本文引用格式 / Please cite this article as:

Zingraff-Hamed, A., Martin, J., Lupp, G., Linnerooth-Bayer, J., & Pauleit, S. (2019). Designing a Resilient Waterscape Using a Living Lab and Catalyzing Polycentric Governance. Landscape Architecture Frontiers, 7(3), 12-31. https://doi.org/10.15302/J-LAF-1-020003

通过“生活实验室”和多中心治理设计韧性水景

DESIGNING A RESILIENT WATERSCAPE USING A LIVING LAB AND CATALYZING POLYCENTRIC GOVERNANCE

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https://doi.org/10.15302/J-LAF-1-020003　收稿时间 RECEIVED DATE / 2019-05-07　中图分类号 / X522, C934　文献标识码 / A

摘要

多中心治理和“生活实验室”概念均基于去中心化的参与式规划、协同设计和决策而建立。尽管“生活实验室”的概念在近几年才刚刚兴起，但于2000~2011年施行的伊萨河计划既已对其进行了开拓性探索。该计划沿德国慕尼黑市伊萨河对多种基于自然的解决方案进行了选择、协同设计并予以实施。虽然多个管理部门参与了伊萨河计划的决策过程，但时至今日尚缺乏对促成该项目的多中心治理的研究分析。本文以利益相关者访谈及文献综述为基础，对伊萨河计划的修复规划流程进行了分析。文章阐述了伊萨河计划治理架构的演变，论述了“生活实验室”的协同治理方法，并分析呈现了多中心治理如何增进信任和相互交流，以及韧性水景的协同设计。最终，本文认为，当各具自主权的多层级决策者共同参与政策方案制定时，“生活实验室”可以成为一种实施多中心治理的方法，反之亦然。

关键词
参与式过程；社会－生态修复；城市研究；河流管理；水资源治理；生活实验室；多中心治理

ABSTRACT

The both polycentric governance and Living Labs concepts are based on decentralized participatory planning, co-design, and decision-making. While the concept of Living Lab is still emerging, the Isar-Plan (2000 ~ 2011) pioneered the approach for selecting, co-designing, and implementing nature-based solutions along the Isar River in Munich, Germany. Despite multiple governing authorities involved in the decision-making process of the Isar-Plan, the polycentric governance that led to the success of the project has to date not been analyzed. This paper presents the results of an ex-post-analysis of the Isar-Plan restoration planning process based on stakeholder interviews and a literature review. The contribution describes the evolution of Isar-Plan governance arrangements and discusses the Living Lab approaches to cooperative governance. The analysis demonstrates how polycentricity facilitated trust, learning, and the co-design of a resilient waterscape. The paper concludes that Living Labs can be a way of applying polycentric governance when autonomous and multi-scale decision-makers are collaboratively involved in the design of policy solutions, and vice-versa.

KEY WORDS
Participative Process; Socio-Ecological Restoration; Urban Study; River Management; Water Resource Governance; Living Lab; Polycentric Governance

基金项目
“欧盟展望2020”研究与创新计划基金项目“以自然为依据”（编号：776681）

Research Fund
“According to Nature” (PHUSICOS) project, European Union’s Horizon 2020 research and innovation program (No. 776681)

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EDITED BY TIAN Xiaojie　**TRANSLATED BY** LI Huiyan　TIAN Xiaojie

1. 社会－生态系统内各要素间相互作用的理论框架（改绘自参考文献[6]）。

1. Theoretical framework of interactions in the socio-ecological system (adapted from Ref. [6]).

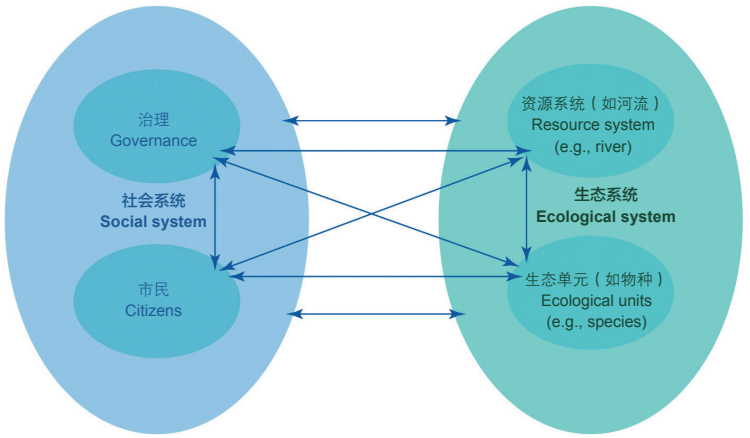
1 引言

为我们提供了大量生态系统服务的河流如今却正面临着全球性的社会—生态危机。历史上，由于淡水资源对于经济发展和人类福祉极为重要，大多数城市都临河而建[1]。作为一种公共资源，“公地悲剧”正在世界各地的河流中上演[2]。对河流生态系统的过度开发、城市化，以及工业化已经严重影响到了河流本身[3]，最终导致许多河流难以继续发挥其全部的社会—生态功能。根据联合国教科文组织对河流文化的定义[1]，生态恶化将直接影响人类福祉。

社会系统与生态系统被整体视为社会—生态系统[4]。其基础是4个彼此密切相关的核心要素：治理、市民、生态单元，以及资源系统（图1）。它们之间的相互作用促使社会—生态系统不断演进，从而长期保持韧性[5]。因此，为了实现该系统的可持续性，识别并分析这4个要素之间的关系至关重要[6]。

河流修复等基于自然的解决方案（NBS）在重建河流社会—生态功能方面的重要性已得到共识[7]。根据欧盟委员会的定义，NBS“旨在通过资源节约型的适应性解决方案来应对各类社会挑战，并兼顾经济、社会和环境效益”[8]。不同于主要用于保护人类安全的工程类解决方案，NBS与社会、自然及二者的相互作用均密切相关。除技术、生态和社会—经济因素外，协作水平也是成功实施NBS的重要因素[9]。由于参与其中的利益相关者有着不同的目标和关注点，协作可能会使规划过程变得更加复杂，但却可以使最终决策更易为各方所接纳，并促进其贯彻落实。协作可能发生在决策层面，如多中心治理模式，也可能发生在解决方案制定层面，如“生活实验室”方法。

本文将阐释多中心治理模式及“生活实验室”方法如何推动NBS在河流系统的实施，通过辨析其相似点和潜在联系，揭示这两个概念背后的理论，并以伊萨河计划为例，阐述这两种模式的应用。本文旨在展示如何将多中心治理模式和“生活实验室”方法相结合，并探究二者将如何推动NBS的实施。



1

1 Introduction

Rivers provide abundant ecosystem services, yet they are facing a socio-ecological crisis globally. Historically, major cities were built close to rivers because of the substantial contribution of freshwater to economic development and human well-being[1]. As a common resource, rivers provide a classic illustration of the tragedy of the commons[2]. The exploitation of the services provided by rivers, urbanization, and industrialization have severely impacted rivers[3]. As a result, many river systems can no longer support the whole spectrum of their socio-ecological functions. According to the concept of river culture defined by the UNESCO[1], ecological degradation and human well-being are directly correlated.

The linkage between society and ecosystems has been defined as the socio-ecological system[4]. It is based on four core, intensively interacting elements: governance, citizens, ecological units, and the resource system (Fig. 1). Their interactions enable the socio-ecological system to continuously evolve to achieve a long-term resilience[5]. Thus, to establish the sustainability of the system, it is crucial to identify and analyze the relationship between the four elements[6].

Nature-based solutions (NBS), such as river restoration, have been recognized as essential to re-establish socio-ecological functions of rivers[7]. According to the European Commission, NBS are “designed to address various societal challenges in a resource-efficient and adaptable manner and to provide simultaneously economic, social, and environmental benefits”[8]. Contrary to engineered solutions that primarily serve human safety, NBS are strongly linked to society, nature, and their interactions. Besides technical, ecological, and socio-economic factors, the level of cooperation is an important factor of success for the implementation of NBS[9]. Cooperation can make planning processes more complicated because of the different goals and centers of interest of the stakeholders involved, but would instigate higher acceptance of and adherence to a given decision. Cooperation can happen at the decisional level, e.g., the polycentric governance model, and at the solution design level, e.g., the Living Lab approach.

This article will present how polycentric governance and Living Labs can drive NBS implementation in the context of a river system. The theory behind the two concepts will be presented while highlighting their similarities and potential linkage, combined with a case study of Isar-Plan illustrating the application of the models. The objectives of this contribution are twofold: 1) to demonstrate how polycentric governance and Living Labs can go hand in hand; and 2) to investigate how polycentric governance and Living Labs can drive NBS implementation.

2 方法

2.1 案例研究：伊萨河计划

发源于奥地利的伊萨河（图2）向北流经德国巴伐利亚州，是卡文德尔山脉的重要河流之一，最后在代根多夫县汇入多瑙河。其流域面积约为9 000km^2，全长295km，是巴伐利亚州第四大河流。伊萨河属辫状高山河流，拥有大面积砾石沙洲和先锋植被，从河床干涸到洪水泛滥的极端水文状况皆时有发生。河流流经慕尼黑市，为城市提供了淡水、能源、食物，以及包括砾石和木材在内的多种原材料[10]。

尽管欧洲滨海城市自中世纪以来一直强制建造混凝土河堤，但伊萨河主要形态的改变发生在20世纪[11]。历史上，由于伊萨河发生过若干次特大洪水，当时的城市规划者不得不在居住区和洪泛平原之间保留一段安全距离[10]。但到了19世纪末，人们开始占用洪泛空间，木桥也被石桥所取代，如建于1725年的慕尼黑路德维希大桥[12]。1813年和1899年的两次洪水冲毁了这些新的定居点并造成了桥梁坍塌。为了应对此类灾害，河流形态改造和河水流量调节工作逐步展开[12][13]。20世纪20年代，由于巴伐利亚州政府决定利用伊萨河进行水力发电，伊萨河的管理策略出现了历史性转折。为了修建43座水力发电站，州政府对伊萨

2 Method

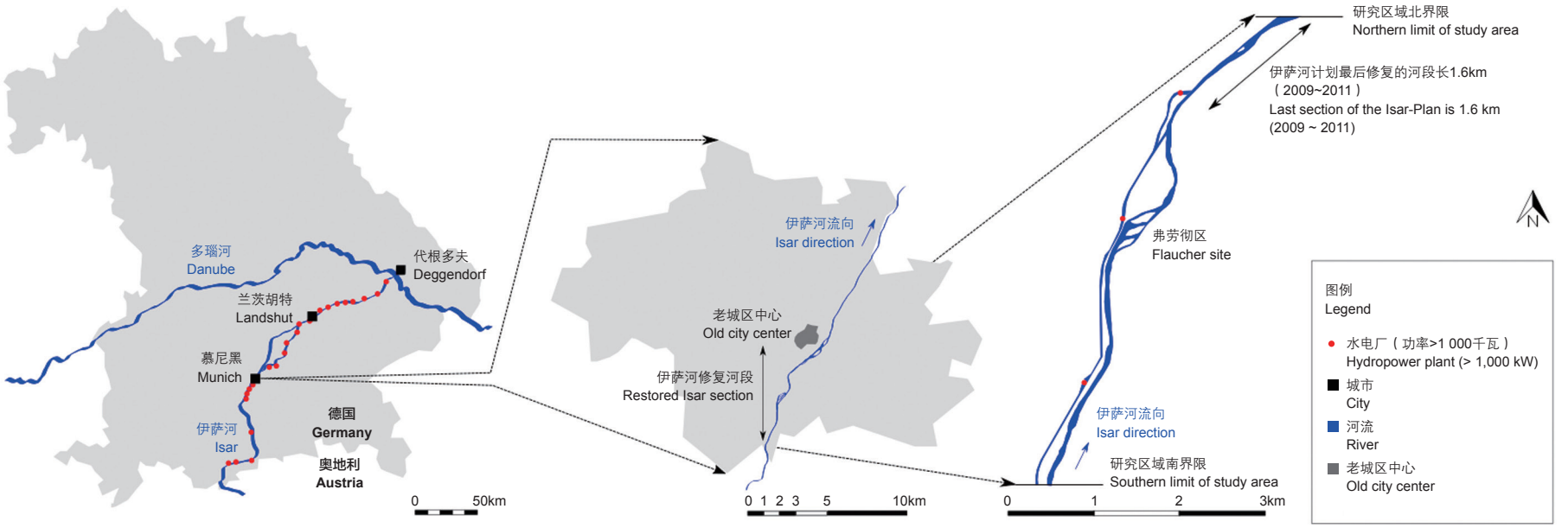
2.1 Case Study: The Isar-Plan

The Isar River (Fig. 2) has its source in Austria, flows north through Bavaria in Germany, draining an important part of the Karwendel Mountains, and joins the Danube River in the town of Deggendorf. Its catchment area is around 9,000 km² and this 295-kilometer long river is the fourth largest river of Bavaria. The Isar River is a braided alpine river with large gravel bars, pioneer vegetation, and extreme water regimes ranging from dry riverbeds to severe flood events. It flows through the city of Munich, providing it with freshwater, energy, food, and raw materials such as gravel and wood[10].

