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Abstract

This paper introduces a participatory framework for Sustainability Assessment (SA) for urban Integrated Watershed Management (IWM). The framework is applied to the Lihu Lake Basin (Wuxi City), where between 2002 and 2012 an IWM program was implemented, coordinating water environmental management measures with urban planning. The framework for SA introduced in this paper is based on a Multi-Criteria-Decision-Analysis (MCDA) approach integrating criteria of environmental, economic, and social sustainability. Local stakeholders were engaged in focus group discussions (FGDs) to validate and weigh criteria and attributes employed in the SA framework. Results of the model application indicate that the programme implemented in the Lihu Basin yielded positive results in enhancing environmental conditions, providing more sustainable avenues of environmental management funding, and fostering economic growth. Despite efforts put forward by local authorities, performance of social indicators was comparatively worse, due to relocation policies, increase in housing prices, and scarce public participation. Results show that decision makers pursued viability, rather than comprehensive sustainability.

Keywords	water management, urban renewal, sustainability, assessment, MCDA, China
Manuscript region of origin	Europe

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Submission Files Included in this PDF

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Lihu_Participatory SA_Authors.pdf [Cover Letter]

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Lihu_Participatory SA_Response to Reviewer's Comment [No.1].pdf [Response to Reviewers]

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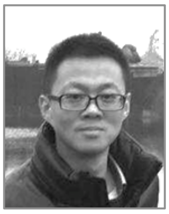
Authors' Profiles

Daniele Brombal is researcher at the Department of Asian and North African Studies, University Ca' Foscari Venice. His current research focuses on China's decision-making processes in the fields of environmental management and territorial planning. Between 2007 and 2010 he was research consultant and programme officer at the Embassy of Italy Beijing. He was 2009 fellow of the United Nations Department for Economic and Social Affairs (UN/DESA). Between 2012 and 2015 he took part in the EU FP-7 Marie Curie IRSES projects 'Evaluating Policies for Sustainable Energy Investments' (EPSEI) and 'Global Partners in Contaminated Land Management' (GLOCOM), being hosted as IRSES fellow by the Chinese Research Academy of Environmental Sciences (CRAES). Since 2016 he has been contributing to the activities of the EuropeAid project 'New Pathways for Sustainable Urban Development in China Medium-Sized Cities' (MEDIUM). He is research associate of T.wai (Torino World Affairs Institute), a think-tank devoted to policy oriented research in the field of global politics. Daniele holds a PhD in Languages, Cultures and Societies (University of Venice, 2012). His recent works are published on the journals *Environmental Impact Assessment Review*, *Land Use Policy*, *Journal of Cleaner Production*, and *China Perspectives*.



Niu Yuan is associate professor at the Chinese Research Academy of Environmental Sciences (CRAES). His research focuses on lacustrine environmental management and freshwater ecology. He is author/coauthor of over 20 papers published in international peer reviewed journals.

Lisa Pizzol holds a Ph.D. in Environmental Science at the University Ca' Foscari Venice. Her research focuses on risk assessment and management of contaminated sites and brownfields, analysis of stakeholders' roles and perspectives in land regeneration projects, application of multi-criteria decision analysis methodologies for the evaluation and ranking of different stakeholders' perceptions, sustainability assessment of remediation alternatives and development of Decision Support Systems for environmental issues. She has been involved in the preparation of the white paper related to Sustainable Remediation in Italy edited by the Sustainable Remediation Forum (SURF) Italy. She was in China in 2008 and 2011, as visiting fellow at the Chinese Research Academy of Environmental Sciences (CRAES) for the application of DESYRE (Decision Support Systems for the rehabilitation of contaminated sites) to a Chinese case study, within the IRSES project EPSEI. She was the coordinator of the research activities within the Work Package 1 of the Timbre project: TIMBRE (Tailored Improvement of Brownfield Regeneration in Europe), EC FP7 (Grant Agreement Number: 265364), 2011-2014. She is the president of the spin off company GreenDecision srl. She is now working in the sustainability assessment of products, processes, services and organizations by applying Life Cycle Assessment (LCA) software, carbon footprint and water footprint tools.

Angela Moriggi is researcher at Natural Resources Institute Finland (Luke) and EU Marie Curie ITN fellow of the SUSPLACE project. Her current research focuses on sustainable placeshaping practices. She has spent extended periods of time in China, as Marie Curie IRSES fellow at the Chinese Research Academy of Environmental Sciences (CRAES) and Beijing Normal University (BNU), as intern at the Science, Technology and Environment Section of the EU Delegation in China, and as student at the Chinese Academy of Social Science (CASS) and at Zhejiang University (ZJU).

Jinzhi Wang is a research fellow at the Institute of Wetland Research, Chinese Academy of Forestry. Her research focuses on the biogeochemical cycle of nitrogen and phosphorus in the wetland ecosystem. Between 2012 and 2016, she was a postdoctoral fellow of Chinese Research Academy of Environmental Sciences, and in 2014 took part in the EU FP-7 Marie Curie IRSES programs 'Evaluating Policies for Sustainable Energy Investments' (EPSEI) and 'Global Partners in Contaminated Land Management' (GLOCOM). Jinzhi Wang holds a PhD in Environmental Sciences (University of Chinese Academy of Sciences, 2012). Her recent works are published on *Journal of Environmental Quality*, *Environmental Science and Pollution Research*, *Environmental Earth Sciences*, and *Waste Management*.

Andrea Critto is associate professor at the Department of Environmental Sciences, Informatics and Statistics of Ca' Foscari University Venice. Actively involved in international/national project proposals and development. He is member of SETAC Europe and EGU. Research activity on Environmental Risk Assessment associated with: formulation of Environmental Quality Standards and planning of environmental monitoring; development of Decision Support Systems for the integration of environmental, technological, economical and societal issues; selection/comparison of remedial technologies for contaminated sites; nanotechnology; climate change environmental impacts. He was awarded a scholarship from the Science & Technology Fellowship Programme in China (STF CHINA), supported by the European Parliament to build bridges between the EU and China in the Science & Technology domain. He has been a foreign expert confirmed by the State Administration of Foreign Expert Affair of the People's Republic of China. He is also senior scientist at the Risk Assessment and Adaptation Strategies Division at the Euro-Mediterranean Centre for Climate Change (CMCC, Italy). He has more than 80 scientific publications in international refereed journals.

Jiang Xia is researcher at the Chinese Research Academy of Environmental Sciences. Her research focuses on surface waters environmental quality. Amoing other duties, she is Secretary of the water environment branch of the Chinese Society of Environmental Sciences, Member of the "National Experts Group for the Sperimentation of Comprehensive Remediation of Land, Rivers, and Lakes" of the Minisrtry of Finance, Ministry of Environmental Protection, and Ministry of Water Resources, and Editor of the journal *Reserach of Envioronmental Sciences* (huanjing kexue yanjou). With her team in recent years she has devoted much efforts to the study of environmental conditions in the Lihu basin.

Beibei Liu is associate professor at School of the Environment, Nanjing University and adjunct professor at Johns Hopkins-Nanjing Center. She conducts research in the field of Environmental Policy Analysis and Sustainable Energy Management. Till now she has published more than 30 peer-reviewed articles on international journals including *Environmental Science &Technology*, *Journal of Environmental Management*, *Environment and Planning C: Government and Policy*, *Environmental Communication*, *Science of the Total Environment* and so on. Meanwhile, she works as principal investigator in more than 10 multi-lateral, national and provincial research projects.

Antonio Marcomini is professor of Environmental Chemistry at the University Ca' Foscari of Venice. Graduated from the University of Padua, he was post-doctoral fellow at the University of Toronto, Lash Miller Chemical Institute, Canada (1982–83), and tresearch associate at the Polytechnic of Zurich, ETH-EAWAG, Switzerland (1985–86). Coordinator/partner of several international and national research projects, he is author/coauthor of over 230 papers published in international peer reviewed journals, editor and coauthor of two books. Consultant of national and international advisory/expert committees on chemical environmental quality, environmental risk/ impact for assessment, definition and implementation of environmental quality standards. More information on http:/www.ecraunit.com.

