水适应性景观认知与研究框架解析
——以北京市门头沟地区为例

COGNITION AND RESEARCH FRAMEWORK OF WATER ADAPTIVE LANDSCAPES WITH THE CASE STUDY ON MENTOUGOU DISTRICT, BEIJING

1 前言

“水适应性景观”（water adaptive landscape）从适应性概念发展而来。自2001年开始，联合国政府间气候变化专门委员会先后6次发表评估报告，将“适应性”定义为“对实际或预期的气候及其影响进行调整的过程”以及“在人类系统中，‘适应’旨在通过行动减轻或避免有害的影响或利用有利的机会”[1]。借鉴这一概念，“水适应性”（water adaptation）可被简单归纳为水系统对实际或预期的气候及其影
1 Introduction

The term “water adaptive landscape” is derived from the concept of adaptation. Since 2001, the Intergovernmental Panel on Climate Change has published six assessment reports, which hold that adaptation is “the process of adjustment to actual or expected climate and its effects,” and “in human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities.” Based on such understanding, water adaptation can be briefly referred as the adjustment process of water system to actual or expected climate and its effects. It is also defined by Chinese scholars, from the perspective of human beings, as a systematic process of continuous learning and adjustment to environmental changes for the improvement of planning and management strategies of water resources. Different from research on water adaptation in the fields of Biology, Climate Science, Geography, Ecology, and Political Economics, research on water adaptation in Landscape Architecture that focuses on the regional territory where the process happens, the interaction pattern between people and water, and the form of landscape appearance represents a subfield of research on adaptation through studies of relevant elements.

2 The Definition and Research Scope of Water Adaptive Landscapes

The concept of adaptation, referring to the biochemical and behavior characteristics of individual living beings after a long-term evolution that supports species reproduction multiply in a certain environment, was first developed by biologists in research on biological phenotypes of organisms’ evolution.
and later widely applied in the fields of Sociology, Geosciences, (Landscape) Ecology, Climatology, etc. Sociologists hold that adaptation, under human selection and intervention, is the outcome of cultural practice in dynamics\(^5\); in Geography, theories of adaptation are developed to estimate the impact of global environmental changes on natural ecosystems and human societies, by assessing human measures for adaptation\(^6\); in (Landscape) Ecology, adaptation refers to changing characteristics of landscapes, as mosaics on land, in types, components, and hierarchies in different time / space dimensions at varied levels to maintain their major functions against the background of global changes\(^7\); adaptation in Climatology refers mainly to the response of natural or human systems to actual or expected climatic stimuli with positive or negative impacts\(^8\). In the sphere of Climatology, in 1999 Barry Smit first proposed a framework for systematically defining adaptation and the three major components\(^9\)^{10} (Fig. 1): 1) objects of adaptation, i.e., “adaptation to what,” can be climate-related stimuli or non-climate forces and conditions, the existing or possible responses to which can be both adverse and active;
括预测响应；2）适应主体，即“谁或什么来适应”，指自然生态系统和人类社会经济系统两大适应性主体，及其实践、过程与结构；3）适应过程，即“如何适应”，是指适应主体对客体进行适应的方式以及适应策略的选择，分为自发性适应和计划性适应两类[11]。

各相关学科对适应性的研究虽各有侧重，但研究视角与内容在以下几个方面体现出交叉性特征：

1）系统：研究均强调系统性调整，以减少系统的脆弱性，从而提升对环境和气候变化的适应能力；

2）过程：不论是生物体还是景观系统，与环境变化表现适合都是经过自然与人工长期适应的结果，是在动态适应过程中所表现出的阶段性特征，并被纳入到对于未来的调整管理之中——这一属性意味着适应性研究的重点在于调节的发展过程，而非控制结果；

3）空间：适应性的发生、评价及预测均涉及适应性主体所处的空间尺度与范围——从区域、地域到国土尺度；

4）行为：即适应的策略及方式。

上述适应性及水适应性研究视角可简要概括为：适应性研究是基于系统分析与调整的过程性研究，从空间或行为入手，主要包括适应客体、适应主体及适应过程三个方面；水适应性是适应性研究的专项内容，研究视角可概括为将水系统作为适应客体和适应主体两类。水适应性景观研究强调适应性研究与景观研究的结合，并在此基础上探讨如何适应的问题。因此，在总结水适应性景观概念之前，有必要对其中的“景观”一词的主要含义进行阐释。

