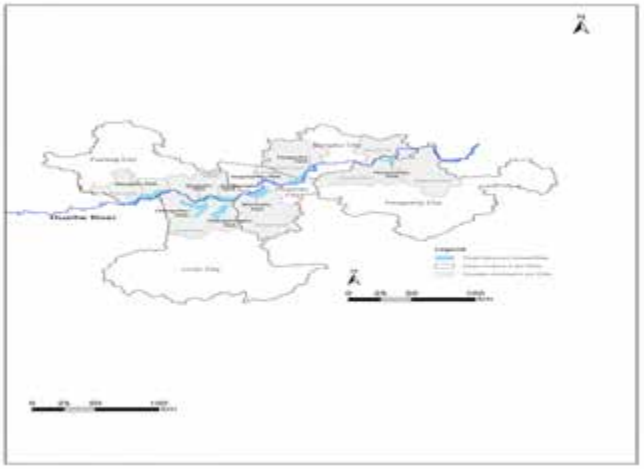

Fig.3 The 5 cities and 9 counties covered by 9 key FDAs

Table 2 Cities and Counties with FDAs and Their Spatial Planning

Crucial Flood Detention Areas	Related City-County	Municipal Spatial Planning	County-level Spatial Planning
Mengwa FDA	Fuyang-Funan	Fuyang Master Territorial Space Plan (2021-2035)	Funan Master Territorial Space Plan (2021-2035)
Qiujiahu FDA & Jiangtanghu FDA	Fuyang-Yingshang		Yingshang Master Territorial Space Plan (2021-2035)
Lu'an-Huoqiu	Lu'an Master Territorial Space Plan (2021-2035)	Huoqiu Master Territorial Space Plan (2021-2035)	
Chengxihu FDA	Lu'an-Huoqiu		
Chengdonghu FDA			
Shouxiihu FDA	Huainan-Shouxian	Huainan Master Territorial Space Plan (2021-2035)	Huaiyuan Master Territorial Space Plan (2021-2035)
Tangyuhu FDA	Huainan-Panji		Panji Master Territorial Space Plan (2021-2035)
Bengbu-Huaiyuan	Bengbu Master Territorial Space Plan (2021-2035)	Huaiyuan Master Territorial Space Plan (2021-2035)	
Jingshanhu FDA	Bengbu-Huaiyuan		
Huayuanhu FDA	Bengbu-Wuhe		Wuhe Master Territorial Space Plan (2021-2035)
Chuzhou-Fengyang	Chuzhou Master Territorial Space Plan (2021-2035)	Fengyang Master Territorial Space Plan (2021-2035)	
Chuzhou-Mingguang		Mingguang Master Territorial Space Plan (2021-2035)	

4.1 Provincial Spatial Planning

1) Three Zones and Three Lines: "Three Zones" refer to Agricultural Space, Ecological Space and Urban Space; "Three Lines" refer to Permanent Basic Farmland Protection Line, Ecological Conservation Red Lines and Urban Development Boundaries. Delineate flood risk control zones incorporating FDAs and riparian lands;

2) Ecological Restoration: Designate Huaihe River ecological recovery zones (Fuyang, Huainan, Bengbu, Chuzhou, Lu'an), enforce riparian flood-control standards, phase out development threatening flood safety, and enhance flood regulation;
3) Settlement Relocation: Relocate high-risk villages;
4) Infrastructure: Expand water storage capacity through basin adjustments, resident relocation, and channel dredging;
5) Regional Coordination: Implement integrated governance aligned with rural revitalization;
6) Heritage Conservation: Strictly protect hydraulic engineering heritage sites.

4.2 Comparative Analysis of Municipal Planning

Municipal planning, as the operational implementation of provincial-level strategies, serves as the foundational basis for county and township-level spatial planning and development activities. The comparative analysis reveals systematic deployment across five dimensions: "Three Zones and Three Lines" spatial patterns, ecological function optimization, agricultural development, infrastructure improvement, and regional coordination.

4.2.1 Three Zones and Three Lines Spatial Layout

Uniform designation of flood risk control lines with strict restrictions on non-flood control construction. Fuyang

and Chuzhou adopt zonal control mechanisms to prohibit irrelevant development, implementing a dual-track approach (dike reinforcement + wetland restoration).

Fuyang and Lu'an emphasize integrated population resettlement and spatial layout optimization, while Huainan innovatively proposes proactive avoidance of high-risk zones in urban development boundaries, reflecting resilience-oriented spatial governance.

4.2.2 Ecological Restoration and Governance
Watershed-based ecological restoration focuses on rehabilitating Huai River wetland systems. Bengbu establishes an "Ecological and Healthy Water Network System," enabling integrated governance of flood storage areas with river-lake-wetland complexes.