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Venice, January 15, 2018

To:
Prof. Martin Beniston
Editor-in-Chief
Environmental Science & Policy

Dear Prof. Beniston,

please find attached our manuscript entitled "A participatory sustainability assessment for integrated watershed management in urban China" for review and possible publication on *Environmental Science & Policy*. The paper stems from two EU research projects, namely "Global Partners in Contaminated Land Management" (GLOCOM) and "New Pathways for Sustainable Urban Development in China Medium-Sized Cities" (MEDIUM).[1]

Our work seeks to contribute to the definition of scientifically reliable, politically relevant, and socially considerate tools for the evaluation of territorial management. We focus in particular on the integration of watershed management with urban policies and its potential to sustain the pursuit of sustainability. The issue is of great political and societal relevance in China, where relentless urbanization has brought about a plethora of institutional and technical innovations seeking to link environmental management with urban policies for sustainable development.

To what extent these initiatives have contributed to foster sustainability remains uncertain. This is due both to scientific and sociopolitical factors. Many assessments carried out so far are either analytically inconsistent, or suffer from the dearth of accurate data and information. Moreover, they are often characterized by a lack of public engagement, that jeopardizes their relevance to the local context and to aspirations of local actors.

With our work we have tried to address these shortcomings, by developing a participatory Sustainability Assessment (SA) framework through the engagement of local residents, political actors, and scientists. The framework follows a multi-criteria logic, in order to better grasp impacts on different sustainability dimensions and enhance its relevance to the local environmental, social, and political peculiarities. We have applied our model to the case of the Lihu lake basin, located under the jurisdiction of Wuxi city (Jiangsu province). The case is generally considered in China as epitomizing the emergence of novel paradigms of territorial management.

[1] GLOCOM was funded by the EU FP-7 Marie Curie IRSES scheme, whole MEDIUM is funded by the EuropeAid EU-China Research and Innovation Partnership ICI+/2014/348-005.

We are convinced that our work would be of great interest to the audience of *Environmental Science and Policy*, both thanks to its innovative nature and its topical focus. Indeed, the manuscript introduces an original tool for the assessment of integrated watershed management, developed by means of participatory practices engaging a wide array of actors. Secondly, it relates to an area of science-policy-societal interaction greatly debated in today's China and destined to have far reaching consequences for environmental and urban policy.

In my role of corresponding author, I therefore look forward to your acceptance of the present submission. For this purpose, I hereby certify that the work included in the manuscript is original and has not been previously published in whole or in part. I also certify that all authors have perused the final draft of the manuscript and approved its submission to *Environmental Science and Policy*.

Please do not hesitate to contact me for any further clarification you may deem necessary.

Yours sincerely

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Venice, March 19, 2018

To:
Prof. Martin Beniston
Editor-in-Chief
Environmental Science & Policy

Dear Prof. Beniston,

please find attached our revised manuscript, entitled "A participatory sustainability assessment for integrated watershed management in urban China". We have amended the manuscript based on the Reviewer's comments received on March 4, 2018. You can find modifications in paragraph 3.1 (lines 148-152, 154-160, note[6]), 3.2 (lines 172, 175-6), and in references (line 608). Acknowledgments have been slightly modified as well. All modifications are in track change.

The Reviewer provided one comment and one suggestion. The comment related to the usefulness of semi-quantitative assessment systems such as the one we have employed. We concur with the reviewer in that scoring systems may have limitations, since they reflect choices made by the researchers in defining thresholds of relevant classes. Indeed, this is one of the key challenges inherent in MCDA modeling. We believe that this limitation can be overcome by avoiding black-box effects. By allowing the reader to fully understand the logic of scoring, the model is left open to future improvements and adjustments to different cases/projects. This logic guided us through our work and can be appreciated both in the methodological section of the paper and in its supplementary materials, where we provide a thorough explanation of the procedures used in defining classes and relevant scoring. With reference to weighing, we applied similar principles of transparency during stakeholders participatory processes, by clarifying the method of importance scoring and that it would be translated into weighs (cfr. paragraph 3.2). In fact, we agree with the Reviewer that at times weighs may not adequately convey the preference attributed by stakeholders to one dimension (or criterion) or another. For this reason, based on the stakeholders' input we decided to include in the equation a veto function (θ) reflecting the importance attributed by participants to environmental quality (par. 3.5).

Apart from these general comments, the Reviewer suggested to consider the new ISO standard on sustainable remediation (ISO18504:2017) as a relevant benchmark. We have carefully read the new standard. Indeed it constitutes an useful instrument, providing researchers and practitioners with guidance on the structuring of assessment processes. The standard provides as well a ready-to-use checklist to appraise the applicability of assessment tools for a specific project/case. The perusal of the standard has allowed us to (a) further refine the normalization of the terminology used in the manuscript; and (b) reflect on the procedure of assessment and the rationale behind the choice of multicriteria modeling. As a matter of fact, by reading the standard we were reassured about the appropriateness of the procedure followed during preparation and application of our assessment. This is probably due to the fact that we had considered as benchmarks also practices developed by organizations/networks cited in the ISO standard as point of reference in the field. The manuscript has been amended consistently in paragraphs 3.1 (lines 148-152, 154-160, note[6]) and 3.2 (lines 172, 175-6), and in references (line 608). This said, we believe it should be clarified here that the standard was not yet available when we were carrying out our research work and as such it would have been impossible for us to employ it. This is a pity, since it could have provided a streamlined guidance, improving the efficiency of our work.

I hope this reply and modifications made to the manuscript can address the Reviewer′s concerns about our work. Please do not hesitate to contact me for any further clarification you may deem necessary.

Yours sincerely

Daniele Brombal
Corresponding Author

A participatory sustainability assessment for integrated watershed management in urban China.

Highligths:

- IWM in urban China obtains positive results in overcoming the environment-economy divide.
- This happens at considerable social costs.
- Social sustainability needs streamlining into China's integrated territorial management.
- Participatory research must play a role in fostering sustainability of China's integrated territorial management.
- The methodology employed in the present study can assist in such processes.

A participatory sustainability assessment for integrated watershed management in urban China.

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Abstract: This paper introduces a participatory framework for Sustainability Assessment (SA) for urban Integrated Watershed Management (IWM). The framework is applied to the Lihu Lake Basin (Wuxi City), where between 2002 and 2012 an IWM program was implemented, coordinating water environmental management measures with urban planning. The framework for SA introduced in this paper is based on a Multi-Criteria-Decision-Analysis (MCDA) approach integrating criteria of environmental, economic, and social sustainability. Local stakeholders were engaged in focus group discussions (FGDs) to validate and weigh criteria and attributes employed in the SA framework. Results of the model application indicate that the programme implemented in the Lihu Basin yielded positive results in enhancing environmental conditions, providing more sustainable avenues of environmental management funding, and fostering economic growth. Despite efforts put forward by local authorities, performance of social indicators was comparatively worse, due to relocation policies, increase in housing prices, and scarce public participation. Results show that decision makers pursued viability, rather than comprehensive sustainability.

Keywords: water management; urban renewal; sustainability; assessment; MCDA; China.