对于“景观”一词含义的诠释已有较为全面的研究，此处只引用约翰·布林克霍夫·杰克逊在《发现乡土景观》一书中较为简明的定义：“景观是一个由人创造或改造的空间的综合体”[12]。这一定义将景观的基本范畴概括为空间要素及人类行为，作为一个在此处更偏向人文地理学认知的概念，其强调的是景观作为目之所及的存在性而非单纯美学性。因此，水适应性景观并非景观美学范畴中的水景营造，这一认知在此处尤为重要。基于这一概念认知便可对景观的特征进行拓展：景观是地理的、历史的、文化的、本土的、变化的、过程的、连续的、系统的……由此可见，景观的非美学属性与适应性的关联性更强。景观概念的加入应该更强调对于适应性空间形态及其发生演变
3 The Progress and Major Achievements of Research on Water Adaptive Landscapes

Existing studies on water adaptive landscapes in China and abroad can be summarized into empirical analysis of spatial patterns and construction of water adaptive landscapes, evaluation of water adaptive landscapes, and narrative analysis of water adaptive landscapes.

3.1 Empirical Analysis of Spatial Patterns and Construction of Water Adaptive Landscapes

Basically, such research applies the perspectives and methods of landscape spatial pattern studies into the exploration of evolving laws and mechanisms of water systems. It includes research on landscape patterns and their evolution at watershed scale and the one on spatial patterns of water systems at city scale, both of which emphasize the integration of all kinds of natural and cultural elements in the systems as a whole.

Studying and building ecologically sustainable landscape patterns of watersheds is one of the current and future research interests on watershed integrated management. Quantitative analyses of variation characteristics of landscape patterns are often used, based on watershed-scaled remote sensing images and landscape typological maps in different time periods, through calculation of landscape indexes and evaluation of ecosystem services. This helps further identify the correlations between variations in landscape patterns and impact factors such as runoff, economic values of watershed ecology, correlations between spatial distributions of fauna and flora habitats with hydrographic processes, watershed hydrographic circulation processes, etc.

Research on spatial patterns of water systems at city scale mainly focuses on specific water systems in urban / rural areas and usually adopts qualitative analyses on the characteristics of relations between water system patterns and urban / rural
3.2 Evaluation of Water Adaptive Landscapes

The evaluation and prediction of adaptive capacity and tendency of the whole systems and different sorts of components is one of the most important aspects in research on adaptation and water adaptation. There are two major models in application: context-driven and decision matrix.

The context-driven model is the mostly-applied method in research on adaptation, which follows a series of steps: 1) problems finding (identifying study area and contents, as well as relevant agencies); 2) selection of evaluation method suitable for most issues; 3) test method selection and sensitivity analysis; 4) selection and application of climate change scenarios; 5) evaluation of the impacts on organisms, natural ecosystems, and socio-economic systems; 6) evaluation on existing spontaneous adjustment measures; and 7) evaluation on adaptive strategies.

Decision matrix model often relies on the application of adaptation decision matrixes with Excel or Lotus to develop evaluation criteria according to the objects and goals, which are weighted based on researcher’s empirical knowledge in further analyses. For instance, targeting the semi-arid irrigation farming ecosystems in Kenya, Paul McCord et al. analyzed and worked out the factors to the regional irrigation systems that would impact the application of climate adaptive strategies, which were further assessed with a logistic regression model.

Through qualitative document analysis and with manual integrated scoring standards, Uche T. Okpara et al. analyzed the Lake Chad basin in Africa and reviewed relevant cross-boundary policies and intervention documents in order to map out governance methods that integrate goals in climate adaptation, water remediation, and conflict management.
developed by Global Water Partnership, is an integrated management system in urban water supply, rainwater and waste water treatment, and public health, so as to maximize the sustainability in economy, society, and environment.\(^{[27]}\) Scholars have applied it into water vulnerability analyses in land use changes, water quality and hydrology, rivers and floods, urban drainage systems, wetlands, ecosystems, social vulnerability, etc.\(^{[28]}\)