While European riverine cities have since the middle age been progressively forced into concrete river banks, the main morphological modifications of the Isar occurred in the 20th century[11]. Because of the extreme flood events of the Isar, city planners historically maintained a safe distance between housing areas and the floodplain[10]. In the late 1800s, population began to occupy the space that had until then belonged to the river and wood bridges were replaced by stone bridges (e.g., the Ludwigsbridge in Munich built in 1725[12]). Two major floods in 1813 and 1899 respectively caused severe damage to these new settlements and the collapse of bridges. As a response to these events, morphological river modifications and flow regulations were undertaken[12][13]. The Isar management strategy took a decisive turn in the 1920s, when the Bavarian government decided to exploit the Isar for hydropower production. Therefore, major morphological modifications and many water

2. 伊萨河以及本研究所涉及的修复河段区位图

2. Location of the Isar and the studied restored river stretch



河进行了重大形态改造，并开展了大量河流改道工程，导致河流系统的社会—生态功能遭受严重破坏，无法继续提供相应的文化及生态服务[11]。

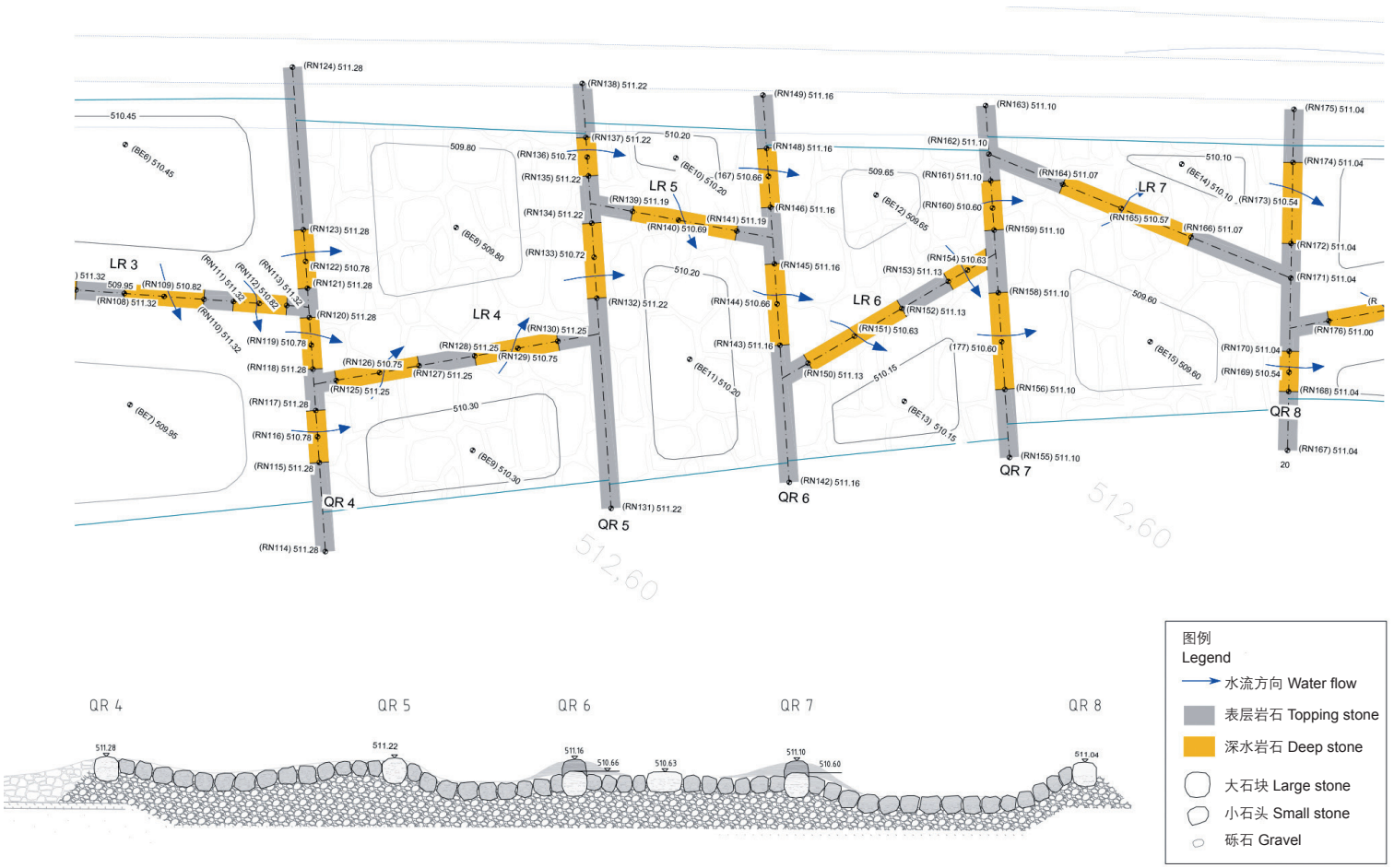
20世纪90年代，桑多兹化工厂爆炸事件致使莱茵河遭受重大污染，这一事件激发了德国水资源治理方向的转变，并使之开始施行加强河流修复政策支持的环境治理改革[14]。于是，众多旨在提升生态及社会—经济系统的河流修复项目得以开展，这些项目涉及沿河生活的各个方面。伊萨河修复工作最早于1995年开始实施[15]。而在2000~2011年间开展的慕尼黑伊萨河修复（也称“伊萨河计划”或“伊萨河的新生”）则聚焦于社会—生态修复。例如，修复一段长度为8km的河段共计花费3 500万欧元，其中700万欧元被用于清除二战时残留的废弃物及净化土壤。伊萨河计划旨在实现三个目标[16]：首先，通过提升河流两岸的滞洪能力降低洪水风险；其次，通过恢复河床的水文环境条件、重建河流的形态和横纵向的连续性，以及恢复自然栖息地等措施，提升栖息地品质，增加鱼类、鸟类、两栖动物和昆虫的数量；再次，提升河流景观及其休闲娱乐潜力，通过参照弗劳赫地区的成功经验，重新设计河流，使河流便于到达且益于公共健康。不同于构筑混凝土堤防的传统方法，该项目通过建造蜂窝结构这一创新性解决方案，实现了修复河床、增加产卵区，以及增大水流量等目标（图3）。

伊萨河计划是享誉国际的城市河流修复项目。该计划于2007年获得了德国首个河流开发奖项——Gewässerentwicklungspreis奖。其已被指定为河网组织、欧洲河流修复中心、欧洲气候适应平台、由“欧盟展望2020”研究与创新计划资助的“基于自然的城市创新”项目和“以自然为依据”项目，以及由欧盟东南部国家跨国合作计划资助的“看见河流”项目等多个系统组织及行为主体进行学习效仿的优秀案例。伊萨河计划之所以能够获得广泛认可，主要是由于其在修复实践中采用了创新性的社会—生态方法[17]。该项目开拓性地采用了基于多中心治理的决策背景，并通过“生活实验室”方法选择并实施NBS。

diversions occurred to enable the construction of 43 hydroelectric power plants, resulting in the socio-ecological collapse of the river system that no longer provided cultural and ecological services[11].

In the 1990s, after the Sandoz Industry disaster causing a major pollution of the Rhine River, Germany took a new direction in water resources governance and initiated new policies for river restoration to strengthen environmental governance[14]. This resulted in many river restoration projects aiming to enhance ecological and socio-economic systems and targeting all aspects of life along the river. At the Isar, restoration measures started from 1995[15]. The Isar River restoration in Munich implemented from 2000 to 2011, known as the Isar-Plan or “New Life for the Isar,” was a socio-ecological program. The restoration of an eight-kilometer-long river section cost EUR 35 million including EUR 7 million to remove debris from World War II and to decontaminate the soil. The goal of the project was threefold[16]. First, the Isar-Plan was expected to mitigate flood risk by increasing the water retention capacity of the riverine area. Second, habitat quality and the quantity of fish, birds, amphibians, and insects were expected to be increased by restoring the hydro-morphological condition of the riverbed, re-establishing the morphological processes, the longitudinal and lateral continuity, and revitalizing natural habitats. Third, the Isar-Plan was expected to improve the riverscape and related recreational potential by redesigning the river following the example of an urban reference site, the Flaucher, and by making the river accessible for people and safe for public health. Innovative solutions were developed to reach all these goals such as the construction of honeycomb structures to fix the riverbed, instead of concrete bars, while providing new spawning areas and increasing the water flow (Fig. 3).

The Isar-Plan is an internationally renowned urban river restoration project. In 2007, it won the first German award “Gewässerentwicklungspreis” for river development. The project has been designated as a good practice and a learning case by multiple networks and actors, including the River Network, the European Center for River Restoration, the European Climate Adaptation Platform Climate-ADAPT, the NATURVATION project and PHUSICOS project funded by the European Union’s Horizon 2020 research and innovation program, and SEE-River project funded by the European Union’s South-East Europe Transnational Cooperation Program. The international acclaim of the Isar-Plan is mainly due to its innovative socio-ecological approach to restoration practice[17]. The project is also a forerunner in embedding a polycentric governance decision context and a Living Lab approach for selecting and implementing NBS.



3. 蜂窝状结构斜坡平面图及剖面图。该结构可减缓水流对河床深度的侵蚀、提升栖息地多样性与水体含氧量，并形成一处独特景观（图中RN意为天然石；QR指横向元素；LR指纵向元素）。

3. Plan and section of a row ramp with honeycomb structure that stabilizes depth river bed erosion, provides habitats diversity, re-oxygenates the water, and creates scenery (RN: rock in nature; QR: transversal element; LR: longitudinal element).

2.2 信息采集

为了厘清多中心治理的概念，我们在同行评议文章数据库Scopus中搜索关键词“polycentric governance”或“polycentri* AND govern* OR politic* OR polic* OR jurisdiction* OR legal*”。随后采用系统评价及元分析首选报告项目法选择其中58篇文章，并对其进行深入的定性分析。

同样，为了厘清“生活实验室”的概念，我们在Web of Sciences引文数据库中对“Living Lab*”这一关键词进行检索，并在此基础上对126篇同行评议论文进行了系统性的文献综述。

为了广泛收集关于伊萨河的研究及论文，并对其进行批判性分析，我们在科技论文、灰色文献（例如在互联网上非正式发表的文章或报道）、新闻报道、政府文件和影像纪录片等56份资料的基础上进行了定性文献综述，并分别用英语和德语搜索关键词“Isar–Plan”“Isar Plan”“Isar AND restor*”“River AND restor* AND

2.2 Information Collection

To study the concept of polycentric governance, the peer-reviewed article database Scopus was used with the title search keywords “polycentric governance” or “polycentri* AND govern* OR politic* OR polic* OR jurisdiction* OR legal*.” Subsequently, only 58 relevant articles were selected using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method to perform an in-depth qualitative analysis.