1. Introduction

In the last quarter century a wide consensus has emerged over the potential of Integrated Watershed Management (IWM) in fostering sustainable urban development (Kidd 2007; Schussel and Neto 2015). IWM's theory and practice are informed by the concept of Integrated Territorial Management (ITM), aiming at the harmonization of environmental, economic, and social goals in the development of spatially defined areas (UN 1992; De Quevedo 2014). Such harmonization requires the establishment of multi-sectorial synergies and the re-scaling of policy, planning, and management functions, based on natural systems' boundaries. Water management in densely populated areas and rapidly urbanizing regions has constituted one of the main fields for experimentation in this respect (De Graaf and Van Der Brugge 2010). In China, IWM has been subject to intense scrutiny and debate. The experience matured in the EU with the Water Framework Directive (WFD) has been a particular source of inspiration for Chinese researchers and decision-makers, informing research and policy action (Deng et al. 2016). With particular reference to urban areas, in 2014 the National Development and Reform Commission (NDRC)[1] called for the establishment of a nationwide pilot program for 'the integration of several plans into one' (*duoguiheyi*), based on ITM principles (Tzou et al. 2017). Cities where pressing issues of water contamination and pollution intersected with rapid urbanization have been particularly active in experimenting with the harmonization of water environmental management and urban planning (Brombal and Moriggi 2017). In their relentless growth, many Chinese cities have expanded to include areas previously destined to agriculture, severely affected by non-point sources water pollution. The economic potential for residential and recreational exploitation of areas close to rivers, lakes, and wetlands has put in place incentives to establish watershed environmental management programs, closely coordinated with urban planning. To what extent these initiatives have contributed to meet sustainability goals remains unclear. This uncertainty is due to several factors. First, despite inter-sectorial coordination at local level, ex-post evaluation systems remain fragmented. Programs

[1] NDRC is the most important China's ministerial body, responsible for policy macro planning

of watershed management are still evaluated vis-à-vis the achievement of goals of environmental quality and resource utilization. Second, the evaluation of progress towards urban sustainability is carried out by taking administrative entities as units for data collection and analysis. It is therefore difficult to appraise the contribution made by measures devised according the boundaries of natural systems, as in the case of IWMs. Moreover, sustainability indicators systems used in China are known to be scarcely effective in grasping the social dimension of sustainability (Shen and Zhou 2014). Finally, participatory processes are still in their infancy in China. On the one hand, the country has widely experimented with forms of public participation within environmental and urban planning processes (Yang 2008). On the other hand, such processes have been frustrated by the peculiarity of China's political system and by the "expert cult" (*zhuanjia chongbai*) phenomenon, causing a gross underestimation among decision-makers of the public's capacity to contribute to decisions whose outcomes affecting their lives (Tang et al. 2008, Jacka 2009, Zhang and Barr 2013). This ambivalence has jeopardized the possibility to establish meaningful participatory processes aimed at defining the criteria for evaluation of public projects, programs, plans, and policies (Brombal, Moriggi and Marcomini 2017). Our work seeks to contribute to addressing these gaps, by developing a participatory ex-post Sustainability Assessment (SA) framework applicable to IWM programs tied to urban planning. The framework is used to appraise the case of the Lihu Lake Basin (Wuxi City), where between 2002 and 2012 a government-led program was carried out to reduce water environmental pollution. The program was informed by an integrated territorial planning approach, combining water environmental management, functional rezoning, and urban renewal. The paper is divided in five parts. We first introduce our case study and the criteria used in its selection (paragraph 2). The following paragraph presents the methodology used in developing our Sustainability Assessment (SA) and the participatory practices used to engage local stakeholders[2] (paragraph 3). In the fourth paragraph, we introduce the results of the model application to the Lihu lake basin. We then move to the discussion of our findings, against the background of China's integrated territorial management in urban areas (paragraph 5). The conclusive paragraph introduces the implications of our work for research, policy, and practice.

2. Case introduction

The case discussed in this paper was selected based on its ability to epitomize current trends and future developments in the integration of China's watershed management and urban planning. Five prerequisites were set forth to guide the selection of the case study:

(a) **Time**: the case deals with processes of integration of environmental management and urban planning that have been already implemented, therefore allowing for an ex-post analysis.
(b) **Location and spatial scale**: the case is located in a urban and/or peri-urban area and is characterized by a clearly identifiable spatial scale.
(c) **Relevance:** the case is considered a best practice by the domestic community of practitioners and decision-makers.
(d) **Accessibility and availability of data**.
(e) **Willingness of local stakeholders to take part in participatory practices.**

The triangulation of scientific literature, media reports, and materials collected through key-informants interviews and participant observation concurred in indicating in Lihu−also called Wulihu−a case suitable for our analysis.[3] Lihu Lake Basin is located in Wuxi, a middle-sized city of Eastern China's Jiangsu province. The basin measures 35 km^2 and is home to roughly 600,000 people[4] (Wuxi Statistical Yearbook

[2] We endorse the definition of stakeholders provided by the World Bank, as follows: "A stakeholder is any entity with a declared or conceivable interest or stake in a policy concern [. . .] [Stakeholders] can be individuals, organisations, or unorganised groups." Cfr. http://www1.worldbank.org/publicsector/anticorrupt/PoliticalEconomy/stakeholderanalysis.htm .
[3] Another case was identified which complied with most of prerequisites, that of the Qionghai lake basin, located in the Liangshan Yi Ethnic Autonomous Prefecture (Sichuan Province). However, due to limited access to data and local stakeholders, the research tea had to drop the case entirely. For an overview of the Qionghai case, see Chen and Wang (2003).
[4] This number have been estimated based on the number of residents in the Binhu district, Taihu subdistrict, and Xuelang subdistrict.

2011). Like the nearby Taihu lake, in the mid-1990s Lihu started being affected by severe eutrophication, caused by non-point source pollution from agriculture and fish farming (Ma 2007, Xia et al. 2014). The environmental crisis in Lihu triggered a radical rethinking of both the basin's function and is management structure, involving local authorities, environmental experts, and urban planners. Change was favored by the transformation of city's economic fabric, due to the growing importance of real estate sector and of the tertiary industry. The 2001 Wuxi city master plan designated the basin as a key spot for recreation, tourism, and real estate development (Brombal and Moriggi 2017). In 2002, the city government launched the "Lihu Comprehensive Remediation project" to address environmental issues affecting the lake. The project was devised in coordination with the change in the basin's functions called for in the master plan. It included six main components: (1) construction of sewages; (2) hydraulic works regulating the inflow from and outflow to Taihu lake; (3) dredging of lake sediments; (4) wetlands ecological restoration; (5) reconversion to water of areas that had been previously reclaimed for agriculture; and (6) functional rezoning of the basin, converting most of it from agricultural to recreational purposes (Xia et al. 2014). Figure1 shows an aerial image of the basin before and after the implementation of water management measures.

Figure 1. Lihu lake basin before in 2002 (left) and 2015 (right)[5]

The transition towards an integrated watershed management model was formalized in 2005, with the enactment of the "Lihu Lake Protection Plan". The plan explicitly framed the development of the basin management system in terms of comprehensive sustainability, prioritizing the achievement of environmental quality as a prerequisite for economic growth. Moreover, the plan called for the establishment of an inter-sectorial and inter-scalar administrative body, in charge for the overall management of the basin. This body was introduced in 2008 by merging staff from several government departments, and eventually evolved into a public-private partnership in 2012-13 (Brombal and Moriggi 2017). In the ten years elapsed from the launch of the remediation plan and the reform of management institutions, extensive urban renewal took place in the basin. Two key projects in this respect were the establishment of the Lihu lake Scenic Area and the construction of Lihu New Town (*Lihu xincheng*), which according to official claims embodies the harmony between human and nature (Wuxi City 2008). Also as a result of these projects, during the 11th Five-Year Plan (2006-10) Wuxi established itself as one of the models for sustainable urbanization in China (Wu and Li 2014, Brombal and Moriggi 2017). In 2011, the city's experience was included in among Asia's best practices for urban development endorsed by the United Nations Environmental Programme (UNEP 2011). Given the incremental nature of China's policy processes, whereby successful pilots are replicated locally or scaled up to inform national policies, the appraisal Lihu's experience can therefore provide an insight over future development of IWM in China, and its integration with urban planning.