### 3.3 Narrative Analysis of Water Adaptive Landscapes

Narrative analysis of landscapes is a representative method in studies of adaptation in Anthropological Sociology.\(^{[29]}\) Landscape narrative, originated from the theoretical study and design practice of spatial narratives in the 1980s, considers movements of events a driving force of the generation and evolution of landscapes, where narrative is a basic method to gain experience and form understanding of landscapes.\(^{[29]}\) In relevant research on water adaptive landscapes, it has been mostly applied by combining literature review and interviews about regional knowledge and experience. For example, Vera Köpsel and Cormac Walsh analyzed how professionals from different fields and stakeholders perceive and understand the same coastal landscapes, based on theories on social constructivism landscapes and through in-depth qualitative landscape narratives and interviews about their perceptions,
市供水、雨水和废水处理、公共卫生的整体性管理来实现可持续的经济、社会和环境目标。相关学者将其应用于水脆弱性分析，包括土地使用变化、水质水文分析、河流洪水、城市排水、湿地、生态系统、社会脆弱性等方面。

3.3 水适应性景观叙事分析

景观叙事分析是人类社会学领域研究适应性的代表性方法之一。景观叙事源于20世纪80年代空间叙事的理论研究与设计实践，将事件的运动视为景观生成与演变的动力，并将叙事作为人们形成经验和理解景观的一种基本方法。应用于水适应性景观的相关研究多采用文献分析与访谈相结合的方式，针对地域认知及经验展开。例如，薇拉·科赛尔和科马克·沃尔什基于社会建构主义的景观理论及通过深入定性化的景观叙事及感知访谈，分析不同专业从业者和利益相关者对同一沿海景观的认知与理解，从而为气候适应性背景下的景观管理提供借鉴。

3.4 小结

1) 总体来看，当下以“水适应性景观”为主题的水相关研究较少，对适应性的概念、原有学科领域中的研究视角与方法、应用于景观学科体系下的研究范畴等基本议题缺乏系统性认知，尚不足以体现“水”“适应性”“景观”三者结合的叙事意义。

2) 从研究内容上来看，水适应性的研究视角与方法同适应性研究关联度较高，但目前仅在较大尺度上开展了特定案例研究。国内相关研究主要侧重于景观空间格局与要素分析以及经验总结；相较而言，国外研究侧重于将适应性研究方法应用于相关评估和预测分析。

3) 从研究方法上来看，适应性研究强调定量研究与定性研究相结合、数据分析与生态性思维相结合——这意味着相关研究的最终落脚点不是对研究对象得出静态的量化结果，而应关注研究对象功能正常与否，以及是否能向着持续、高效、稳定的方向发展。

4 水适应性景观的研究框架

基于上述分析，本文试图构建水适应性景观的研究框架（图2）：研究以北京市门头沟地区为对象，由水适应性景观数据库建立、适应性过程梳理、适应性能力评估三部分构成，具体包括水适应性景观分析要素提取与归类研究、水适应性形态与水适应性行为研究、水适应性趋势及限制因素研究，以及水适应性策略研究等内容。
4.1 水适应性景观数据库建立

水适应性景观数据库的建立主要通过对典型地域环境的适应性对象进行提取与分类（即确定“适应什么”），适应性对象总体上可分为气候因素和非气候因素两类。前者主要包括气候变化导致的洪涝、干旱、滑坡、泥石流等相关时空资料，后者主要包括人为条件影响下的水利灌溉、水体污染、水土流失、水权制度等相关时空资料。收集数据资料时应体现适应性的过程属性，除了极端条件变化情况，也应当包括非极端环境情况。资料的初步获取途径包括文献研究、田野调查及地形影像资料收集等，在此基础上进行数据标准化处理并按时空结构进行分类，以为后续适应性分析与应用提供基础。

4.2 适应性过程梳理

如前文所述，适应性表现是动态变化过程中的阶段性产物。基于这一认知，适应性过程的梳理强调的是包含历史与当下的整体性脉络研究（即“谁或什么来适应”）的问题，具体研究内容包括水适应性景观形态与水适应性景观行为两类。