To study the concept of Living Labs, a systematic literature review was performed based on 126 peer-reviewed papers indexed in Web of Sciences using the search terms “Living Lab*.”

In order to collect and critically analyze multiple research studies and papers on the Isar-Plan, a qualitative literature review was performed based on 56 contributions, including scientific papers, grey literature (including articles and information released unofficially on the Internet), press articles, governmental documents, and film documentaries. The documents have been researched by using the keywords “Isar-Plan,” “Isar Plan,” “Isar AND restor*,” “River AND restor* AND Munich, ”“Isar AND

Munich”“Isar AND Munich”以开展相关研究。此外，在2013~2018年间，我们还对当地利益相关者进行了非正式对话访谈，听取他们对于伊萨河计划的深入看法。选择访谈者的依据是其曾参与设计NBS，并对项目相关背景有所了解。这种个人访谈侧重于将口述知识转录为文字材料。由于涉及保密性，此处将不过多地探讨访谈分析的细节。

2.3 分析

为了实现前文所述的目标，本文设计了一种以文献综述和案例分析为核心要素的研究方法。

针对多中心治理和“生活实验室”概念进行的文献综述旨在1）明确这两个概念的内涵，2）将二者的主要特征进行综合，3）对比两个概念及其关键要素。

而案例分析对两个概念进行的描述性说明则可对文献综述进行补充，以识别出能够确保“生活实验室”工作流程成功实施的关键性影响因素。案例分析以实践为导向，并对文献综述中未包含的观点进行整合。

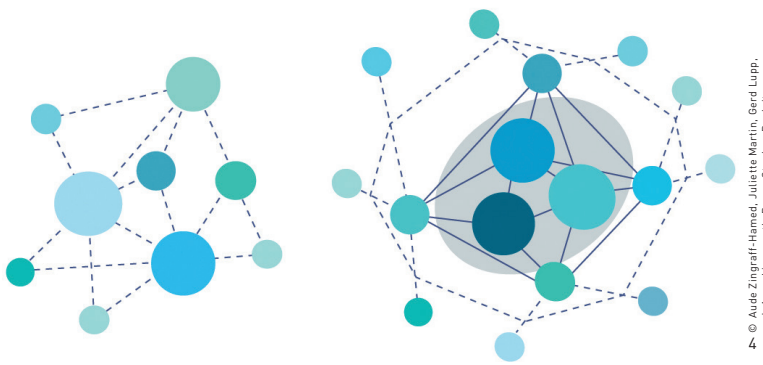
3 结果

3.1 多中心治理的概念

3.1.1 多中心治理

根据文森特和埃莉诺·奥斯特罗姆的核心研究[18][19]，“多中心性”（polycentricity）是指在不同管辖层级和尺度上（如国家、地区、全球）进行决策的系统，或通过多个独立的决策中心制定决策（图4）。“多中心治理”（polycentric governance）的概念源自对美国通过去中心化的协议合作机制解决跨辖区问题的观察[20]。

一直以来，关于多中心理论的争议主要集中在效率方面。然而，以美国大都市区的公共物品供给为例，文森特·奥斯特罗姆、查尔斯·M·蒂伯特，以及罗伯特·沃伦[19]提出，具有重叠管辖权的去中心化治理组织反而有利于高效的公共物品供给，这与人们的普遍认知截然不同。此外，治理模式的多样性使其具有更快解决复杂冲突的潜力[19]。因此，多中心概念逐渐发展为不仅讨论基于不同尺度的治理模



4. 图解多中心治理的不同类型、行为主体（彩色点，主体的重要性通过彩色点的大小来表示）、沟通联系（虚线）、正式伙伴关系（实线），以及合作项目/试验（灰色区域）。左图表示可支持多行为主体相互协调的简化交流网络单元。右图表示多中心秩序的最典型形式，其中包括关键性行为主体之间的密切联系、合作项目，以及和外部行为主体之间的沟通联系（改绘自参考文献[21]）。

4. Schematic representation of different types of polycentric governance systems, their actors (coloured dots, with sizes illustrating the importance of a node), communication linkages (dotted lines), formal partnerships (regular lines), and joint projects / experiments (grey areas). Left: a simple communication network allowing for mutual adjustment in multi-actor settings. Right: the strongest form of polycentric order involving strong formal ties between key actors, joint projects, and communication linkages to peripheral actors (adapted from Ref. [21]).

Munich” in English and German. Furthermore, informal and conversational interviews with local stakeholders were performed to provide in-depth insights to the case. Interviews were performed between 2013 and 2018. Interviewees were selected based on their knowledge of the project through their participation in the ad-hoc process of NBS co-designing. The personal interviews focused on knowledge transcription. Because of confidentiality issues, no further detail on these interview analyses can be published at this point.

2.3 Analysis

In order to achieve the objectives of the contribution, a methodological approach based on two core elements was designed: 1) literature review and 2) case study analysis.

The literature review of the polycentric governance and Living Lab concepts aimed at 1) defining the concepts for the readers, 2) synthetizing their main characteristics, and 3) comparing both concepts and their key elements.

This literature review was complemented by a descriptive illustration of these concepts through a case study analysis to identify key impact factors for successful Living Lab procedures. The case study analysis enabled a practice-oriented approach and the integration of insights which were not covered in the literature review.

3 Results

3.1 The Polycentric Governance Concept

3.1.1 Polycentric Governance

Lying at the heart of Vincent and Elinor Ostrom’s work[18][19], polycentricity denotes a system in which decisions are taken at different jurisdictional levels and scales (e.g., national, regional, global) sometimes through formally independent decision centers (Fig. 4). The concept of polycentric governance emerged from observations of how in the USA solutions to cross-jurisdictional problems were implemented through decentralized and contractual agreements[20].

Behind the rationale of polycentricity stands amongst others an argument of efficiency. Using the provision of public goods in metropolitan regions in the USA as an illustration, Vincent Ostrom, Charles M. Tiebout, and Robert Warren[19] argued that a decentralized governance organization with overlapping jurisdictions is, contrary to common perception, more beneficial for efficient public good provision. Additionally, the diversity of formal and informal governance arrangements would have the potential to resolve complex conflicts faster[19]. The concept of polycentricity has since then evolved to include not only forms of governance mixing different scales, but also different mechanisms (e.g., types

式，而且还关注不同的机制（如指令类型和管理条例）和行为主体[22]。不过，个体行为主体本身并不能代表决策中心，但他们可加入不同的决策中心或与之进行合作。由此，一个融合了临时性决策中心和更为稳定的决策中心的动态网络得以形成，可为不同部门的行为主体提供支持[23]。表1列出了多中心治理的核心特征。

尽管多中心治理最初是一个政治学概念，但其很快就被借鉴到了其他学科[23]。例如，人们提出通过多中心主义来解决气候变化[24]、全球健康[25]，以及网络安全[26]等全球问题。其中，多中心治理在自然资源管理领域的应用最为显著[23][27]。虽称不上是解决一切问题的万能之策，但由于经常涉及跨辖区和多尺度问题，多中心治理被特别应用于管理公共资源及服务[28][29]。

对于以上发展现状，一种可能的解释是行政辖区边界通常与实际治理边界不一致[30]，导致生态系统管理规模与社会—政治边界之间发生错配[31]，故而利用行政辖区边界治理生态系统困难重重。此外，由于生

of command and control regulations) and actors[22]. However, individual actors do not represent decision centers themselves — rather, they may collaborate with or join various decision centers. This forms a dynamic web of a mix of transitory and more fixed decision centers, which support actors from a variety of sectors[23]. The core characteristics of polycentric governance are listed in Table 1.

While being initially a Political Sciences concept, polycentric governance quickly expanded to a variety of different disciplines[23]. For example, polycentrism has been proposed as an approach to resolve global challenges as vast as climate change[24], global health[25], and cyber security[26]. However, polycentric governance most notably expanded in the field of natural resource management[23][27]. While not considered as a panacea, polycentric governance was specifically proposed as an approach to manage common goods and services[28][29] as they often range over various jurisdictions and scales.

表1：多中心治理的核心特征
Table 1: Core characteristics of polycentric governance

核心特征 Core characteristic	含义 Description	伊萨河计划案例 Example: Isar-Plan
多层级利益相关者参与 Multi-scale stakeholder engagement	治理系统由不同层级的利益相关者共同领导[19][20][27][35] The governance system is led by stakeholders at multiple scales[19][20][27][35]	√ 该案例涉及来自不同决策中心的利益相关者 Stakeholders from different decision centers were involved
多个独立的决策中心 Multiple independent decision centers	治理决策由拥有自治权的决策中心制定[19][27][30] Governance decisions are made by autonomous decision centers[19][27][30]	× 治理决策由（在纵向和/或横向上）相互影响的决策中心制定 Governance decisions are made by decision centers that interact (vertical and / or horizontal linkage)
多种尺度及机制 Various scales and mechanisms	将存在于治理系统内的机制（如正式的、非正式的）和层级（如国家层级、地方层级）进行融合[19][23][29] A mix of mechanisms (e.g., formal, informal) and scales (e.g., national, local) exists within the governance system[19][23][29]	√ 不同的尺度（从国家到地方）和机制（正式/非正式协定） Different scales (state to district) and mechanisms (formal / informal agreement)
合作生产 Co-production	不同的决策中心合作产出商品和服务[19][20][23][36] Knowledge to produce goods or services is cooperatively generated by different decision centers[19][20][23][36]	√ 每个决策中心都会分享各自领域的专业知识，以共同制定决策 Each decision center shared its expertise to cooperatively generate a decision
适应性 Adaptiveness	决策中心持续地采用并不断适应最佳治理策略[23][30][37] Decision centers continually adopt and adapt the most successful governance strategy[23][30][37]	√ 决策中心根据使用者需求进行调整 The decision center adapts to users' demands
协商及学习机制 Mechanisms for deliberation and learning	建立起允许决策中心进行信息与实践交流的机制[28][37][38] There are mechanisms allowing exchange of information and practices among decision centers[28][37][38]	√ 定期交流意见、开展会议、实地考察，以及推进正规化流程的平台 Platforms such as regular exchanges, join meeting, site visits, and formalized procedures
试验性 Experimentation	不断开展的试验可以持续地提升和适应治理系统[23][38][39] There is ongoing experimentation to continually improve and adapt the governance system[23][38][39]	× 无相关信息 No information found
创新性 Innovation	将制度创新引入治理框架，以适应不断出现的变化[29][40][41] Institutional innovation is introduced in the governance framework to cope with change[29][40][41]	– 仅存在少量支持不同决策中心进行合作的制度创新 Sporadic institutional changes to enable cooperation between decision centers
韧性 Resilience	治理系统能够适应潜在的系统变化或系统崩溃[23][38][42] The governance system can adapt to potential system change / collapse[23][38][42]	√ 治理系统试图将使用者需求和非政府组织的诉求进行整合 The governance system adapts to integrate users' and NGOs' demands

注释
×表示“不具备该项核心特征”；√表示“具备该项核心特征”；–表示“不确定”
NOTE
× means characteristic not met, √ means characteristic met, and – means inconclusive analysis

态系统一直处于不断的时空变化之中，且物种分布范围有时会绵延数千公里[32]，通过促进多种行为主体及其各自具有不同管辖尺度的决策中心的共同参与，多中心治理可灵活应对以上问题[30]。

多中心治理的另一个核心概念和潜在优势在于风险防范[23]。有观点认为拥有制度多样性和适应性的治理体系更有可能适应系统的变化和/或抵御系统整体崩溃，从而降低政策失灵的风险。于是，人们提出利用多中心治理提升生态系统韧性，优化生态系统服务，并将多中心治理列为斯德哥尔摩韧性中心的7项原则①之一，这些原则可将韧性思维用于指导生产性生态系统的建构之中[33]。此外，有学者提出多中心可以从6个方面提升生态系统韧性，即提供学习和试验的机会、实现更广泛的参与、提高连通性、创建模块化、提升响应多样性的潜力，以及构建冗余，尽可能地减少和纠正治理过程中所犯的错误[34]。