[5] Authors' elaboration. Historical satellite images retrieved from Google Earth.

3. Methodology

3.1 Theoretical and analytical background

The notion that the pursuit of sustainable development requires holistic approaches is key to the theory and practice of IWM. Therefore, the evaluation of IWM initiatives should be able to grasp impacts on different sustainability dimensions and be tuned with the local social and political context. Sustainability Assessment (SA) can help in achieving both goals. SA is a combination of procedures, methods, and tools by which a policy, program, or project may be judged as to its impacts on the sustainability of a system, and the distribution of those impacts within and among the economic, social, and environmental dimensions (Berger 2007, OECD 2010a,b, USEPA 2014). Its major objectives are to provide evidence to inform policy development and to promote~~, by means of participatory research practices,~~ the engagement of stakeholders in the process of policy appraisal (USEPA 2014). SAs ~~frameworks~~ typically employ Multi-Criteria-Decision-Analysis (MCDA), since it ~~because it~~ provides~~es~~ a semi-quantitative~~a~~ framework that assists in integrating information on ~~pertaining to~~ different dimensions—environmental, economic, social—and ~~and~~ expressed in different metrics~~units~~. Moreover, i~~I~~t provides ~~as well~~ the capacity to integrate stakeholders' preferences with regard to indicators~~,~~, by means of ~~and their relevant~~ weighs and veto functions~~t~~ (Munda 2005, CASTLE Project 2014, USEPA 2014, ISO 2017). In developing our SA model~~ to evaluate Lihu's case~~, we opted for Multi-Attribute-Value-Theory (MAVT), as it allows to structure a problem by classifying it into criteria and attributes in ways that are readily understandable, ~~therefore~~ avoiding black-box effects and facilitating participatory ~~research~~ processes (Herwijnen 1999, Bottero et al. ~~,~~2015). The assessment was conducted according to the following phases: (a) definition of assessment's objectives; (b) stakeholders identification and engagement; (c) definition of the assessment's scale, criteria, and metrics, through collaboration with stakeholders; (d) modelling; (e) data collection; (f) data processing; (g) interpretation of results. This process was modelled on established practice in semi-quantitative SA, consistently with benchmarks set by relevant international standards (cfr. ISO 2017: 9, 19).[6]

3.2 Stakeholders engagement

Substantial stakeholders engagement is a key component of SA. Over the past few years, participatory approaches have become a common feature of much research in the field of sustainability science. Through such approaches, different stakeholders are engaged side by side with academics in a process of co-generation of knowledge about socio-ecological systems (Blackstock et al 2007). This allows the creation of a community of inquiry where "knowledge is validated not by reference to predefined criteria, but through an iterative and adaptive process in which theoretical refinement and practical experimentation are connected through social learning and the confrontation of different reasoned perspectives" (Popa et al 2015, p. 47). On the one hand, this approach has ~~is substantiated by~~ instrumental and substantive reasons, reflecting the need to gain both valuable inputs and social acceptance among the public over a specific issue at stake (ISO 2017). Indeed, participatory processes enhance the relevance and responsiveness of the researchers' work to local conditions and sustainability challenges, while facilitating access to data and information that would be otherwise out of researchers' reach. Early input from stakeholders can lessen the limitations of an assessment and improve its societal relevance (ISO 2017). On the other hand, participatory processes are also driven by normative stances, echoing principles of deliberation, collaborative governance and democratization of science (Wang et al 2008; Gollagher and Harz-Karp 2013). Quality of such processes is to a large extent a function of *who* is involved in the participatory exercise. For the purpose of Lihu's SA, firstly we carried out a stakeholder analysis to identify and characterize individuals and organizations who may meaningfully contribute to our study. A panel of six Chinese experts with diversified background and affiliations (see figure 2) was enrolled in a two-stage Delphi survey, moderated remotely by research team members (on

[6] The ISO standard on sustainable remediation (ISO18504:2017) provides researchers and practicitioners with an useful guidance on the structuring of assessment processes and the selection of assessment tools. With particular reference to the latter, the standard provides a ready-to-use checklist to appraise the applicability of assessment tools for a specific project/case (ISO 2017: 19).

Delphi methods, see Hsu and Sandford 2007). In order to avoid possible biases in responses, the Delphi was conducted by guaranteeing anonymity to respondents.

Figure 2. Participants in the Delphi survey for stakeholders' identification and characterization

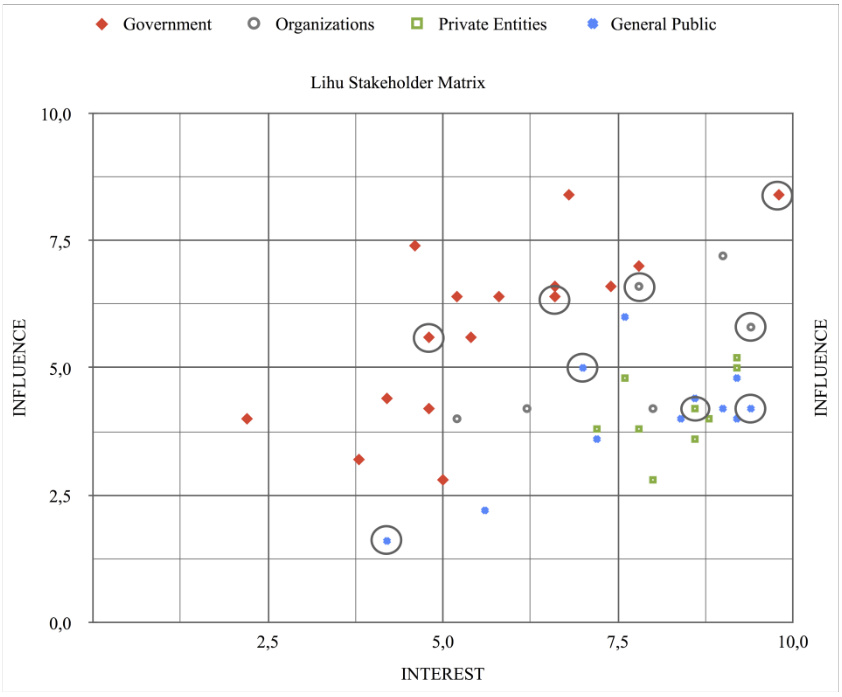
No.	Field of Expertise	Affiliation(s)	Familiarity with case study	Sex
1	Environmental management	Local (Wuxi) government department	High	F
2	Integrated watershed management	Local (Wuxi) government department	High	M
3	Social and economic development	Local (Wuxi) academic institution	High	F
4	Public governance	Local government	Low	F
5	Environmental and social sustainability, public participation	National academic institution	Low	F
6	Economy	National NGO organization	Low	M

In the first stage of the Delphi, participants had to draw and agree upon a tentative list of stakeholders based on a checklist, adapted from the seminal work by Mason and Mitroff (1981):

(a) Who have clear roles in the situation?
(b) Who have relevant policy responsibilities?
(c) Who take part in project/programme activities?
(d) Who influence opinions about the issues involved?
(e) Who fall in social groups affected by the problem?
(f) Who live in areas adjacent to the situation?
(g) Who are the sources of discontent to what is going on?
(h) Who do you think others regard as 'important' actors'?