4.2.1 水适应性景观形态

水适应性景观形态的研究包含系统维度和要素维度，前者的研究对象是总体系统及其各个分系统的形态布局，后者则对单一典型要素的形态结构进行研究。以北京市门头沟地区为例，在系统维度上，门头沟地区整体上属于典型的中国北方山地沟谷农业景观，其中包含河谷、滩地、盆地、农业灌渠系统、塘坝水库等水适应性景观子系统，各系统中的相关景观要素形成不同的网络化体系。研究重点应放在跨时间尺度的形态布局演变特征及规律。要素维度是对于系统中各典型构成要素——如自然河道和溪流、山体沟道、坑塘、村落、关城、农田、梯田、淤地、水渠、水库、水井等——的景观形态、类型划分、结构特征及演变等进行细分研究（表1，图3）。

4.1 Establishment of Database of Water Adaptive Landscapes

Basically, the building of a database of water adaptive landscapes is to extract and categorize adaptive objects within a typical regional environment (i.e., to determine “adaptation to what”). The objects can be categorized into climatic and non-climatic factors: the former includes time / space data of floods, droughts, landslides, and mudslides caused by climate changes and the effects, and the latter involves time / space data of irrigation, water pollution, water and soil loss, institutions of water right, etc. impacted by human activities. The process attribute of adaptation makes data collection cover both the changes in extreme and ordinary climate conditions. Preliminary data can be acquired through literature review, field study, and collection and analysis of topographic graphic data, which is then processed in accordance with specific scientific criteria and sorted out by time / space structure, to support subsequent analysis and application of adaptation.

4.2 Examination of Adaptive Processes

As mentioned above, the forms and actions of adaptation are results on a certain stage in a dynamic changing process. At this point, the analysis of adaptive processes should highlight holistic contextual research, both historical and present (i.e., to identify “who or what adapts”). This section examines the morphologies and behaviors of water adaptive landscapes.

4.2.1 Morphologies of Water Adaptive Landscapes

Morphologies of water adaptive landscapes can be studied by system and element, corresponding to the research on the morphological layout of the whole system and its subsystems, and research on the morphological structure of a single typical element. Overall, the study area sees a morphology of a mountainous valley agricultural landscape system that is commonly found in north China, and its subsystems of water adaptive landscapes range from valleys, floodplains, basins to farmland irrigation systems, ponds, dams, and reservoirs, each forming a network of its landscape elements. This research should focus on the evolutionary characteristics and patterns of the morphological layouts across time scales. At the same time, each typical component of the landscape systems — including natural rivers and streams, mountain ravines, ponds, villages, farmlands, terraced fields, soil land, ditches, reservoirs, and wells — can be studied by morphology, category, structural features, and evolution patterns (Table 1, Fig. 3).
### 表1：研究区域内典型水适应性景观系统要素类型

| 典型水系统类型 | 典型水系统要素 | 代表佳村落 | 典型现状 |
|----------------|----------------|------------|-----------|
| **典型水系统类型**
Typical categories of water systems | **典型水系统要素**
Typical elements of water systems | **代表佳村落**
Representative villages | **典型现状**
Typical appearances |
| 河道 | **典型水系统要素**
River | 东/西胡林村、付家台村、青白口村、丁家滩村、沿河城村
East-/West-Hulin Village, Fujiatai Village, Qingbaikou Village, Dingjiatan Village, and Yanhecheng Village | ![图片](image1.png) |
| 自然资源类 | **典型水系统要素**
Natural resource | **典型水系统要素**
Natural resource | ![图片](image2.png) |
| **典型水系统要素**
Natural resource | **典型水系统要素**
Natural resource | **典型水系统要素**
Natural resource | ![图片](image3.png) |
| **典型水系统要素**
Natural resource | **典型水系统要素**
Natural resource | **典型水系统要素**
Natural resource | ![图片](image4.png) |
| **典型水系统要素**
Natural resource | **典型水系统要素**
Natural resource | **典型水系统要素**
Natural resource | ![图片](image5.png) |
| **典型水系统要素**
Human living and production | **典型水系统要素**
Human living and production | **典型水系统要素**
Human living and production | ![图片](image6.png) |
| **典型水系统要素**
Human living and production | **典型水系统要素**
Human living and production | **典型水系统要素**
Human living and production | ![图片](image7.png) |
| **典型水系统要素**
Human living and production | **典型水系统要素**
Human living and production | **典型水系统要素**
Human living and production | ![图片](image8.png) |
| **典型水系统要素**
Human living and production | **典型水系统要素**
Human living and production | **典型水系统要素**
Human living and production | ![图片](image9.png) |
| **典型水系统要素**
Flood retention and disaster prevention | **典型水系统要素**
Flood retention and disaster prevention | **典型水系统要素**
Flood retention and disaster prevention | ![图片](image10.png) |
| **典型水系统要素**
Flood retention and disaster prevention | **典型水系统要素**
Flood retention and disaster prevention | **典型水系统要素**
Flood retention and disaster prevention | ![图片](image11.png) |
| **典型水系统要素**
Flood retention and disaster prevention | **典型水系统要素**
Flood retention and disaster prevention | **典型水系统要素**
Flood retention and disaster prevention | ![图片](image12.png) |
| **典型水系统要素**
Flood retention and disaster prevention | **典型水系统要素**
Flood retention and disaster prevention | **典型水系统要素**
Flood retention and disaster prevention | ![图片](image13.png) |
| **典型水系统要素**
Flood retention and disaster prevention | **典型水系统要素**
Flood retention and disaster prevention | **典型水系统要素**
Flood retention and disaster prevention | ![图片](image14.png) |
4.2.2 水适应性景观行为