3.1.2 利用多中心治理进行修复的多种驱动因素

伊萨河计划的成功得益于其在多层级利益相关者的参与以及多决策中心协作方面的长期经验[43]。慕尼黑的城市发展呈同心圆式向外扩张，20世纪中叶开始逐渐与相邻城市合并。这意味着慕尼黑市政府有着与周边城市进行协作的悠久传统[44]，而水资源治理尤其需要长期合作。伊萨河是一条动态的河流，其河道在宽阔的河床上不断摆荡。特大洪水使河道发生了剧烈改变，导致村庄被夷为平地，居住区的主要水源也被切断[10]。为了保护贸易路线、港口活动、水资源安全和城市安全，慕尼黑市与伊萨河沿岸村政府开展了一系列合作[45]。此外，自19世纪以来，为了利用水力发电，一些颇具影响力的大家族与地方政府建立了牢固的关系，并参与到当地水资源管理策略的制定当中[46]。另外，自中世纪以来，每逢冬季或旱季，地方政府都需要和河流使用者进行

① 由斯德哥尔摩大学与瑞典皇家科学院北尔生态经济研究所联合发起的斯德哥尔摩韧性中心于2007年启动，现已成为世界领先的科学中心，致力于解决人类面临的复杂挑战。其7项原则分别为保持多样性和冗余度、管理连通性、管理慢变量和反馈、促进复杂的自适应系统思考、鼓励学习、扩大参与，以及促进多中心治理。

① Launched in 2007, Stockholm Resilience Center, a joint initiative between Stockholm University and the Beijer Institute of Ecological Economics at the Royal Swedish Academy of Sciences, has developed into a world-leading science center for addressing the complex challenges facing humanity. Its seven principles are maintaining diversity and redundancy, managing connectivity, managing slow variables and feedbacks, fostering complex adaptive systems thinking, encouraging learning, broadening participation, and promoting polycentric governance.

One possible explanation for this development is the difficulties in governing ecological systems using jurisdictional boundaries which typically do not coincide with man-made boundaries[30], often resulting in a mismatch between the scales of ecosystem management and socio-political boundaries[31]. Furthermore, since ecological entities are highly dynamic in space and time, with species' ranges sometimes stretching over thousands of kilometers[32], polycentric governance offers a way to reflect this flexibility by involving a variety of actors and their respective decision centers at different jurisdictional scales[30].

Another core concept and potential advantage of polycentric governance is risk reduction[23]. This stems from the idea that a governance system with institutional diversity and adaptability is more likely to be resilient to system change and / or collapse, thereby reducing the risk of policy failure. Polycentric governance has thus been proposed to enhance the resilience of ecosystems and the services they provide, making it one of the Stockholm Resilience Center's seven principles① for applying resilience thinking to production ecosystems[33]. It was argued that polycentricity contributes to ecosystem resilience in six ways by providing opportunities for learning and experimentation, enabling broader levels of participation, improving connectivity, creating modularity, improving potential for response diversity, and building redundance that can minimize and correct errors in governance[34].

3.1.2 Multiple Drivers of the Restoration Leveraging Polycentric Governance

The Isar-Plan has been benefited from long-term experience in multi-scale stakeholder engagement and cooperation between multiple decision centers[43]. Munich is a concentric city that did not incorporate neighboring municipalities before the middle of the 20th century. This meant that the municipal local government had a long history of cooperating with independent neighbors[44]. Especially water governance required long-term cooperations. Because of its dynamic form, the course of the Isar River itself evolved in a broad riverbed. Major floods could dramatically change the river location leveling villages or isolating housing areas from the crucial water resource[10]. To secure the trade route, port activities, water security, and the city's safety, the Munich municipality developed the cooperation with governments of the surrounding villages located along the Isar River[45]. Furthermore, since the 1800s, influential families exploiting the water power to produce energy developed strong relationships with the local government and were associated with the water management strategy[46]. Moreover, allocating and sharing the Isar's scarce water in winters and dry periods has required negotiations with local governments and users since the Middle Ages[10]. In this context,

协商，以分配伊萨河的稀缺水源[10]。在这种情况下，若想了解随着20世纪生态修复浪潮的兴起，当地水资源治理发生了哪些变化，就必须明确推动当地和区域水管理机构网络构建的环境和社会驱动因素。

本研究通过利益相关者访谈和文献综述的方法来明确实施伊萨河项目的驱动因素，以及各个机构及合作伙伴之间的联系（图5）。

伊萨河计划的成功得益于治理机制、多层级的决策中心，以及多个驱动力的共同作用（表1），其将多种水资源治理政策需求整合为一个综合的规划框架[17][47]。首先，水力计算表明，水坝无法抵御慕尼黑百年一遇的洪水[48]，且由于气候变化，由夏季降雨造成的伊萨河特大洪涝事件的发生概率可能会增加25%[49][50]。在这一背景下，负责水资源管理与防汛工程的巴伐利亚州政府敦促地方水利局进行了有效的防洪设计。其次，按照欧洲《浴场水指导总则（1975）》中规定的标准，伊萨河的水质不满足水上休闲活动的安全性要求。公共健康问题一般由市政府负责，但市辖区政府亦非常关注水体健康及安全问题，并竭力主张采取相关措施确保休闲用水安全[51]。再次，流入伊萨河的水量不足以支撑其生态功能和休闲用途[48]。当该项目处于设计阶段时，《水框架导则》这一重要的欧洲环境法尚未正式出台。尽管如此，非政府自然保护组织注意到了这些问题，在推动与能源生产方进行密集谈判的同时，也对州政府未承担起相应的道义责任进行谴责。最后，慕尼黑市规划局将伊萨河廊道确定为可提升生活品质的重要自然资产[52]。从1950年到1975年，慕尼黑城市人口翻了一番，达到将近150万，而汽车数量的持续增长则导致城市出现了雾霾污染。穿市中心而过的沿河区域应当在污染消解方面发挥更加积极的作用。此外，尽管市民对绿地的需求在不断增加，但人均可利用土地中可供休闲娱乐的公共绿地比例少得可怜[44]，而尚未进行地产开发的沿河区域在建造大型公园方面具有很大的潜力。1983年，《城市发展计划》将伊萨河修复列为首要政治举措。然而，慕尼黑滨水区从未施行过针对城市风貌提升方面的项目。人们迫切希望重新设计河流景观，并恢复因灰色基础设施建设而受损的区域，重塑河流在展现当地人身份认同等方面的文化功能[53]。1984年，一项名为《城市中的自然》的市政法案提出，在保留河流水力发电的同时，重视河流的生态修复[52]。

面对诸多现实挑战和多种驱动因素，参与多中心治理的各方一致认为，伊萨河计划的成功在于各个决策中心之间的共同协作、相互适应，以及专业知识交流。基于此，所有机构和利益相关者之间都建立了密切的合作关系[17]。最终，通过开展跨部门合作以及提出一系列创新措施，该修复项目改变了政策的实施模式。例如，通常情况下，巴伐利亚州政府会承担增加滞洪区所需费用的75%，而新型合作模式则会施行不同的费用分摊方式[17]——项目费用的55%由州政府承担，余下的45%由地方税收支付。这一分配方式也符合项目的多重目标。

to understand the changes in the local water governance, as the emerging ecological restoration trend in the 20th century, it is necessary to identify the environmental and societal drivers of the local and regional political network of the river.

Interviews with stakeholders and a literature review were carried out to identify the driving forces in the implementation of the Isar-Plan, as well as the linkages between the institutions and partnerships to leverage the restoration project (Fig. 5).

The Isar-Plan has been also benefited from a mix of governance mechanisms, multi-scaled decision centers, several driving forces (Table 1), and integrated policy demands across various water governance poles into comprehensive planning frameworks[17][47]. Firstly, a hydraulic calculation revealed that the dam could not protect the capital city of Munich against the estimated HQ 100 flood (100-year flood level)[48]. Furthermore, it was found that in the context of climate change, summer precipitation causing the strongest flood events at the Isar may increase by 25%[49][50]. In this context, the Bavarian State, which is responsible for water management and flood protection, urged the regional water agency to implement an efficient flood protection design. Secondly, the water quality of the Isar was too poor to assure safe recreational activities as defined by the European bathing water legislation — Bathing Water Directives (1975). Local municipalities are responsible for public health and the district authorities, being concerned about health and safety, urged measures to assure safe recreational uses[51]. Thirdly, the water amount flowing into the river was not sufficient to support ecological functions and recreational uses[48]. When the project was designed, the Water Framework Directive, one of the most substantial piece of European environmental legislation, was not yet ratified. However, NGOs for nature conservation were concerned by these issues and drove intensive negotiations with the energy producers denunciating the ethical responsibility of the state. Finally, the Isar corridor has been defined by the City of Munich's Planning Department as a key asset for improving quality of life[52]. The number of urbanites doubled between 1950 and 1975 reaching almost 1.5 million of inhabitants and the city suffered from smog pollution caused by car traffic expansion. The riverine area crossing the city at its center should play an important role in pollution diversion. Furthermore, while the citizen demand for green spaces increased, per capita land use left few public green open spaces for recreational purposes[44]. The riverine area that remained free of housing offered great potential for a large public park. In 1983, the Urban Development Plan placed the Isar restoration at the top of the political agenda. Finally, Munich's waterfront was never designed to improve the cityscape. Users urged the re-establishment of the cultural services

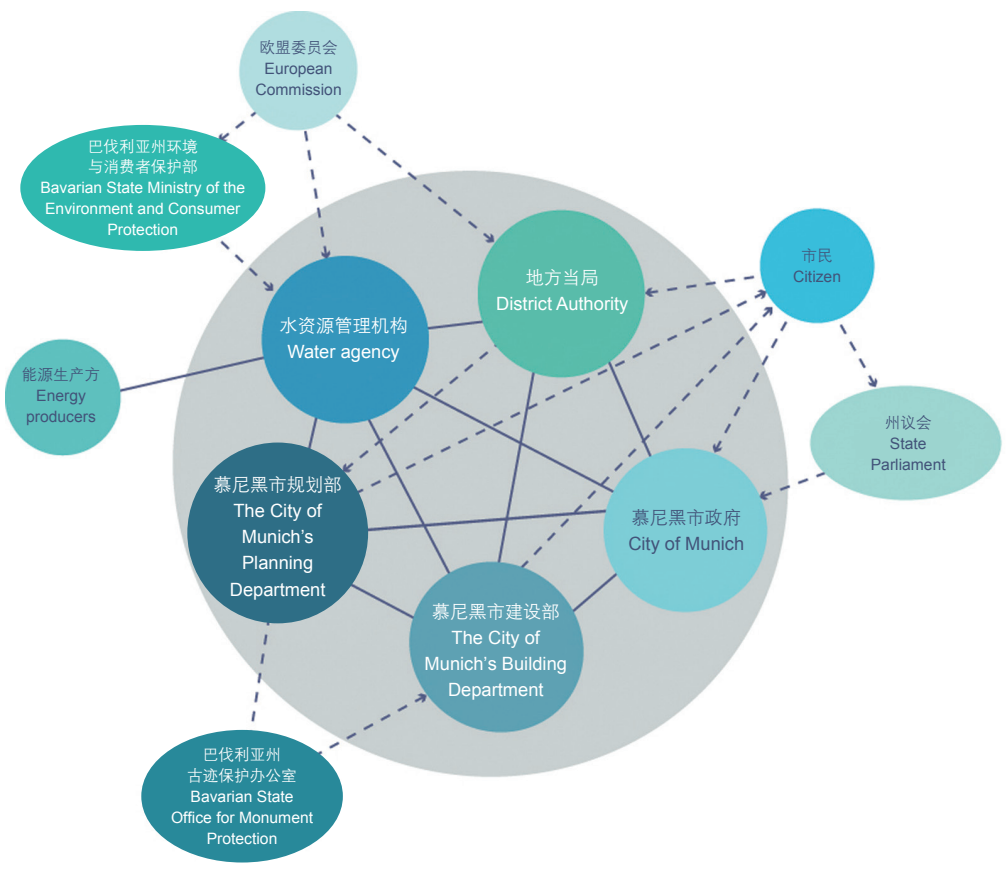
为了解决跨辖区问题，NBS（在此以河流修复的形式）的实施有赖于在不同的管辖层级及尺度上开展的治理工作，以及多个决策中心的参与。伊萨河修复案例表明制度多样性和适应性有助于提升生态韧性，并减少政策失灵导致的风险。多中心治理可构建由持不同价值观的利益冲突方组成的积极而强有力的“生活实验室”，促使各方达成折衷的解决方案。