A total of 43 stakeholders, individuals and organizations, were thus identified. Once completed the identification, participants moved on to characterization. They were requested to reflect on the level of interest and influence of each of the identified stakeholders, vis-a-vis Lihu's IWM measures. We define 'interest' as the priority and importance that stakeholders attach to the issue object of analysis (WB 2009). 'influence' was defined as the capacity of stakeholders to marshal resources to promote their position on the policy, program, or project targeted by the analysis (WB 2009). For each of the stakeholders, experts were asked to give a score ranging from 0 to 10, expressing the relevant degree of interest and power. Once agreed upon by all Delphi participants, results were input in a stakeholders' matrix, synthetizing findings of the stakeholder analysis. As can be seen in figure 3, stakeholders were also subdivided based on their socio-economic and political function. Three broad categories were employed for this purpose: (a) Government entities, including departments at all level within the Chinese bureaucracy; (b) Other organizations, including the media, NGOs, research institutions; (c) Private entities, including companies and/or individuals conducting private business in the basin; and (d) General public, i.e., those who live, dwell, or travel in/to the basin. Results of the Delphi constituted the basis for the selection of stakeholders to be engaged in Focus Discussion Groups (FDGs) aimed at supporting researchers in defining SA's scale of analysis, criteria, and attributes. The logic of stakeholders engagement was to ensure their capacity to represent and convey diverse perceptions over Lihu's IWM and its implication on sustainability, and to integrate views of individuals and organizations characterized by different degrees of interest and influence in relevant processes of planning, implementation, and management. Direct contact with local stakeholders was established by members of the research team familiar with the local context. A total of 14 individuals accepted to take part in FDGs, representative of both government departments, private companies, other organizations, and of the general public residing in the lake basin (see figure 3).

Figure 3. Stakeholders Matrix. Categories represented in FDGs are circled in black *(figure next page)*

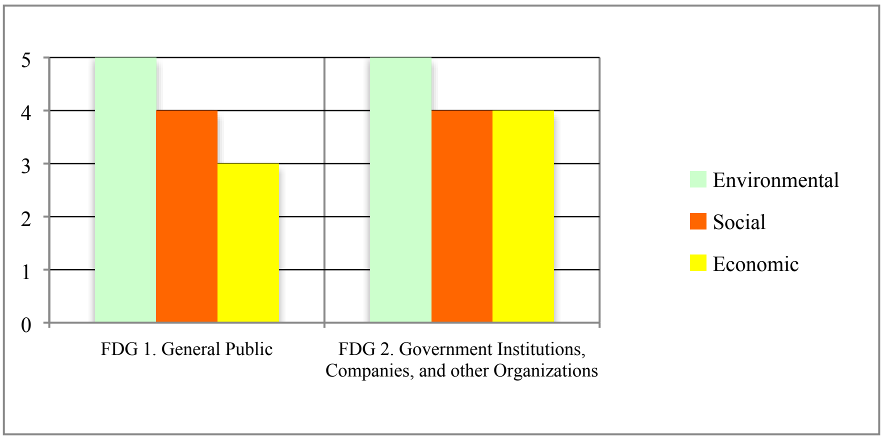


Two single-round, panel FDGs were carried out in the city of Wuxi in Autumn, 2015. FDGs involved respectively members of the general public (FDG1), and representatives from government departments, companies, and other organizations (FDG2). This modality was useful to ensure that members of the general public could express their views freely, without the constraint they may have felt at the presence of government officials. Indeed, relevant literature suggests that in officially sponsored deliberation forums governmental civil servants wield most power. This entails a twofold challenge: on the one hand, officials might dominate the dialogue at the expenses of members of the general public; on the other hand, the latter might feel challenged by the inability to conform to the communication standards and technical jargon employed by policy-makers and researchers alike (Barnes 2008, Wang et al 2008). In both cases, FDGs had a duration of half a day, followed the same procedure, and were moderated by members of the research groups. After an informal self-introduction of each participant, the moderator introduced the goals of the study and FDG's goals and procedure. Participants were allowed to interrupt with questions and requests for clarification. After participants' queries had been replied by the moderator, the discussion moved to the SA scale of analysis. Three possible scales, relevant to the expected impacts of Lihu's IWM measures, were proposed for discussion: (a) prefectural scale (i.e., the entire area under Wuxi's city administration); (b) Wuxi metropolitan area; (c) Lihu lake basin. In both FDGs, all participants quickly reached an agreement, indicating the Lihu basin as the most appropriate scale of analysis for the SA. The rationale for this choice was the fact that, although impacts of Lihu's IWM might be felt also outside the basin, they would be difficult to isolate from other, wider phenomena at play. A preliminary criteria tree for the SA (see paragraph 3.3) was then introduced to participants, eliciting their opinions on the relevant importance of different dimensions and criteria. Participants were first asked to give individual importance scores to each dimension and criterion, based on a five point Likert scale ranging from 'not important' (score 1) to 'extremely important' (score 5). Scores given individually were then discussed by the whole panel, reaching an agreement over the importance scores to be attributed to each dimension and criterion. Results among the two groups were largely consistent (see figure 4). In both cases, participants attributed more importance to the environmental dimension, clearly depicting it as a prerequisite for economic development. As one local resident commented during FDG1, "If the environment would be in a bad state, nobody would come here to work, nor invest here. The economy would not grow anymore."[7] However, participants from the general public appeared to be more aware of social impacts, attributing higher importance to the social than to the

[7] *Huanjing bu hao, dou bu dao zher gan huo, dou bu dao zher touzi, jingji gao bu shang qu le.*

economic dimension. Conversely, participants to the second FDG (government representatives, companies, other organizations) gave the same importance to the social and economic dimension.

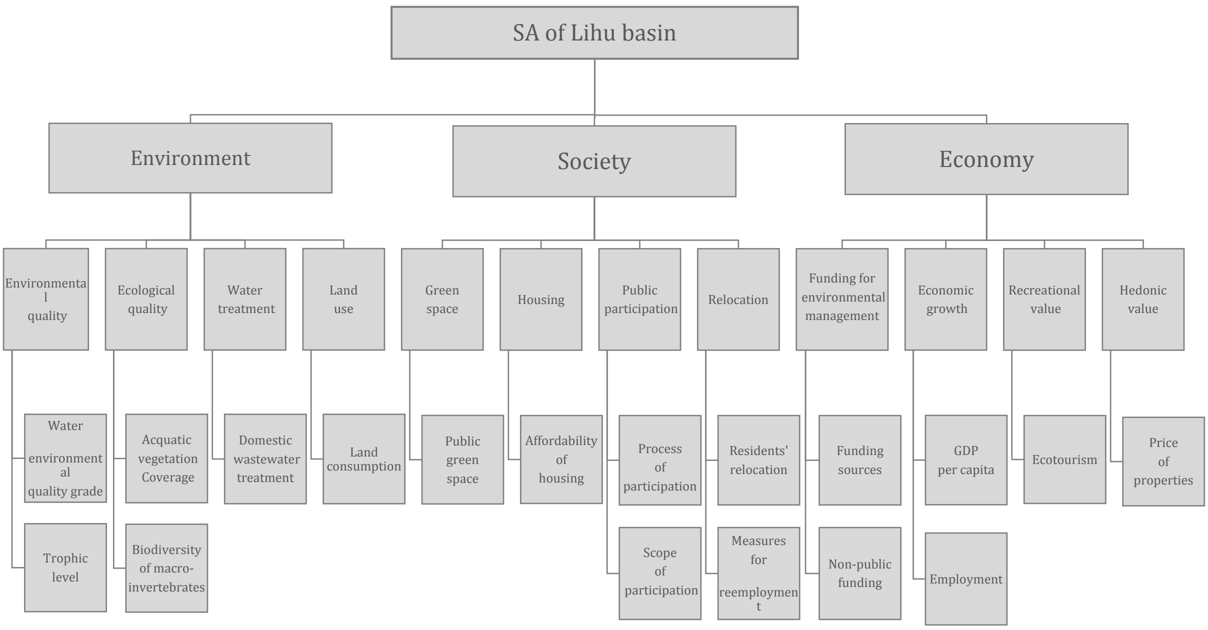
Figure 4. Importance scores attributed to the different dimensions of sustainability by FDG 1 and FDG2



3.3 Criteria tree: dimensions, criteria, and attributes

The criteria tree validated by the stakeholders had been defined prior to the FDGs, based on expected direct and indirect impacts of Lihu's IWM measures implemented between 2002 and 2012. A preliminary list of criteria was drawn based on the review of international and Chinese sustainability assessment systems (see in particular Bardos, Lazar and Willenbrock 2009, Li et al. 2014, Shen and Zhou 2014). Criteria applicable to the case study were thereafter evaluated and chosen from the list, based on relevance, analytical consistency, and communicability (Marcomini, Suter II and Critto 2009). With particular reference to the issue of relevance, criteria were chosen based on their capacity to reflect progress made vis-à-vis key targets of the integrated watershed program, as well as in consideration of possible negative impacts of the program (Wuxi City 2005, 2008; Jiangsu Wuxi Basin Urban Environment Project Office 2003). For each of the three dimensions (environmental, economic, and social), four criteria were individuated, for a total of 12 composing the criteria tree. Six criteria were further subdivided into two complementary attributes (see figure 5).