水适应性景观行为是指人类对待水、利用水、管理水、治理水的行为模式，是适应性空间形态表现的内部驱动因素，同时也是水系统及水要素得以正常运转并发挥适应性能力的关键保障。水适应性景观行为包括价值认知、制度管理、工程技术、文化习俗4个层面。在价值认知层面的适应是指人们对于环境变化、已有水适应性行为及影响景观系统未来适应性发挥的行为的认识与理解；制度管理层面的适应是指通过经济和财政手段、立法和组织变革来提高用水效率的相关行为；工程技术层面的适应是指通过工程技术措施和流程保障水适应性景观要素正常运转的行为；文化习俗层面的适应是指通过文化实践增进人－水和谐共生的行为。水适应性景观行为的过程梳理应着重体现人类活动在各个层面和阶段对于景观表达及其适应性的作用与影响。

具体就本研究区域而言，首先，门头沟的聚落历史起源于约一万年前清水河谷的东胡林人聚落，人类的生活、生产、防卫等行为不仅缓慢而持续地影响了水环境，也促生了局部水适应性行为的出现，这—早期水适应性行为应作为研究内容之一；其次，永定河在历史上呈周期性泛滥，对下游危害极大，而北京西部地区的开阔平原用水需求量较大，曾多次引流永定河水以缓解灌溉与运输问题，因此研究应包含以永定河为主体的治河与水利灌溉工程；第三，门头沟整体山体沟谷切割较为剧烈，易发生山洪，同时山区大部分区域缺乏可用地表水资源，尤其是西部深山区，因此研究也应包含山地水土保持、防洪、储水等相关适应性行为。

4.3 适应性能力评估

适应性能力评估是针对上述研究对象在当下及预测情景下的适应性功能及作用进行的定性与定量研究，研究结果用以解决“如何适
the above interests in current and predicted scenarios, and the
research findings should offer answers to the question of “how
does adaptation occur.” An evaluation includes selection of
indicator criteria, evaluation on the capacity of spontaneous and
planned adaptation, and development of adaptive strategies.

4.3.1 Selection of Indicator Criteria

Different from the water environmental problems encountered
in plains, the major problems in mountainous rural areas
are the control of massive torrential runoff and the uneven
spatiotemporal distribution of water resources. The evaluation
indicator criteria of most existing studies are selected under
theories of Ecology and landscape aesthetics[37][38], which, however,
usually could not work well through planning and design
approaches because of the lack of targeted and feasible indicator
criteria to mountainous environment. Therefore, based on the
categories in the examination of adaptive processes, the indicators
selected in this paper include morphological and behavioral
criteria.