Huainan innovates by converting coal mining subsidence areas into flood regulation reservoirs, creating a "subsidence remediation-space expansion" composite model; Fuyang develops watershed-partitioned restoration units to refine systematic governance frameworks.

4.2.3 Disaster Prevention and Infrastructure Support
Standardized flood control and drainage systems are implemented, with Fuyang and Lu'an prioritizing urban-rural resilience through Baizhuangwei construction. Huainan explores integration of mining subsidence remediation with disaster prevention systems.

Bengbu establishes specialized heritage site protection mechanisms, balancing cultural conservation with flood control demands.

4.2.4 Regional Coordination
Optimization of upstream-downstream flood control systems in the Huai River Basin is universally adopted. Fuyang and Huainan construct cross-regional disaster prevention networks to enhance emergency response capabilities; Bengbu and Chuzhou integrate with the Yangtze River Delta urban agglomeration, advancing transportation and economic synergy.

Lu'an innovates inter-regional population resettlement and ecological land ratio optimization mechanisms, offering institutional innovation for regional coordinated development.

4.2.5 Short Summary of Municipal Planning
Municipalities align on flood risk management and ecological restoration objectives, adopting a watershed-based governance framework with rigorous risk zoning to reinforce dual "flood regulation + ecology" functions and promote regional coordination. However, divergent resource endowments and spatial strategies lead to differentiated approaches:

1) Functional Orientation:
Fuyang: Prioritizes flood storage integrity and emergency coordination.
Huainan/Lu'an: Integrates mining remediation with basin-scale ecological coordination.
Bengbu: Balances flood protection with heritage conservation.
Chuzhou: Aligns with Yangtze River Delta eco-economic integration.
2) Utilization Models:
Bengbu/Chuzhou: Focus on wetland restoration and biodiversity enhancement.
Fuyang/Huainan: Expand depression management and multifunctional flood regulation space.
Lu'an: Optimize population resettlement through territorial spatial planning.
3) Regional Coordination:
High-risk dense areas (Fuyang/Lu'an/Huainan): Establish cross-regional flood control networks.

Yangtze River Delta-linked areas (Bengbu/Chuzhou): Promote Huaihe River ecological corridor integration with regional development.

4.3 County-level Spatial Planning

County-level planning refines provincial/municipal territorial spatial strategies, focusing on "Three Zones and Three Lines" patterns, ecological protection, agriculture, infrastructure, and regional coordination in flood storage zones, with most plans emphasizing safety resilience. Panji District, integrated into Huainan City after administrative reorganization, follows municipal planning; Fengyang and Mingguang jointly cover the Huayuanhu FDA, where draft plans remain incomplete and strategies are consolidated at the municipal level.

4.3.1 Three Zones and Three Lines Spatial Layout

Counties integrate along-Huaihe FDAs, rivers, and lowlands into flood control lines under the "Three Zones and Three Lines" framework, enforcing strict regulations and optimizing flood prevention. Upper-middle reaches (Funan, Yingshang, Huoqiu) apply rigid constraints due to high pressure; middle-lower reaches (Shouxian County, Huaiyuan, Wuhu) prioritize ecological restoration with flood engineering.

4.3.2 Ecological Restoration and Governance

Ecological restoration focuses on key areas: Funan's Wangjiaba Wetland, Huoqiu's Chengdonghu / Chengxihu, and Wuhu's Huayuan Lake. Yingshang targets dynamic water balance ("inflow, flow, outflow"); Shou County divides ecosystems into "flood regulation and biodiversity zones"; Huoqiu balances ecology with tourism.

4.3.3 Agriculture Development

Agriculture emphasizes farmland protection: Funan values ecological functions, Huoqiu (grain base) addresses disaster risks, and Wuhu consolidates rural settlements for urban resource concentration.

4.3.4 Disaster Prevention and Infrastructure Support

Disaster resilience includes Funan's Mengwa drainage and irrigation, Yingshang's emergency command centers, Shou County's "sponge city," and Wuhu's integrated water transport-flood engineering.

4.3.5 Regional Coordination

Regional coordination involves Funan/Yingshang in spatial collaboration and Wuhu in Huaihe River eco-economic integration and rural revitalization.

4.3.6 Short Summary of County-level Planning

Counties adopt watershed-based flood-ecology integration, delineate flood risk control lines, and emphasize synergy between flood regulation and ecological restoration. Divergences arise from geographical positions and resource endowments:

1) Functional Priorities:
High-pressure areas (Funan, Yingshang, Huoqiu) focus on infrastructure and disaster resilience, supporting flood storage zone restoration and regional coordination; low-risk areas (Shou County, Huaiyuan, Wuhu) leverage resources for development.
Specific strategies: Funan enhances safety resilience, Huoqiu balances flood control and grain security, Shou County integrates flood prevention with tourism, Wuhu adjusts population/resource layouts.
2) Utilization Models:
Ecology-led (Yingshang, Shou County, Wuhu): Link FDAs with ecological functions via natural/historical resources;
Agriculture-composite (Funan, Huoqiu, Huaiyuan): Balance farmland protection with agricultural expansion.
3) Industrial Integration:
Huoqiu and Yingshang propose "mine remediation + flood regulation + ecological restoration" synergies.