Figure 5. Assessment Criteria Tree



3.4 Indicators and normalisation

For each attribute, a relevant indicator was selected based on its sensitivity and the availability and accessibility of verification sources. Out of 18 indicators, 13 employ quantitative metrics, and the remaining five qualitative metrics. Parameters relevant to each indicator were normalised by converting them into a point scale, ranging from 0,00 to 1,00. Each point in the scale corresponds to a class grouping observable variables. Classes were defined based on the review of scientific and grey literature. For three economic criteria (economic growth, recreational value, and hedonic value), for which no agreed standard could be retrieved, classes were defined by means of experts judgment.[8] Parametrisation of classes reflect a sustainability rationale. If no direct inference could be made about the affinity of a certain class to a sustainability rationale, we opted for a negative-to-positive scale: a hypothetical best scenario is associated to the score of 1,00, and the worst to 0,00 or 0,10 (see figure 6. Detailed explanatory notes relevant to indicators' selection, normalization, and verification sources are provided in Supplementary materials).

Figure 6. SA criteria, attributes, and normalised measurements *(table continues next page)*

Dimension	Criterion	Attribute	Type	Indicator	Class	Score
Environ.	Env1 Environmental quality	Env 1.1 Water environmental quality	Quant.	Water quality grade	Grade I	1,00
					Grade II	0,75
					Grade III	0,50
					Grade IV	0,25
					Grade V/V+	0,00
		Env 1.2 Trophic level	Quant.	Trophic Level Index (TLI)	TLI < 30	1,00
					30≤TLI≤50	1,00
					50< TLI≤60	0,66
					60< TLI≤70	0,33
					TLI 70	0,00
	Env2 Ecological quality	Env 2.1 Aquatic vegetation coverage	Quant.	Coverage of Submerged Macrophyte Plants (SMP) on the total lake surface	SMP>40%	1,00
					20%<SMP≤40%	0,75
					10%<SMP≤20%	0,50
					5%<SMP≤10%	0,25
					SMP<5%	0,00
		Env 2.2 Biodiversity of macroinvertebrates	Quant.	Macroinvertebrates Shannon diversity index (SI)	SI>4	1,00
					3<SI≤4	0,75
					3<SI≤2	0,50
					2<SI≤1	0,25
					SI<1	0,00
	Env3 Water treatment	Env 3.1 Wastewater treatment	Quant.	Domestic wastewater treated (TWW) on the total discharged	TWW≥90%	1,00
					80%≥TWW<90%	0,90
					70%≥TWW<80%	0,80
					60%≥TWW<70%	0,70
					50%≥TWW<60%	0,60
					40%≥TWW<50%	0,50
					30%≥TWW<40%	0,40
					20%≥TWW<30%	0,30
					10%≥TWW<20%	0,20
					0%>TWW<10%	0,10
	Env4 Land use	Env 4.1 Land consumption	Quant.	Coverage of built-up area (BUA) on the total land surface of the basin	≤20%	1,00
					20%<BUA≤30%	0,80
					30%>BUA≤40%	0,60
					40%>BUA≤50%	0,40
					50%>BUA≤60%	0,20
					60%>BUA≤70%	0,10
					>70%	0,00
Social	Soc1 Green space	Soc 1.1 Public green space	Quant.	Sqm of public green space (GS) per capita	>30	1,00
					15≥GS<30	0,75
					9≥GS<15	0,50
					5≥GS<9	0,25
					GS<5	0,10
	Soc2 Housing	Soc 2.1 Affordability of housing	Quant.	Ratio of average house price (HP) to income	HP≤3	1,00
					3>HP≤5	0,66
					5>HP≤10	0,33
					HP>10	0,00
	Soc3 Public participation	Soc 3.1 Participation process	Qual.	Procedures of public participation	Citizen juries, ballots, delegated decisions	1,00
					Citizen advisory committees, participatory decision making	0,75
					Focus groups, workshops, deliberative polling	0,50
					Surveys, public meetings, platforms for experts public comment	0,25
					Information provision through fact sheets, web sites, open houses	0,10
		Soc 3.2 Participation scope	Qual.	Scenarios of lake basin remediation and renewal considered in consultation processes	Public is consulted on ≥ 2 scenarios, including zero option	1,00
					Public is consulted on ≥ 2 scenarios, NOT including zero option	0,75
					Public is consulted on a single scenario. Space left for adjustments in planning	0,50
					Public is consulted only on measures to mitigate impacts	0,25
					Public is not consulted	0,00
	Soc4 Relocation	Soc 4.1 Residents' relocation	Qual.	Modes of relocation	No relocation	1,00
					In situ relocation, preserving access to sources of traditional livelihoods	0,75
					In situ relocation, NOT preserving access to sources of traditional livelihoods	0,50
					Relocation within the lake basin	0,25
					Relocation outside of the lake basin	0,00
		Soc 4.2 Reemployment	Qual.	Measures for reemployment of relocated residents	Preexisting employment preserved	1,00
					Targeted measures for reemployment, consistent with skills of affected people	0,75
					Targeted measures for reemployment, inconsistent with skills of affected people	0,50
					Non-targeted measures. Working opportunities offered in areas affected by relocation	0,25
					No measures for reemployment	0,00

[8] A panel of five senior experts was engaged, based on the complementarity of their fields of expertise: economy, city planning, civil engineering, environmental science, and public policy.

Econ.	Eco1 Environmental management funding	Eco 1.1 Funding sources for environmental management	Qual.	Number of different sources of funding	≥5	1,00
					4	0,75
					3	0,50
					2	0,25
					1	0,10
		Eco 1.2 Participation of the non-public sector in funding environmental management	Quant.	Share of environmental management funding (EMF) covered by non public sources	EMF≥50%	1,00
					40%≥EMF<50%	0,80
					30%≥EMF<40%	0,60
					20%≥EMF<30%	0,40
					10%≥EMF<20%	0,20
					0%≥EMF<10%	0,10
					EMF=0%	0,00
	Eco2 Economic growth	Eco 2.1 Per capita GDP	Quant.	Ratio of the per capita GDP in the lake basin to Wuxi city's average	GDP≥1,35	1,00
					1,10≥ GDP<1,35	0,75
					0,90≥ GDP<1,10	0,50
					0,75≥ GDP<0,90	0,25
					GDP<0,70	0,10
		Eco 2.2 Employment	Quant.	Ratio of the employment rate (ER) in the lake basin to Wuxi city's average	ER≥1,35	1,00
					1,10≥ER<1,35	0,75
					0,90≥ER<1,10	0,50
					0,75≥ER<0,90	0,25
					ER<0,70	0,10
	Eco3 Recreational value	Eco 3.1 Ecotourism	Quant.	Share of revenues from ecotourism (ET) on the total of Wuxi city's tourism revenues	ET>15,0%	1,00
					12,5%≥ET<15,0%	0,66
					10,0%≥ET<12,5%	0,33
					ET<10,0%	0,00
	Eco4 Hedonic value	Eco 4.1 Market value of real estate properties	Quant.	Ratio of prices per sqm of properties (PP) in the lake basin to Wuxi city's average	PP≥1,35	1,00
					1,10≥PP<1,35	0,75
					0,90≥PP< 1,10	0,50
					0,75≥ PP<0,90	0,25
					GDP<0,70	0,10