Morphological indicators should be selected with spatial
considerations, including:

1) Flood discharge surface volume of ravines: the study area is
categorized by its terrain of mountainous ravines, where a larger
flood discharge surface volume means a stronger adaptation to
massive torrential instantaneous runoff;

2) Morphology of waterfronts: it covers all kinds of
waterways within the water systems of the Yongding River and
the Qingshui River in the study area. In upper reaches the more
winding and zigzagging the morphology of a waterfront is, the
higher water resistance it has, while that in lower ones the more
straight, the higher efficiency of runoff regulation it has;

3) Permeability of waterway bottoms and banks: the higher
(smaller / constructed) permeability is, the better the effect of
flood control and drought relief will be, without impact on the
safety of flood discharge structure;

4) Width of vegetation buffer in waterfronts: a great number
of research findings prove that vegetation buffers of no less than
30 meters in width can effectively prevent water and soil loss
while helping filter pollutants and improving the downstream
stability[39];

5) Water resistance of slopes: slope is the main surface of
runoff in mountainous areas; a higher water resistance would
help reduce runoff, facilitate infiltration of runoff, and mitigate
water and soil loss and risks of landslides and mudslides;

6) Connectivity of water systems: it includes structural and
 hydraulic connectivity[40], the higher the connectivity is, the safer
a water system will be;
7）水库与水塘数量：在径流线路的适当位置增加水库及水塘的数量可提高径流调节的效能，并增加日常及旱季用水的补给量。

行为指标应从如下方面对不同地域特征的居民/机构进行评估：
1）对水适应性的认知情况、认知渠道和认知表现；
2）在水资源开发管理过程中采用的适应性政策与行动；
3）水利设施建设与定期维护情况；
4）生产及生活过程中的雨水收集及利用情况；
5）生产及生活过程中的污染物排放和控制情况。

4.3.2 自发性和计划性适应能力评估

此步骤是在指标选取的基础上，结合ArcGIS空间分析、情景及经验决策、逻辑回归模型、景观叙事等方法，对不同情景模式下的适应性形态及行为进行评估的过程。自发性适应是系统为应对气候变化的影响而形成的自发性调节；计划性适应是指人类基于对已发生、正在发生和可能发生的状况及应对措施可能产生的后果的认识，而进行的有计划的行动。计划性适应不仅需要能够预测全球变化的状况并对可能的后果进行有效评估，而且需要具备合理的适应性策略并采取有效的经济和技术保障手段。

各学科在适应性能力评估方面的研究均强调研究对象结构与功能层面的复杂性与不确定性。而在生物学领域，对于适应性的探讨还有两个重要维度——可逆性和有限性，前者指适应性的某些形态及生理变化是可逆的，后者强调适应性所涉及的形态及行为具有适应极限。由于适应的过程及变化趋势相对难以被量化，且多体现出非线性特征，因此适应性研究的关键在于识别适应过程中影响适应性绩效的适应性约束/限制。

7) The number of reservoirs and ponds: by suitably increasing the number of reservoirs and ponds along runoff paths, the efficiency of runoff regulation can be improved, and the supply volume of water for daily and dry-season can be increased.

Behavioral indicators should be selected to evaluate the people / agencies in geomorphologically different regions as follows:
1) The status quo, assess, and reaction of residents of cognition of water adaptation;
2) Policies and actions of adaptation adopted in the management and development of water resources;
3) Construction and regular maintenance of water conservancy facilities;
4) Collection and utilization of rainwater in daily life and production;
5) The discharge and control of pollutants in daily life and production.

4.3.2 Evaluation on the Capacity of Spontaneous and Planned Adaptation

Based on the selection of indicator criteria and combined with research methods such as ArcGIS spatial analysis, scenario and experiential decision-making, logistic regression model, and landscape narratives, this step evaluates the morphologies and behaviors of adaptation in different scenarios. Spontaneous adaptation refers to systems’ natural adjustments to the impact of climate changes; planned adaptation refers to humans’ programmed actions according to their cognition of past, present, and potential situations, as well as possible outcomes of associated actions. Planned adaptation not only needs to effectively predict global changes and possible impacts, but also develop sound adaptive strategies and employ efficient economic and technical guarantee measures.