3.2 生活实验室

3.2.1 生活实验室的概念

面对日新月异的世界，寻求应对气候变化、资源枯竭和人口过剩等社会挑战的新方法已成为当务之急。尽管“生活实验室”（Living Lab或Living Laboratory）概念的提出最早可追溯至18世纪[54]，但学界通常认为该术语由麻省理工学院的威廉·J·米切尔教授首先提出[55]。广义来讲，“生活实验室”是一种支持使用者或利益相关者进行协作式和开放式创新，以应对环境、经济和社会问题的挑战的方法[54]。近几年来，“生活实验室”在世界范围内不断涌现[56]，例如欧洲生活实验室联盟、北欧智慧城市生活实验室等。

迄今为止，“生活实验室”尚没有统一的定义，原因在于其定义在很大程度上取决于应用情境[57]（表2）。“生活实验室”最初是一种鼓励开放性创新的方法，如今代表着一种逐步向自下而上的使用者驱



5. 图解伊萨河不同的多中心治理系统、行为主体（彩色点）、沟通联系（虚线）、正式伙伴关系（实线），以及合作项目（灰色区域）。

5. Schematic representation of different Isar River polycentric governance systems, their actors (colored dots), communication linkages (dotted lines), formal partnerships (regular lines), and the joint project (grey areas).

5 © Aude Zingraff-Hamed, Juliette Martin, Gerd Lupp, JoAnne Linnerooth-Bayer, Stephan Pauleit

of the river, e.g., Bavarian identity and pride, by designing and restoring the riverscape damaged by grey infrastructure[53]. In 1984, a municipal bill labelled “Nature in the City” (Natur in der Stadt in German) stressed the ecologic restoration of the river while maintaining its economic use for energy production[52].

The authorities involved in the polycentric governance adapted to the real-life setting and multiple drivers. All agreed that to be successful, the design of the Isar-Plan should result from co-production, adaptations, and expertise exchange between decision centers. The result was a close partnership of all institutions and stakeholders[17]. Consequently, the restoration project changed the policy implementation pattern by creating links across sectors and new arrangements. For example, while usually the state paid 75% of measures to increase water retention areas, the new collaboration scheme resulted in a different share of the cost reflecting the multiple goals of the projects[17]. The project costs were covered 55% by the state and 45% by local taxes.

To solve cross-jurisdictional problems, the NBS, namely the restoration of the river, was implemented through governance at different jurisdictional levels and scales and multiple decision centers. The case of the Isar restoration showed that institutional diversity and adaptability can drive ecological resilience and reduce the risk of policy failure. The polycentric governance empowered an active and powerful Living Lab composed of a broad variety of stakeholders with different worldviews and conflicting interests to reach a compromise.

3.2 The Living Lab

3.2.1 The Concept of Living Lab

Finding new ways to tackle societal challenges such as climate change, resource depletion, and overpopulation has become imperative in today’s changing world. While the concept of “Living Lab” or “Living Laboratory” dates back as early as the 18th century[54], the introduction of the term itself is often accredited to professor William J. Mitchell from the Massachusetts Institute of Technology[55]. In the broadest sense, the Living Lab is an approach supporting collaborative and open innovation through user or stakeholder involvement in order to address environmental, economic, and societal challenges[54]. The Living Lab has recently proliferated across Europe, such as the European Network of Living Labs (ENoLL) and the Nordic Smart City Living Labs, and globally[56].

To date, there is no universal definition of Living Labs since how they are defined largely depends on specific application contexts[57] (Table 2). The Living Lab was initially introduced as a means for open innovation and is representative of a progressive

动型创新转变的工作方式[58][59]。因此，“生活实验室”常被应用于行业市场评估领域，以使产品和服务实现快速商业化[59]-[62]。

然而，“生活实验室”的出现和发展恰好可以协调各利益相关方之间复杂甚或充满矛盾的诉求。于是，“生活实验室”概念逐渐扩展到了包括可持续能源和医疗在内的其他领域[63]。在社会科学领域，“生活实验室”概念最早出现在20世纪90年代的一门大学课程概述中，修读这门课程的学生会在市中心附近开展实际落地项目[64]。由此可见，“生活实验室”包含技术和社会两个层面[65]。

近年来，“生活实验室”作为一种参与过程被应用于景观规划领域，以使利益相关者参与到景观解决方案（如NBS）的共同规划、设计和验证过程中[65]。不同于传统的多方参与，“生活实验室”在整个规划过程中仅赋权于一个相对稳定的利益相关者团体[66]-[68]。桑德拉·福梅斯特等[69]发现，迄今为止，大多数利用“生活实验室”进行景观规划的研究均通过所谓的“城市生活实验室”解决城市问题[70]。尽管“生活实验室”的要素（如合作生产[71]或合作学习[72]）已被用于减灾预警中，但其应用潜力尚未被充分挖掘。尽管“生活实验室”拥有丰富的外延（表2），但它们都呈现出某些一致的核心特征（表3）。

“生活实验室”包括几种不同的参与步骤（表4），如萨坡·利米宁[73]将其分为4个步骤（框架一），汉斯·谢弗等[74]和哈维尔·加西亚·古兹曼等[75]提出5个步骤（框架二），克里斯·施特恩等[68]列出8个

shift towards bottom-up and user-driven innovation[58][59]. Thus, the Living Lab has most frequently been used in industrial contexts as a market evaluation process enabling the quick commercialization of products and services[59]-[62].

Yet, the emergence and propagation of the Living Lab was also fuelled by the need to satisfy complex and sometimes conflicting stakeholder views. The Living Lab accordingly expanded to other fields, including sustainable energy and healthcare[63]. In social sciences, the Living Lab concept was first introduced in the early 1990s to describe a university course in which students undertook real-world projects in an inner-city neighbourhood[64]. Indeed, there are two types of Living Labs: technical and social[65].

More recently, the Living Lab has been used for landscape planning as a participatory process allowing stakeholders to be engaged in the co-planning, co-design, and co-testing of landscape solutions, such as NBS[65]. The empowerment of a relatively stable group of stakeholders throughout an entire planning process sets Living Labs apart from traditional stakeholder engagement[66]-[68]. Sandra Fohlmeister et al.[69] found that to date, most studies using the Living Lab for landscape planning to address adaptation and mitigation in urban settings using so-called “Urban Living Labs” (ULLs)[70]. While elements of the Living Lab, such as co-production[71] and co-learning[72], have been applied in the context of disaster risk reduction, full applications of the Living Lab are lacking. Despite these diverse definitions (Table 2), the Living Lab presents consistent core characteristics (Table 3).

The Living Lab can also be defined through their various

表2：“生活实验室”在不同学科中的定义
Table 2: Definitions of Living Labs according to the discipline in which they are applied

定义 Definition	学科 Discipline
“一个由具有丰富经验的自然人组成的网络，以及一种可进行用户驱动型创新的新途径”[76] "A network of real people with rich experiences and a new way to deal with user-driven innovation"[76]	社会学 Sociology
“‘城市生活实验室’即城市中可供利益相关者对社会－技术创新进行实时设计、验证与学习的场地”[77] "ULLs represent sites in cities that allow stakeholders to design, test, and learn from socio-technical innovations in real time"[77]	城市规划 Urban Planning
“一种通过联系、交流、合作实现创新的社会形态”[78] "A social configuration that is organized for innovation creation by contact, communication, and collaboration"[78]	政治学 Political Sciences
“一种试验性环境，在该环境中，技术在现实环境中得到了应用，同时，（终端）使用者也被视为‘合作生产者’”[79] "An experimentation environment in which technology is given shape in real-life contexts and in which (end-)users are considered as 'co-producers'"[79]	工科 Technology

注释
“生活实验室”的更多定义见参考文献[69]。
NOTE
For further definitions of Living Labs, see Ref. [69].

表3：“生活实验室”的核心特征
Table 3: Core characteristics of Living Labs

核心特征 Core characteristic	描述 Description	伊萨河计划案例 Example: Isar-Plan
多种利益相关者参与 Diverse stakeholder engagement	众多利益相关者参与其中，包括市民、公共机构、民间组织及学者[59][66][70] A wide range of stakeholders are engaged, including citizens, public institutions, private organizations, and academia[59][66][70]	√ 市民、公共机构、民间组织，以及学者参与了“生活实验室”从目标设定到解决方案设计，再到方案实施的各个阶段 Citizens, public institutions, private organisations, and academia were engaged in all phases of the Living Lab process, from goal setting to solution design and implementation
合作生产 Co-production	“生活实验室”终端产品、服务，以及解决方案由不同的利益相关者共同产出[60][65][76] The Living Lab's end-product, service or solution are produced collaboratively amongst different stakeholders[60][65][76]	√ 所有的利益相关者都被邀请参加圆桌会议，并共同提出解决措施 All stakeholders were invited to participate at round tables to co-design the measures
现实环境 Real-life context	基于现实环境开展[57][59][61] A real-life or realistic setting is used[57][59][61]	√ 目标设定和NBS协同设计方法均被应用于伊萨河项目中 Both goal setting and NBS co-design were taken up and implemented at the river
创新性 Innovation	“生活实验室”的结果具有创新性[54][61][78] The Living Lab's result is innovative[54][61][78]	√ 这一于2000年开展的社会－生态修复工作是一项创新性解决方案 A socio-ecological restoration in 2000 was an innovative solution
试验性 Experimentation	“生活实验室”终端产品、服务和解决方案由各方共同检验[57][77] The Living Lab's end-product, service or solution are tested collaboratively[57][77]	√ 检验由各方共同设计的解决方案需要两年时间 Testing the solution co-designed and the re-design required two years of collaborative work
学习平台 Learning arena	“生活实验室”可促进利益相关者之间互相学习[57][72] The Living Lab allows for learning amongst the stakeholders[57][72]	√ 利益相关者的开放态度促成了彼此之间的交流学习 Stakeholder openness and exchange allowed learning amongst the stakeholders
影响评估 Evaluation of impacts	监测、评估“生活实验室”造成的影响[57][60] Impacts of the Living Lab's results are monitored and evaluated[57][60]	√ 由水资源管理机构对伊萨河进行生态监测 Ecological monitoring has been performed by the water agency √ 由规划部对用户满意度进行评估 User satisfaction was evaluated by the planning department
适应性 Adaptiveness	对“生活实验室”方法及其各个阶段进行持续的迭代改进，直到完全满足利益相关者的要求[59][80] Living Labs and their various phases can be used iteratively until the full satisfaction of the stakeholders is reached[59][80]	– 经过11年的反复协商，满足了绝大部分参与者要求的解决方案已经落地 After 11 years of discussion, the solution that satisfied most of the participants has been implemented

注释
×表示“不具备该项核心特征”；√代表“具备该项核心特征”；–表示“不确定”
NOTE
× means characteristic not met, √ means characteristic met, and – means inconclusive analysis

步骤（框架三）。桑德拉·福梅斯特等[69]提出用于共同设计NBS的“生活实验室”可被划分为三个阶段（框架四）：

第一阶段：了解、调查、计划、探索；

第二阶段：创造性地协同设计和改进；

第三阶段：评估与验证。

通过这些阶段，参与其中的利益相关者可以达成各方均认可的合理结果，这些结果可能是高度一致的共识，也可能是各方让步后的折衷解决方案。本文将通过由表格所列核心特征定义的“生活实验室”分析伊萨河修复措施的规划流程。

participatory steps (Table 4), for instance, four steps described by Sappo Leminen[73] (framework one), five by Hans Schaffer et al.[74] and Javier Garcia Guzman et al.[75] (framework two), or even eight steps by Kris Steen et al.[68] (framework three). Sandra Fohlmeister et al.[69] suggest that the Living Lab applied to co-design NBS should have three different working phases (framework four):

Phase 1: Understand, investigate, plan, and explore;

Phase 2: Creative co-design and refinement;

Phase 3: Evaluation and testing.