3.5 Weighing and Aggregation

Importance scores attributed by stakeholders to dimensions and criteria were first aggregated by means of a simple mathematical average[9] and hence converted into weighs via the following equation:

Eq. (1) $$w_x = \frac{< S_x >}{\sum_{i=1}^{n} < S_{x_i} >}$$

Where x indicates either the dimension or the criterion, S denotes the respective importance score, and n is the number of dimensions or criteria−depending on which one of the two we are considering. The final SA score was computed as follows:

Eq.(2) $$S_{Sust} = \left[W_{Env} \left(\sum_{c=1}^{4} Env_c \, w_{Env_c} \right) + W_{Soc} \left(\sum_{c=1}^{4} Soc_c \, w_{Soc_c} \right) + W_{Eco} \left(\sum_{c=1}^{4} Eco_c \, w_{Eco_c} \right) \right] \theta \, (Env1)$$

$$\theta(X) = \begin{cases} 0, if X = 0 \\ 1, if X \neq 0 \end{cases}$$

Where:

- S_{Sust} is the sustainability score of the assessed program, in a specific point in time;
- W_{Env}, W_{Soc}, and W_{Eco} are the weights of the environmental, social, and economic dimensions;
- Env_c, Soc_c, and Eco_c are the scores of each criterion;
- W_{Env_c}, W_{Soc_c} and W_{Eco_c} are the weights of each criterion.

The unanimous agreement among stakeholders over the predominance of the environmental dimension is reflected by the veto function (θ) attributed in Eq.(2) to the criteria "Environmental Quality" (*Env*1). Scores for criteria composed by two attributes (*Env1*, *Env2*, *Soc3*, *Soc4, Eco1*, *Eco2*) were computed by means of a simple mathematical average of attributes' scores.

4. Results

4.1 Results

Overall, the impact on sustainability of measures implemented in the lake basin was positive (Δ=0,143, see figures 7 and 8). Sensible improvements were made both in the environmental dimension (Δ=0,274) and in

[9] FDGs resulted in different outcomes. Since the difference was marginal, we opted for averaging importance scores.

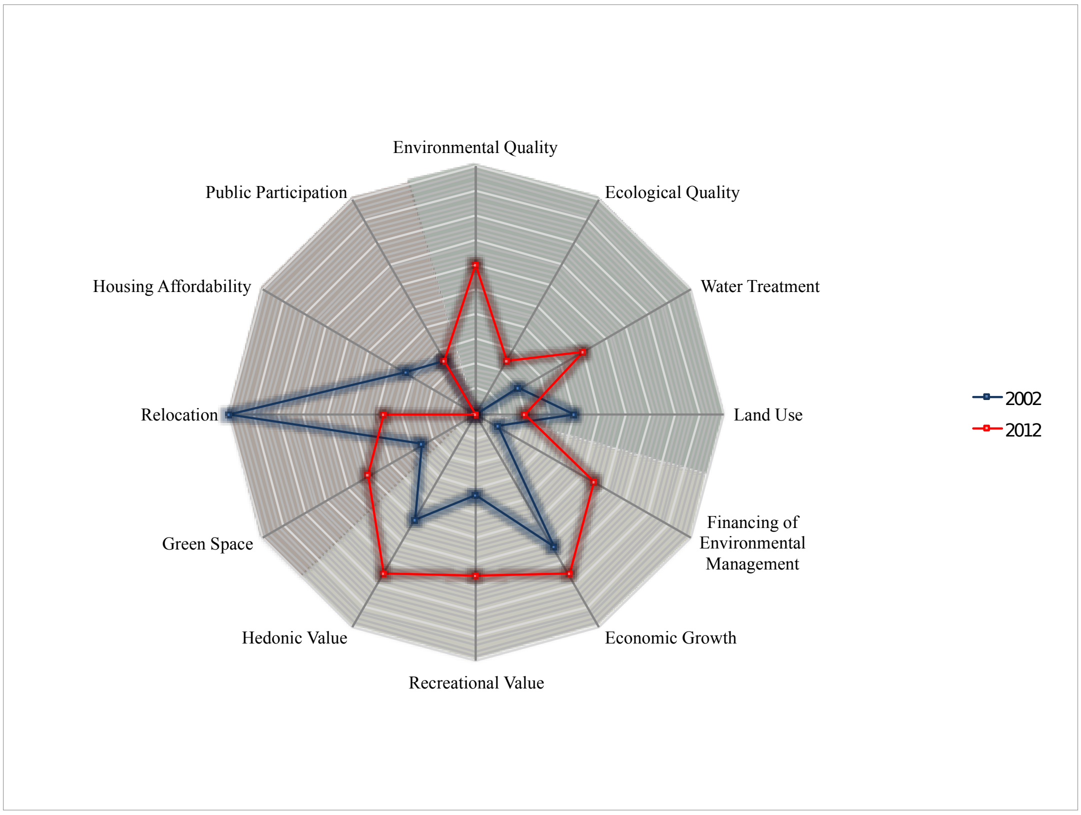
the economic one (Δ=0,293). Despite the efforts by local authorities, the social dimension withstood a negative impact (Δ=0,151).

Figure 7. SA model results

Dimension	Criterion	Attribute	Observed value		Score attribute		Weigh of criterion	Weighed score		Score		Weigh of dimension	Weighed score		SA score	
			2002	2012	2002	2012		2002	2012	2002	2012		2002	2012	2002	2012
Environ.	Environmental quality	Env 1.1	V	III	0,00	0,50	0,290	0,000	0,168	0,127	0,402	0,400	0,051	0,161	0,298	0,441
		Env 1.2	82,87	59,40	0,00	0,66										
	Ecological quality	Env 2.1	0,00%	8,70%	0,00	0,25	0,261	0,000	0,065							
		Env 2.2	0,29	1,65	0,00	0,25										
	Water treatment	Env 3.1	14,2	49,2	0,20	0,50	0,261	0,052	0,131							
	Land use	Env 4.1	41,19%	50,44%	0,40	0,20	0,188	0,075	0,038							
Social	Green space	Soc 1.1	5,22	14,61	0,25	0,50	0,283	0,071	0,142	0,450	0,299	0,320	0,144	0,096		
	Housing	Soc 2.1	8,46	10,08	0,33	0,00	0,208	0,069	0,000							
	Public participation	Soc 3.1	Informative	Informative	0,25	0,25	0,264	0,066	0,066							
		Soc 3.2	Mitigation	Mitigation	0,25	0,25										
	Relocation	Soc 4.1	No relocation	Relocation in lake basin	1,00	0,50	0245	0,245	0,092							
		Soc 4.2	Preexisting employment	Non-targeted measures	1,00	0,25										
Econ.	Environmental manag.funding	Eco 1.1	1	3	0,10	0,50	0,273	0,014	0,137	0,366	0,660	0,280	0,103	0,185		
		Eco 1.2	0%	30%	0,00	0,50										
	Economic growth	Eco 2.1*	1,24	1,50	0,75	1,00	0,255	0,159	0,191							
		Eco 2.2*	1,05	1,00	0,50	0,50										
	Recreational value	Eco 3.1*	11,83%	14,18%	0,33	0,66	0,255	0,084	0,168							
	Hedonic value	Eco 4.1	1,05	1,12	0,50	0,75	0,218	0,109	0,164							

** Data referred to 2002 and 2011.*

Figure 8. Visual representation of SA results



4.1.1 Environmental dimension

The comprehensive water remediation project and the change in functional zoning had a positive impact on environmental and ecological quality, and on domestic wastewater treatment capacity in the basin. The limitation to agricultural activities and fish farming, the dredging of lake sediments, and the construction of hydraulic infrastructures regulating the water inflow from Taihu were effective in ameliorating water quality. Concentrations of total phosphorus (TP) and nitrogen (N) were greatly reduced already between 2002 and 2005, and later stabilized. Water quality improved from grade V+ (the worst according to Chinese environmental standards) to grade III. Improvements of water quality laid the ground for a fairly successful ecological restoration. Both the coverage of submerged macrophites and the presence of macroinvertebrates −two key indicators of lacustrine ecological health−augmented throughout the period of time considered in our analysis, albeit not reaching levels considered optimal by scientific literature. The only criterion reflecting a negative trend is land consumption, which actually increased as a direct consequence of the new plan envisaged by Wuxi authorities for the development of the lake basin. The different function of the lake basin−from predominantly agricultural to recreational and residential−created the regulatory conditions for higher land consumption. Urban renewal and the expansion of city's infrastructures in the northern, eastern, and south-eastern sections of the basin caused considerable consumption of soil.