4) Driving Factors:
Topography, resources, and spatial contexts shape strategies, reflecting "pressure-driven" and "resource-oriented" dual logics.

5. Critical Issues in Spatial Planning Systems

5.1 Deficiencies in Vertical Coordination

Provincial plans macroscopically coordinate regional positioning, standards, and resource allocation; municipal plans mesoscopically decompose watershed and FDA functions; county plans microscopically implement engineering solutions. However, three-tier planning faces coordination failures:

1) Insufficient vertical linkage: Cross-regional FDAs lack management division/compensation mechanisms with unstandardized emergency support;
2) Weak horizontal synergy: Provincial ecological restoration zones misalign with local endowments (e.g., no specialized plans for coal mining area restoration in Huainan City and Lu'an City);
3) Functional conflicts: Mengwa FDA simultaneously pursues flood storage and agricultural expansion, while Huoqiu County's grain production base contradicts flood control functions;
4) Priority ambiguity: Unclear hierarchy among ecological restoration, cultural preservation, and flood control.

5.2 Failure of Horizontal Coordination

1) Jurisdictional overlaps: Water authorities lead personnel transfers, but multi-agency responsibility boundaries remain blurred;
2) Data standard conflicts: Temporal gaps between spatial planning (2021–2035) and watershed plans (2018–2025) cause classification inconsistencies;
3) Implementation deviations: Potential policy conflicts during overlapping plan periods (2021–2025).

5.3 Conflicts in Development Goals and Functional Positioning

1) Goal-Implementation Gap:
While current municipal/county plans promote watershed eco-economic integration and safety resilience (e.g., coordinating Huaihe Ecological Economic Belt development, cross-basin water quality protection), critical deviations exist:
FDAs are still treated as monolithic risk sources (e.g., strict construction restrictions within "Three Zones and Three Lines"); Absence of livelihood-oriented policies for public service facilities and agricultural development;Inadequate support mechanisms for underdeveloped areas (e.g., homogenized facility standards in FDAs).
2) Hierarchical Misalignment:
Identical requirements are categorized differently across plans:
Fuyang City, Funan County, Yingshang County, Wuhe County classify flood risk control lines under "Three Zones and Three Lines"; Lu'an City, Huainan City, Huoqiu County, Shou County, Huaiyuan County categorize them as "basic support systems"; Wuhe County integrates rural settlement consolidation into agricultural planning.
3) Divergent Regional Coordination Priorities:
High-disaster areas (e.g., Funan County) emphasize inter-city disaster emergency coordination; Ecologically sensitive zones (e.g., Shou County, Yingshang County) prioritize ecological governance and flood regulation along the Huaihe, reflecting diverse governance needs.

6. Empirical Study of Mengwa FDAs, Huaihe River Basin

As the primary FDAs in the Huaihe Basin (180.4 km²), Mengwa exhibits chronic flood exposure due to topographical depression and high population density. Its operational protocol consists of three phases: 1) Gate opening for flood storage, 2) Months-long water retention, 3) Controlled discharge upon downstream water level reces-

sion. The registered population (2022: 184,900) is concentrated within 131 Zhuangtai (earthen platforms) and 6 Baozhuangwei (embanked settlements), with agricultural predominance. There 2 key questions:

1) Flood impacts: Complete inundation of low-lying farmlands/roads restricts transportation to dam-bridge networks.
2) Livelihood challenges: Structured interviews with 30 residents and governmental stakeholders identified critical gaps in resettlement compensation, employment, and public service delivery.

6.1 Demographic Structural Imbalance

Stringent migration policies promote out-migration while restricting return, with compensation via land exchange and housing support. Spatial planning data reveal:
1) Resident-to-registered population ratio <70% in Funan County (2020),
2) 12 townships exhibiting >40% hollowing rate,
3) 47% of surveyed residents aged ≥60 years, indicating accelerated aging.

6.2 Compensation Mechanism Failure

1) Housing disparity persists:
1960s/1980s resettlement housing remains overcrowded and structurally deficient. New housing projects, co-funded by residents and government based on registered/resident population quotas, achieve merely 28% occupancy (<30% adoption rate despite 62.3% relocation intent). And compensation standards fall significantly below Yellow River floodplain benchmarks.
2) Post-flood recovery deficit:
34.5% of households require structural reinforcement and 27.6% need interior rehabilitation, yet compensation prioritizes agricultural losses.