These phases can proceed to reach outcomes that are considered legitimate by the participating stakeholders, which can be consensual or, if consensus is not feasible, solutions that reflect a compromise. For the purpose of this paper, the definition of the Living Lab according to the core characteristics described in the tables will be used to analyze the planning process of river restoration measures implemented at the Isar.

表4：各类“生活实验室”框架和伊萨河计划案例的对比
Table 4: Comparison of Living Lab frameworks and the Isar-Plan Case

	框架一 Framework one	框架二 Framework two	框架三 Framework three	框架四 Framework four	伊萨河计划案例 Example: Isar-Plan
设定“生活实验室”流程 Set-up Living Lab processes	无特定步骤，已有确定的利益相关者和使用者，或需要识别出利益相关者和使用者 No explicit step in this concept, stakeholders and users are evident or need to be identified	将本地用户群体发展为关键性行为主体 Development of a local user community to function as key actors	无特定步骤，需要识别出利益相关者和使用者，或已有确定的利益相关者和使用者 No explicit step in this concept, stakeholders and users need to be identified or are evident	利用多种方式进行识别，例如头脑风暴、滚雪球效应、直接和间接招募，以及激励机制 Identification with a variety of tools, e.g., brainstorming exercise and snowball effect, direct and indirect recruitment, and incentivation	利益相关者易于识别，他们会主动加入参与式过程 Stakeholders were self-evident and joined by their own initiative the participative process
		定义兴趣领域和创新举措 Define interest areas and innovation initiatives	通过制定计划，对“生活实验室”流程和工作计划中要解决的主题或问题进行定义和详细说明 Plan development to define and specify the topics or issues to be addressed in Living Lab processes and the work plan	为“生活实验室”设定清晰而务实的工作范围和目标 Definition of clear and realistic scope and goals for the Living Lab work 制定工作计划和参与战略 Establish a work plan and involvement strategy	经过多年的协商，利益相关者已明确三个主要目标：防洪、休闲功能改善，以及生态修复 Three major goals, namely flood protection, recreational improvement, and ecological restoration have been identified by the stakeholders after years of negotiations
“生活实验室”的概念性工作 Conceptual work of Living Labs	探索：鼓励所有利益相关者和使用者参与探索新应用场景和使用方法的共创过程 Exploration: engage all stakeholders and users in the co-creation process for discovering emerging scenarios and usages	鼓励使用者参与产品和服务的开发 Encourage user participation in product and service development	共创设计：利益相关者借助工具和方法共同提出一系列想法、新型应用场景和解决方案 Co-creative design: performed by stakeholders using tools and approaches to co-develop a broad range of ideas, new scenarios, and solutions	了解、调查、规划，并探索新场景 Understand, investigate, plan, and explore the scenarios	由规划师、水文学家、生态学家、工程师、使用者和行政人员组成的跨学科工作组共同设计NBS Interdisciplinary working groups of planners, hydrologists, ecologist, engineers, users, and administration staff co-designed the NBS
	共同创造：将技术推动和应用拉动集成到新型应用场景、概念和相关产品的构思当中 Co-creation: bring together technology push and application pull into a diversity of view the ideation of new scenarios, concepts, and related artefacts			具有创造性的协同设计和设计细化：潜在的解决方案被认为是适当的、可检验的，以及更细致的 Creative co-design and refinement: potential solutions broad up are considered suitable and tested, assessed in more detail	解决方案的设计被整合到总体规划和水文模型当中，并通过圆桌会议对其进行细化 Solution design was integrated in masterplan and hydrology model and refined by round tables
实施解决方案 Solution implementation	试验：通过技术产品获取大量使用者的实时应用场景，并收集相关数据 Experimentation: implement technological artefacts to experience live scenarios with a large number of users, and collect data	鼓励使用者参与产品和服务的实施 Encourage user participation in product and service implementation	实施与改进 Implementation and refinement	实施 Implementation	实施工作由慕尼黑市建设部门负责，该部门具有河流区域的所有权，并领导这一修复过程 Implementation was carried out by the Building Department of the city of Munich that owns the riverine area and led the process
评估过程和措施 Evaluation of the processes and measures	评估：评估现实生活中的新想法、创新概念，以及相关技术产品，以检测其效果 Evaluation: assess new ideas and innovative concepts and related technological artefacts in real-life situations to make observations	所有参与者吸取评估中的经验教训，以提出改进措施 All evaluate lessons learned and prepare further initiatives	无系统性评估步骤 A systematic evaluation step is not considered in this concept	评估和测试：对已实施的解决方案进行评估、产品提升，或返回概念性工作阶段 Evaluation and testing: evaluation of the implemented solutions, refinement and improvement for products, or restart of conceptual work	NBS已通过模型进行测试 NBS has been tested using a model 对实施NBS后的生态结果进行监测（例如鱼类监测），并调查用户满意度 Post-implementation: the NBS ecological outcomes were measured (e.g., fish monitoring), and the user satisfaction was monitored
“生活实验室”的外延 Outreach of Living Labs			传播：交流解决方案，以实现提升，并供其他案例研究参考 Dissemination: communication of solutions for upscaling and pickup by others		吸取经验教训，以提升解决方案，同时扩大“生活实验室”的外延活动，如由“以自然为依据”项目支持的其他区域的参访交流，以及由合作伙伴支持的参观学习活动 Draw lessons for improving solutions upscaling of Living Lab process outreach activities by visits and exchanges with other areas, formalized and supported within the project PHUSICOS, Look and Learn visits, and supporting activities by partners
			复制：提升推广至其他案例 Replication: upscaling to other cases		聚集想法：从其他地区和流域进行收集，涉及从地方（如伊萨河其他河段的修复措施）到全球等多个尺度 Gathering of ideas: collected by other regions and watersheds from local (ideas for river restoration measures at other sections of the Isar) to international scale

3.2.2 共同设计伊萨河计划

伊萨河计划的参与式过程由协商式过程发展而来，随后自然演变为复杂的“生活实验室”结构。早在17世纪，公众就担心随着伊萨河水质的恶化，城市的生活品质将逐渐下降[43]。从1970年开始[81]，伊萨河计划迅速成为一个敏感的政治议题。1987年，灰色基础设施仍是应对洪水的首选解决方案，为了满足政治需求，慕尼黑市政府开启了参与式治水过程[48]，并组织了首个伊萨河计划工作组。这一跨学科项目组由广泛的利益相关者组成，包括市民、公共机构、民间组织和学术界代表。项目由位于慕尼黑的巴伐利亚水资源管理办公室统筹领导，慕尼黑工业大学、慕尼黑大学、生态学家、景观规划师、工程师、水文学家，以及通过伊萨河联盟、慕尼黑论坛和非政府自然保护组织聚集的参与者从旁协助，共同探讨河流修复目标、限制因素和可能的举措。伊萨河计划被认为是较早的社区参与式合作计划，该计划将有意愿参与其中的利益相关者提出的不同目标融合在一起[17]。1995年，得益于慕尼黑市政府和巴伐利亚水资源管理办公室的人员变动，上述参与式过程发生了重大转变[47][51][53][82]。项目确立了防洪、提升休闲功能和生态修复三个主要目标，尽管防洪问题引起了各方的高度重视，但三者之间不再有主次之分[17]。直到2003年，伊萨河的修复设计与实施一直有赖于多层级合作、跨学科分组协作和持续的市民参与。在多次圆桌讨论会和研讨会期间，各工作组为修复措施的制定建言献策[83]。在设计解决方案的过程中，慕尼黑市规划与建设部门牵头举办圆桌会议并领导包括代表市民意见的慕尼黑论坛、河流使用者协会、公共机构、私营企业，以及当地大学等核心机构在内的各工作组共同制定即将实施的修复计划[84]~[86]。此外，设计团队还针对设计细节进行了集中探讨，如台阶级数、石材类型、河岸或礁石是否可以成为人们休憩的最佳场所，

3.2.2 The Co-Design of the Isar-Plan

Starting with a consultative process, the Isar-Plan participative process naturally evolved to a complex Living Lab structure. Public concern about the loss of urban quality of life related to the deterioration of the Isar River goes back to the 17th century[43]. Since 1970[81], the Isar-Plan quickly became a very sensitive and political issue. In 1987, when grey infrastructure was the preferred solution to flood reductions, a participative process was set up by the Munich City Council to satisfy political demands[48]. They also organized the first working group on the Isar-Plan. This interdisciplinary project group was composed of a wide range of stakeholders including citizens, public institutions, private organizations, and academia. The project was headed by the Bavarian State Office for Water Management in Munich and was assisted by the Technical University of Munich, the University of Munich, ecologists, landscape planners, engineers, hydrologists, and the users gathered under the Isar Allianz, the Münchner Forum, and NGOs for nature conservation. Together they discussed restoration targets, limitations, and possible measures. The Isar-Plan was conceived as an early community-involved collaborative program to link the objectives of all stakeholders willing to participate[17]. In 1995, the participative process took an important turn, benefitting from staff turnover within the city government of Munich and within the Bavarian State Office for Water Management[47][51][53][82]. Three major goals, namely flood protection, recreational improvement, and ecological restoration, were identified; despite the fact that flood protection was given strong emphasis, no one goal should dominate over the others[17]. Until 2003, the Isar restoration design and implementation relied on multi-level collaboration, interdisciplinary working groups, and continuous citizen engagement. During repetitive roundtable discussions and workshops, the working groups provided inputs for the design of the restoration measures[83]. During the design of the solution, the City of Munich’s Planning and Building Departments headed roundtables and working groups with a core group of institutions, e.g., Münchner Forum speaking on behalf of citizens, users associations, public institutions, private companies, and local universities, to co-design the solution to be implemented[84]~[86]. Together, they intensively discussed details of the measures to be implemented, e.g., the number of steps, the type of stones used, if river banks or rocks were the best resting area for people, where seeds to green the area should go, etc. The frequency of these meetings varied from weekly to biannually, depending on the project phase[85]. In parallel to this, an intensive information strategy was put into place to organize visits, and

在哪些地方通过播种的方式创建绿地等。此类会议的举办频率取决于项目进展，从一周一次到半年一次不等[85]。与此同时，通过组织参观，提供信息咨询处、宣传册，开展媒体和讲座活动等，可进一步促进人们加入这一参与式过程。2000~2005年间，慕尼黑市规划与建设部开展了6.4km长的河段修复工程。巴伐利亚水资源管理办公室监督并评估了包括修复成功率在内的“生活实验室”成果。

作为该项目的第二部分，1.6km长的伊萨河北部河段修复工程采取了不同的修复流程。2003年，慕尼黑市政府联合巴伐利亚州水务局根据国际规范就这一更具城市特色的河段组织了一项景观设计竞赛。参赛景观设计师和水利工程师团队的设计方案需符合三大修复目标。最终的获胜方案在保留河道的城市特色的同时，加入了少量自然元素，并设计了质朴的灰色防洪基础设施；而获得二等奖的方案则展现了更为浪漫的景观，其所描绘的蜿蜒河流和自然野趣不仅使公众相信通过自然过程修复河流可以成为现实，亦挑战了当前的防洪技术瓶颈[52]。由于评委会的决定与公众的期待相悖，最终，由伊萨河联盟领导的民众组织了反对获胜方案的集会，并获得了当地媒体的支持[52]。虽然根据流程规则，获胜者应按照设计方案进行建造，但由Irene Burkhardt景观设计公司（即现在的BEM公司）、SKI工程公司、Mahl–Gebhardt方案设计公司，以及 Reichenbach–Klinke/Schranner建筑设计公司组成的优胜团队，决定重新考虑他们的设计方案。为了满足公众的要求，新的设计方案融入了浪漫的设计元素，如在防洪基础设施中融入了形态优美的河岸和岛屿（图6）。SKI工程公司对设计进行了测试，而河道的最后100m部分则由慕尼黑工业大学利用1:20的模型进行模拟验证[87]。