Studies of evaluation of adaptive capacity among different disciplines all emphasize the complexity and uncertainty of research objects in structure and function; in the field of Biology, reversibility and finiteness are the two mostly important dimensions in adaptation studies, the former stressing that some morphological and biological changes are reversible while the later emphasizing that limits exist in morphology and behavior of adaptation. As the process and changing trend of adaptation are difficult to quantify and often show non-linear characteristics, it is important to identify adaptation constraints / limits in processes of adaptation, which have an influence on adaptive performance.
4.3.3 Development of Adaptive Strategies

This is the final step and the objective of evaluation of adaptive capacity, which is to identify adaptation constraints / limits through quantitative and qualitative research, and develop targeted solutions and improvement strategies, so as to strengthen the adaptive capacity of studied objects. In terms of the study area in this paper, it involves the following aspects:

1) Optimization of spatial patterns of water adaptive landscapes: considering the ravines and waterways in the mountainous setting, multileveled water adaptive spatial structures (catchment corridors, water retention corridors and wetlands, etc.) should be introduced along key runoff paths to ensure the safety of the water environment at a macro scale;

2) Function integration: according to the status quo of the protection and development of local traditional villages, water adaptive landscapes should be integrated with opportunities in heritage preservation, recreation, and productive tourism, to make the adaptive process and result meet the needs of socio-economic development, environmental improvement, and living standards upgrading;

3) Technical principles: specific design strategies and engineering measures should be devised according to different scenarios in runoff regulation, rainwater and flood control, and water quality improvement;

4) Institutional guarantee: plans on improving current policies and management modes can be presented, to ensure the implementation and performance of adaptation through top-down approaches;

5) Public participation: community platforms should be built through which the government, villagers, research institutions, and enterprises can coordinate in a more efficient way to promote public cognition and practice of water adaptive landscapes.

5 Conclusions and Prospects

1) Research on water adaptive landscapes needs more efforts in the construction of a more systematic and subdivided interdisciplinary research framework. Since the research covers cognition, spatial patterns, landscape elements and behaviors, water culture and history, and adaptive management of adaptation and landscapes in different time periods and geomorphological regions, multiple disciplinary perspectives would offer it great potential to become an emerging research field, yet the development of research depends on the wholeness and guidance of the research framework. Currently, studies in different fields show an increasingly obvious interdisciplinarity,
2) Water adaptive landscapes research needs more efforts in the development and application of scientific quantitative methods. Quantitative research is key in studying adaptation, especially in the evaluation and prediction of adaptation, involving the selection of indicator criteria, identification of impact factors, spatiotemporal data interpretation and precision verification of results through evaluation models in static and dynamic evaluation, etc. Existing methods of quantitative analysis of adaptation fail to support the scientific study of the complexity and uncertainty of water adaptation. For example, the scoring in the decision matrix model largely depends on researchers’ individual knowledge, compromising the reliability of results. In the future, it is important to strengthen the development of scientific and targeted quantitative research methods.

3) Research on water adaptive landscapes needs more efforts in cognition promotion among professionalism and the public. The research is built on the combination of adaptation and landscapes. Though both of them have been widely studied in respective disciplines and general conceptual understanding has been shaped, water adaptive landscapes and the research scope have not been clearly defined with interdisciplinary concerns. Representative studies with “water adaptive landscapes” or similar topics are seldom seen in international academia. Such limitations of cognition also lead to today’s poor cognition on water adaptive landscapes and relevant research among the public, as well as the less application of research results and a low level of public participation. It is necessary to enhance cognition through disciplinary construction and specific methods to educate government agencies, research institutions, social organizations, and the public, so as to broaden the social influence of research on water adaptive landscapes.

4) Research on water adaptive landscapes needs more efforts in enhancing the feasibility and guidance of research findings in practice. The final objective of research on adaptation is to develop adaptive strategies, so as to help improve the adaptive capacity of studied objects. Existing studies on adaptation and water adaptation mostly draw conclusions about empirical summary, adaptation evaluation, identification of impact factors, and prediction of adaptation trends, but provide no further discussion on development of adaptive strategies in spatial planning, institutional establishment, guidance on behavioral patterns, and guidelines on adaptive practice. Water
讨与制定方面（如空间规划、制度建设、行为模式引导、适应性建设等）相对欠缺。而水作为与人类生活、生产及自然生态系统密不可分的物质形态，水适应性策略的发挥需要切实可行的适应性策略的指导。因此，在水适应性景观研究中要注重适应性策略的可落地性，从而指导区域保护及开发的规划和营建等相关实践，而这也将大力促进水适应性景观研究的发展。

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