6.3 Employment-Agriculture Dilemma

1) Limited industrial absorption:
Labor-intensive factories (e.g., Hongliang Bag Factory in Wangjiaba Township: 160 jobs) provide marginal employment.
As for agricultural suppression, prohibition of large machinery (planters/harvesters) to prevent flood damage necessitates manual farming, reducing productivity by 35–40% (estimated).
2) Migration paradox:
While 80% of working-age youth engage in temporary migration, permanent relocation rates remain below 50% due to compensation insufficient to cover actual resettlement costs, and disincentives from forfeiting land revenue streams.

6.3 Public Service Delivery Gaps

1) Allocation inefficiency:
All townships in floodwater detention zones have established health facilities, elderly care centers, and schools per Territorial Space Planning mandates (allocated by administrative divisions or population proportion). However, Funan County's status as Fuyang's lowest public-budget jurisdiction results in: accessibility barriers, quantity-over-quality service provision, and significant service discontinuity between normal and flood periods (Table 2).

Table 3 Flood-Nonflood Service Disparity

Period	Education Access	15-min Medical Coverage
Non-flood	Off-village access required for 55%	56.2%
Flood	Partial school closures	49.2% (Δ=-7.0%)

2) Service accessibility degradation:
Infrastructure underutilization: 50% of nursing homes (3/6) operate on state subsidies. "Three Connections and One Leveling" infrastructure (sanitation/waste/water systems) experiences <40% utilization amid persistent depopulation.

7. Discussion

This study reveals that while China's spatial planning in Huaihe River Basin FDAs exhibits institutional resilience, its effectiveness is constrained by fragmented cross-level coordination, policy fragmentation, and disconnection from livelihood needs.

7.1 Planning Resilience Deficits

1) Vertical implementation gaps: Provincial macro-goals disconnect from municipal/county implementation. For instance, integrated flood regulation-coal mining subsidence restoration-water heritage conservation initiatives lack specialized planning, causing uneven resilience resource allocation.
2) Horizontal coordination failures: Overlapping responsibilities among water resources, planning, and civil affairs agencies reduce efficiency. Absence of standardized cross-city emergency mechanisms undermines disaster response resilience.

7.2 Multidimensional Livelihood Resilience Imbalance

1) Spatial-social resilience disjunction: Overreliance on rigid flood risk control lines neglects dynamic adaptation of public services to population outflow. As Mengwa demonstrates, high housing vacancy and degraded medical/educational services exacerbate social vulnerability.
2) Economic resilience deficiency: Ambiguous industrial positioning and uncoordinated agricultural-ecological functions (e.g., harvesters ban) suppress income growth.

7.3 Pathways for Planning Optimization

1) Strategic innovations:
Multi-scale resilience synergy: Establish a "watershed-administrative region" dual framework to integrate flood control, ecological, and industrial planning, ensuring vertical coherence and horizontal accountability (e.g., aligning spatial and population control planning timeframes).
Dynamic adaptation: Adopt resilience stress-testing tools for iterative planning evaluation.
Livelihood-oriented transition: Embed public service quality (e.g., 15-min medical coverage) and resettlement compensation equity into core assessment metrics.
2) Methodological advancements:
Integrated planning governance: Emulate the Dutch water resilience model (Lu et al., 2020) by coupling water management with spatial planning through multi-stakeholder collaboration.
Specialized livelihood planning: Develop zone-specific strategies for agricultural modernization and emerging industries.

8. Conclusions

Addressing the paucity of systematic research on spatial planning policies for FDAs, this study employed a comparative approach within the Huaihe River Basin. It systematically identified key characteristics and challenges

pertaining to vertical policy transmission and horizontal coordination across provincial, municipal, and county-level territorial spatial plans, contrasting these with the FDA construction and management system. Key findings indicate:

1) Institutional fragmentation, manifesting as vertical transmission gaps and weak horizontal coordination, characterizes China's spatial planning system for FDAs;
2) A predominant focus on disaster risk reduction within both frameworks contributes to multidimensional livelihood resilience deficits;
3) Inadequate integration between spatial planning and construction management systems constrains effective governance, necessitating enhanced institutional coordination with water resources management and flood risk management to advance multi-plan synergy.
From a resilience perspective, future territorial spatial planning must prioritize systematicity, dynamism, and equity. Integrated institutional reforms and technological innovation are essential to catalyze a paradigm shift from «passive flood control» to «proactive adaptation,» strengthening cross-system collaborative governance to achieve the tripartite resilience imperatives of flood safety, ecological restoration, and sustainable livelihoods.

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