最终实施的伊萨河计划可实现蓝绿及混合解决方案相结合的多功能河流景观。该计划在世界范围内引发了广泛影响，被誉为“自然的回归”，其在规模上超越了许多此前的城市河流修复项目[52]。在2005~2013年间，该项目成功降低了极端洪水事件的风险。修复后的伊萨河可抵御1 200m^3/s流量的洪水，而在该NBS实施前，区域内能够支持的最大泄洪流量为900m^3/s。在建有水库的情况下，百年一遇的洪水流量标准约为1 150m^3/s，而在水库建成以前，该地区有记录的最大洪水流量为1 440m^3/s[88]。此外，该项目满足了公众对于滨水休闲娱乐功能的迫切需求，并改善了河流的生态状况[89]。伊萨河计划表明，通过长期的社会、文化和技术协商，防洪方案可以提供休闲空间，而公共空间也可以成为蓄洪空间。该规划过程证明了环境对非常规动态适应性景观规划[90]的需求正在持续增加，这为提升景观韧性带来了新的机遇。除此之外，项目表明尽管公众参与和协同设计在实施过程中可能耗时较长，但其确保了项目能够被广大市民所接受，并有利于鼓励创新。伊萨河计划展示了由城市居民共治共享的NBS设计。该计划提升了社会—生态韧性，并表明生态价值这一更高的社会需求已经出现。

“生态实验室”概念于20世纪90年代早期兴起，并从2006年开始在治理过程中发挥作用[69]，而针对伊萨河计划的“生活实验室”始于

provide info points, brochures, media, and lectures to inform users about how to engage with the participative process. The City of Munich’s Planning and Building Departments carried out the restoration works of the 6.4-kilometer-long river stretch between 2000 and 2005. The Bavarian State Office for Water Management monitored and evaluated the Living Lab outcomes such as the restoration success.

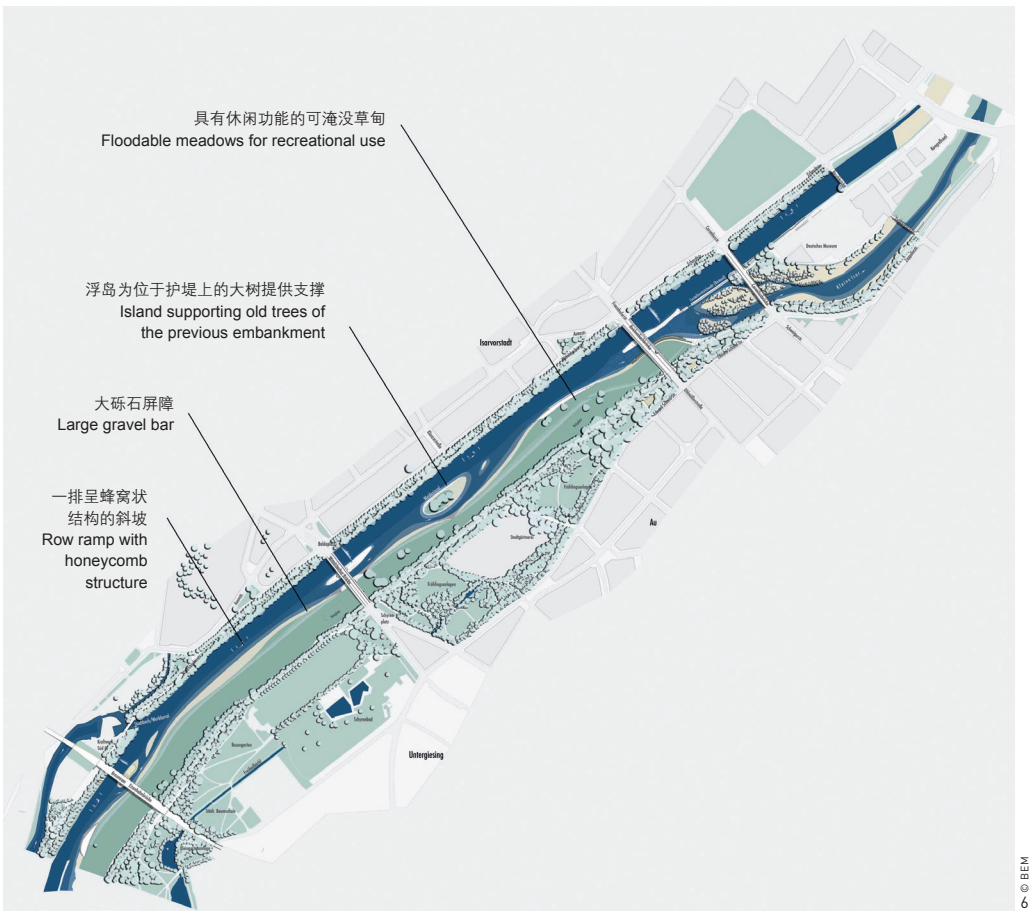
The second part of the project, namely the 1.6-kilometer northern Isar River Stretch, followed a different procedure. This section had an urban character and the City of Munich together with the Bavarian Water Board organized a landscape design competition in 2003 according to international regulations. Teams of landscape designers and hydraulic engineers were asked to provide design schemes that fit the three goals of the restoration. While the design of the first prize had an urban character with controlled nature and an “honest” design of the flood protection infrastructure, the second prize showed a more romantic scenery with meanders and wilderness that endorsed public belief in the possibility of a restoration of the natural processes and that challenged the reality of flood protection technical constraints[52]. The decision of the jury contradicted public expectations. Public engagement led by the Isar Allianz militated against the winner, organized public meetings and got the favours of the local press[52]. While according to the rules of the procedure, the winner should build up their design, the first prize planning team including Irene Burkhardt Landschaftsarchitekten (now BEM), SKI Engineers, Mahl-Gebhardt Konzepte, and Reichenbach-Klinke / Schranner Architekten, decided to review their design. Willing to satisfy public desires, they integrated romantic design elements, such as curvy shores and islands, by covering and greening the flood protection infrastructure (Fig. 6). SKI Engineers tested the design. The final 100-meter section required a simulation by the Technical University of Munich using a 1:20 model[87].

The implemented Isar-Plan is a multifunctional riverscape that combines blue, green, and hybrid solutions. It has been worldwide acclaimed as a “return to the wild” and surpassed many previous urban river restorations in terms of its scale[52]. The project was successful in mitigating risks from extreme flood events in 2005 and 2013. The restored Isar can mitigate a 1,200 m^3/s flood. Before NBS implementation, the area could support a maximal discharge of 900 m^3/s. HQ 100 with the reservoir is estimated at 1,150 m^3/s and the highest flood recorded before the reservoir was built was 1,440 m^3/s[88]. Furthermore, the project has satisfied high recreational demands and improved the river’s ecological status[89]. The Isar-Plan shows that due to long-term social, cultural, and

6. 伊萨河北部河段最后1.6km部分的修复设计方案，该方案融入了浪漫的景观元素。

6. Restoration design of the last 1.6-kilometer Northern Isar River Stretch after integration of romantic elements.

1987年，是这一概念的早期实践先驱。伊萨河修复项目的参与式过程并未遵循既有的概念框架，而是在“生活实验室”应用逐渐成熟后才尝试对其概念进行描述和定义。事后分析表明该计划符合“生活实验室”的全部核心特征（表3）和几乎所有步骤（表4），而一些主要区别则在于组织形式的不同。按照部分“生活实验室”的定义，所有利益相关者都需要通过系统抽样进行招募[69]，而在伊萨河项目中，“生活实验室”的组织形式更加灵活，并以参与规划过程的利益相关者的意愿为基础[85]，且不存在针对利益相关者进行的身份认定、知识图谱分析和激励措施。作为该项目的联合领导者，巴伐利亚州水资源管理机构和慕尼黑市政府邀请所有对河流管理感兴趣的利益相关者（不管是出于个人兴趣，还是工作职责所在）参与规划过程。这一自发过程印证了埃莉诺·奥斯特罗姆[6]的观点，即根据社会—生态原则，自组织使用者和领导者会对资源进行持续有效的管理。然而，作为聚集了本地非政府组织的游说团体，伊萨河联盟本身并没有决策权[86]。在伊萨河最后1.6km河段的协同设计过程中，项目领导者甚至将该联盟排除在外，因为他们更倾向于和每个非政府组织进行直接沟通。因此，伊萨河联盟改用了基层游说的方法。此外，依据部分“生态实验室”的定义，其应当聚焦于在项目实施后对设计方案进行经验总结，并加以推行[69]。



6 © BEM

technical negotiations, risk mitigation solutions can provide room for recreational opportunities and that public spaces can provide room for flooding. The planning process testifies to an increasing demand for informal, dynamic, and adaptive landscape planning[90] offering new opportunities for enhancing landscape resilience. Furthermore, the project demonstrates that public participation and active co-design may take a long time but secure project acceptance and produces innovation. The Isar-Plan is a showcase of NBS design for and by urbanites. It emphasizes that a higher societal demand for ecological values has already emerged, leveraging socio-ecological resilience.

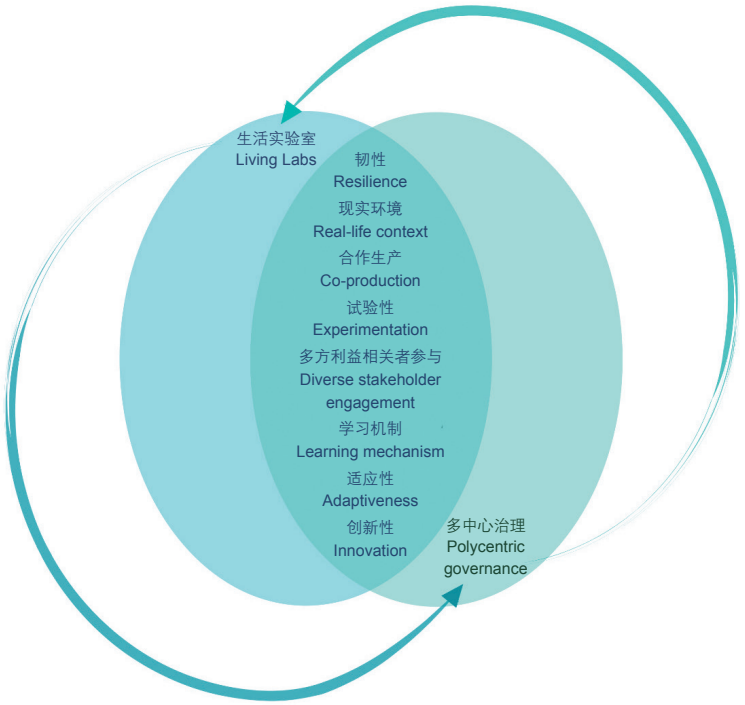
With the concept of the Living Lab emerging in the early 1990s and playing a role in governance processes since 2006[69], the ad hoc Isar-Plan Living Lab began as early as 1987, making itself a forerunner of this concept. The participative process did not follow a conceptual framework but matured progressively before first attempt to capture and define the Living Lab concept. The ex-post-analysis showed that it fulfilled all the core characteristics (Table 3) and almost all the steps of a Living Lab (Table 4). The main difference lies in the Living Lab set-up. Some Living Lab definitions request a systematic sampling and recruitment of all relevant stakeholders involved[69]. At the Isar, the set-up was more ad hoc and based on the willingness of the stakeholders to participate to the planning process[85]. No stakeholder identification, stakeholder knowledge mapping or stakeholder incentivisation took place. All the stakeholders interested in the river management (through personal interest or professional obligation) were invited by the project co-leader, namely the water agency and the City of Munich, to participate to the planning process. This spontaneous process mirrors Elinor Ostrom’s idea[6] that according to the socio-ecological principle, self-organizing users and leaders would develop an effective and sustainable management of a resource. However, the Isar Allianz, an advocacy group gathering local NGOs, did not have the power of decision-making[86]. The project leaders even excluded it from the co-design process of the last 1.6 km, as they preferred dealing with each NGO separately. As a result, the Isar Allianz changed its approach into grassroots lobbying. According to some Living Lab definitions, the Living Lab should focus on the upscaling of the designed solution after implementation[69]. After the Isar restoration, the Isar-Plan Living Lab did focus on the upscaling of the measures up- and downstream, leaving the monitoring and management of the restored area in the hands of the river authorities in charge and the river owners, which were the City of Munich’s Planning and Building Departments. The recent history of the Isar shows that cooperation between the different

在伊萨河完成修复后，该项目的“生态实验室”的确对其河道修复经验进行了总结，并应用于上下游修复工作中，同时责成负责该流域的河流管理局以及河流所有者（即慕尼黑市规划与建设部）对修复区域进行监督管理。伊萨河的这些经验表明，“生态实验室”不同利益相关者之间的合作有利于更好地设计和管理NBS，从而避免出现重大的生态破坏。

3.3 多中心治理与“生活实验室”之间的概念联系

多中心治理和“生态实验室”概念都力求用更全面的方法来解决复杂或“棘手”问题[91]。多中心治理是一种构建政治力量（机构）的概念化方式，而“生态实验室”则是创造服务、公共物品、市场产品或创意的工具或框架。因此，这两个概念在本质上完全不同。其截然不同的应用领域进一步导致二者在既有研究中极少被联系在一起。当在同行评议文章数据库Scopus中按照标题、摘要、关键词及作者等搜索这两个术语时，并未获得任何结果。在检索范围扩展至全文后，共找到27篇文章，但大部分都未对这两个概念进行深入探讨。

然而，从表1和表3可以推断，多中心治理和“生活实验室”有着如图7所示的多个共同要素。因此，“生活实验室”可以满足多中心治理系统的诸多要求，反之亦然。最重要的是，合作生产对于这两个概念而言都至关重要。多中心治理意味着各决策中心在合作关系中需要相互配合，而“生活实验室”则意味着合作生产产品和服务。由于多中心治理和“生活实验室”都明确要求要有广泛的利益相关者参与其中，可通过二者在雪莉·R·阿尔斯坦的市民参与梯度模型[92][93]中所



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7. 图解对比多中心治理和“生活实验室”的关键特征

7. Schematic comparison of the key characteristics of polycentric governance and Living Labs

stakeholders of a Living Lab can enable a better design and management of NBS, thus avoiding major ecological damages.

3.3 Conceptual Linkages between Polycentric Governance and Living Labs

Polycentric governance and the Living Lab concepts both strive for more holistic approaches to resolve complex or “wicked” problems[91]. While polycentric governance is a conceptual way of organizing political power (authority), the Living Lab is a tool or a framework for creating services, public goods, market products or ideas. Both concepts are thus innately different — apples to oranges. Their contrasting application fields further contribute to the fact that the two concepts are rarely associated in literature. Indeed, a search of both terms in main fields (title, abstract, keywords, and authors) in the peer-reviewed article in database Scopus returned no results. When full text was included in the search fields, 27 articles were found, most only mentioning the concepts peripherally.

Nevertheless, as can be deduced from Tables 1 and 3, polycentric governance and the Living Lab share several common elements, captured in Figure 7. This entails that using a Living Lab setting can help fulfil many requirements of an effective polycentric governance system, and vice-versa. Most prominently, co-production play vital roles for both concepts. Polycentric governance connotes that decision centers take each other into account in cooperative relationships, while the Living Lab implies the co-production of goods and services. Wide stakeholder participation being an explicit requirement of both polycentric governance and the Living Lab, a further way to compare the Living Lab and polycentric governance is through the place they occupy on Sherry R. Arnstein’s Ladder of Citizen Participation[92][93]. Arguably, ideal polycentrism and the Living Lab are both situated towards the top of this ladder, implying a higher citizen participation — full citizen control.

As highlighted in Figure 7 (and besides their fundamental difference noted above), one of the two concepts’ main distinctions is the real-world settings being an explicit prerequisite of the Living Lab. While polycentric governance has also been applied in real-life contexts, the lack of concrete principles allowing for the operationalization of polycentric governance represents one of the concept’s criticisms[34]. Yet, both concepts have the potential to complement each other. In the context of landscape resilience, both present advantages for dealing with risks. Landscape resilience issues being likely to span over multiple jurisdictions and governance levels, polycentric governance coupled with the Living Lab could offer the connectivity and adaptiveness required to cope with risks.

处的位置进行进一步对比。可以说，理想的多中心主义和“生活实验室”均处于阶梯顶端，它们都具有非常高的市民参与度，即市民可完全介入。

从图7可以明显看出，除上述基本区别以外，这两个概念的另一个主要区别是“生活实验室”常基于现实生活环境开展。尽管多中心治理也已被应用于现实环境，但由于缺乏可操作性，这一概念常遭到诟病[34]。不过，这两个概念之间存在互补的可能。在景观韧性的背景下，二者都表现出在风险应对方面的优势。景观韧性问题常跨越多个辖区和治理层级，而将多中心治理与“生活实验室”相结合可以在风险应对过程中推动不同辖区的协作与相互适应。此外，二者都提供了处理复杂景观韧性问题的创新方法，而此类问题涉及的各方常常具有不同价值观且利益相互冲突[71]。

因此，这两个概念并非互斥。相反，多中心治理背后的理念常常会为现代的“生活实验室”带来启发[94]。举例来说，当通过“生活实验室”制定公共政策与发展公共服务时，所谓的“政策创新实验室”或“政府创新实验室”可被视为这两个概念的融合，即利用“生活实验室”方法在现实环境中检验政策，并利用多中心治理聚集来自不同机构、不同行业的利益相关者[95]。同样，已应用于气候治理的多中心治理试验[96]也显示出了“生活实验室”和多中心治理的特征。例如，在气候治理试验中，针对气候变化这一现实中的“棘手”问题，可以协同设计政策解决方案并对其进行验证，由此形成一种“生活实验室”模式，同时通过加强多个独立治理部门之间的合作实现多中心性[97]。这些方法的核心都基于同一种认知，即有效的治理变革是自下而上的。

4 结论

本文阐释了如何利用多中心治理和“生活实验室”驱动创新，以提高陆地和河流景观的社会—生态韧性。多中心治理要求决策机构进行合作，以促进不同机构在政策实施过程中达成一致，而“生活实验室”则有助于打破机构的限制实现技术创新。二者均有助于打破思维的桎梏，探索应对社会挑战的创新性解决方案。由于多中心治理和“生活实验室”系统的开发过程耗时极长，因此政治意愿是不可或缺的推动因素，而系统开发成功的关键更在于对多方合作优势进行长期的宣传普及，以及利益相关者之间彼此信任的建立[98]。

伊萨河计划是这两个概念的典型实际应用。该计划通过一个密集而长期的参与式过程，首次促成相关机构和当地利益相关者紧密参与到NBS的协同设计之中。伊萨河计划的治理包含多中心要素，如由不同

Moreover, both concepts offer innovative ways of dealing with the complexity of landscape resilience problems, which generally concern a variety of stakeholders with different worldviews and conflicting interests[71].

Hence, both concepts are far from mutually exclusive. It appears that the ideas behind polycentric governance have often inspired the development of modern Living Labs[94]. For instance, so-called “Policy Innovation Labs” or “Government Innovation Labs,” which consist in the development of public policies and services through a Living Lab setting, could be considered a fusion of both concepts: a Living Lab approach by co-testing policies in a real-life setting, and a polycentric governance aspect by bringing together stakeholders from various institutional levels and straddling various sectors[95]. Similarly, polycentric governance experiments, as have been used in climate governance[96], also present characteristics from both the Living Lab and polycentric governance. For example, in climate governance experiments, climate change provides a real-life “wicked” problem for which policy solutions can be co-designed and co-tested, thereby representing a Living Lab set-up, while simultaneously satisfying polycentricity by enabling the interaction of several independent governance units[97]. At the heart of these various approaches lies the recognition that effective governance change comes from below.

4 Conclusion

This paper has shown how polycentric governance and the Living Lab can drive innovation for enhancing the socio-ecological resilience of land- and riverscapes. While polycentric governance requires the cooperation between decision-making institutions in order to agree and decide on implementation beyond institutional boundaries, the Living Lab approaches help develop technical innovations beyond their source sector. Polycentric governance and the Living Lab promote thinking outside the box to find innovative solutions to societal challenges. The development of polycentric governance and the Living Lab systems are time-consuming processes that require political willingness. Key success factors are the long-term education about the benefit of cooperation and trust built between stakeholders[98].

The Isar-Plan represents a practical illustration of both concepts. The Isar-Plan was a forerunner by closely involving institutions and local stakeholders in the co-design of NBS through an intensive and longstanding participatory process. The Isar-Plan governance presented elements of polycentricity, such as the decision-making process led by different decision centers and the interaction of different sectors at different geographical

决策中心领导的决策过程，以及在地理尺度下不同部门之间的合作。该案例表明“生活实验室”可被灵活应用于各种具有不同环境和社会背景的案例中。本研究凸显了合作对于实现多重目标、创新和长期社会—生态韧性的促进作用。

伊萨河案例展示了如何利用“生活实验室”和多中心治理概念提高社会—生态韧性。尽管这两个概念之间的联系还有待进一步研究，但本文初步尝试探究二者之间潜在的互补关系及其中所蕴含的机遇。该案例表明，当自主的多层级决策者共同参与政策方案制定时，“生活实验室”可以成为一种应用多中心治理的方法，反之亦然。**LAF**

致谢

本文是慕尼黑工业大学战略景观规划与管理系与国际应用系统分析研究所（IIASA）的合作成果。在此，作者感谢“以自然为依据”项目组所有成员的付出，感谢所有资料提供者和审稿人，并向所有支持本研究并为之付出时间、经验和知识的人士表达诚挚的谢意。作者尤其感谢来自Burkhardt | Engelmayer景观设计与城市规划事务所的奥利弗・恩格迈尔和所有受访者，并衷心感谢与我们共同开展建设性会议及访谈工作的克劳斯・巴穆勒、乌尔里希・伊林、丹妮拉・施图斯、沃尔特・宾德尔、尼科・多林，以及罗尔夫・雷纳。

scales. The case analysis suggests that the Living Lab activities could be applied in a flexible way adapting to the environmental and societal specificity of each case. This study highlights that cooperation can help achieve multiple goals, innovation, and a long-term socio-ecological resilience.

The Isar case demonstrates how the concepts of the Living Lab and polycentric governance can leverage increased socio-ecological resilience. While further research is needed to explore the links between the two concepts, this paper represents a first attempt to advance understanding of their potential complementarities and the opportunities they offer. The Isar case shows that the Living Lab can be a way of applying polycentric governance (and vice-versa) when autonomous and multi-scale decision-makers are collaboratively involved in the design of policy solutions. **LAF**

ACKNOWLEDGMENTS

This contribution is a result of a cooperation between the Chair for Strategic Landscape Planning and Management of the Technical University of Munich and the International Institute for Applied Systems Analysis (IIASA). Authors thank all the members of PHUSICOS for their input; thank all the data providers and external reviewers. Authors like to express sincere appreciation to all who contributed time, experience, and knowledge to support the development of this contribution. They especially like to thank Oliver Engelmayer (Burkhardt | Engelmayer – Landschaftsarchitekten Stadtplaner) and all interviewees. Authors gratefully acknowledge the constructive meetings and interviews with Klaus Bäumler, Ulrich Illing, Daniela Schaufuß, Walter Binder, Nico Döring, and Rolf Renner.

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