4.1.2 Economic dimension

The water integrated management program in Lihu translated into a deep process of institutional change, exerting a considerable impact on the funding model for the basin's environmental management. Between 2002 and 2013, administrative and financial functions connected to environmental management were subject to a reform process, aimed at engaging private actors and enlarging the financial basis to complement public with private resources. This created a more stable financial basis for the basin's environmental management, reducing its dependency from city and provincial support. Urban renewal projects and the improvement in environmental conditions exerted a positive impulse for economic growth: in fact, between 2002 and 2012 the economy grew at a much faster rate on the Lihu basin than elsewhere in Wuxi city. However, our data does not suggest a positive impact on employment, possibly due to the number of laid off workers and land-expropriated peasants previously employed in the primary industry. The importance attributed to boosting recreational activities connected with nature, one of the key objectives of the Lihu integrated water management program, is reflected by the increasing importance of eco-tourism in Wuxi's tourism industry. The same can be said for the increase in values of properties in the lake basin if compared with other areas of Wuxi.

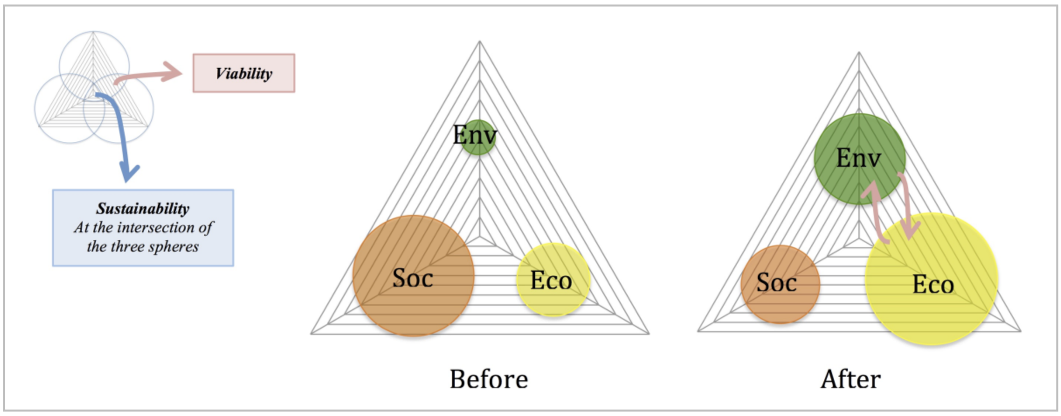
4.1.3 Social dimension

Results relevant to social sustainability reflect achievements and challenges also evident in the other dimensions. The attention given by authorities to enhance the city's livability translated in a considerable increase of public green areas, indeed a remarkable achievement taking in consideration the increase in land consumption in the basin over the period od program implementation. However, the same measures that produced good environmental and economic outcomes implied considerable social costs. Despite commitment shown in this respect by Wuxi authorities, housing affordability worsened in the period considered by our analysis. Similarly, the change in the basin's function meant the relocation for thousands of residents and workers, mostly employed in the local agricultural and fish farming industries. Relocation was not accompanied by appropriate measures to ensure reemployment nor access to traditional sources of livelihoods. This said, it should be recognized that former residents were relocated at a short distance from their former dwellings, and limited reemployment projects were reportedly carried out, employing part of the relocated people for part-time jobs in Lihu parks maintenance. Substantial forms of public participation in the decision-making processes could have contributed to avoid or mitigate negative social impacts. Conversely, throughout the period covered by our analysis, local authorities pursued limited forms of consultation (such as surveys and public hearings), instrumental to smooth project implementation, rather than to complement the decisional process with the views, perspectives, and needs of the local communities.

5. Discussion of results

China has long epitomized the contradiction between the pursuit of economic growth and the establishment of a sustainable pattern of development. In the last quarter century, extensive industrialization processes, changes in agricultural production, and rapid urbanization have triggered a severe environmental crisis. Environmental protection was first institutionalized in the late 1970s, when Beijing established relevant regulations and ad-hoc administrative bodies (Ma and Ortolano 2000). Since the 1990s, the protection of the environment and the promotion of sustainability have gained increasing importance within Party ideology and State policy (Lam 2006, Termine et al. 2017). Despite sustained commitment, concrete progress has been slow and China has struggled to cope with environmental degradation and social inequalities (Economy 2010, Brombal 2017a). The roots of this failure can be identified in various institutional factors, most notably the gap between policy and implementation, the legislative and administrative fragmentation, the persistence of incentive systems promoting the attainment of economic growth in spite of natural degradation, the lack of awareness among decision makers, and the ambivalent attitude of authorities towards those sectors of society bringing forward the cause of sustainability (Economy 2005, Lora-Wainwrigth 2013, Deng et al. 2016, Brombal 2017b). Moreover, the State apparatus long endorsed the idea that environmental degradation and social disruption were acceptable, as long as they would not jeopardize social stability. This logic appeared informed by the assumption that development would *per se* imply a damage to nature and society, which at best could be mitigated. Our analysis of Lihu's IWM shows a significant departure from this logic. Results of our participatory practices highlight a cognitive attitude shared by the public and decision makers: environmental quality is seen as a prerequisite for economic growth, a factor providing Wuxi with a competitive edge over nearby cities. The establishment of such an understanding is closely tied to the emergence of institutional structures aimed at sustaining a comprehensive, multi-dimensional development of the lake basin.[10] As shown by the results of our model, these efforts yielded a positive effect in reconciling economic development and environmental protection. Lihu represents a concrete demonstration of the positive potential of the ongoing change in China's policies of environmental and spatial planning (see Wu 2015, Chung 2015). However, one should be careful in labeling initiatives such as the one implemented in Lihu as conducive to sustainable development. In fact, evidence suggests that goals achieved by the IWM program did have a social cost. Rather than sustainability, Lihu's experience has been so far about *viability*: it has pursued−and to some extent achieved−a closer integration of the environmental and economic spheres (see figure 9).

Figure 9. Visual representation of SA by criteria: Towards viable development*



*Diameters of spheres is based on the sustainability scores of each criterion

While novel in the Chinese context, this approach is not innovative if compared with state-of-the-art knowledge and practice of environmental and urban planning worldwide. Both in Europe and in the USA, recent years have witnessed an increasing integration of social and cultural components into territorial planning. To a large extent this is due to the growing recognition of shortcomings of technocratic approaches to sustainability (Soini and Dessein 2015, Scoones 2016). Another factor informing the increasing relevance attributed to sociocultural considerations is the recognition of negative effects of gentrification, a common by-product of urban renewal (Settis 2014 Urban Europe 2016). Significant−albeit still insufficient−progress has been made in Western countries to provide individuals and communities with the means of pursuing their aspirations, in ways consistent with the need of preserving nature and of projecting into the future the local socio-cultural landscape. This translates into greater engagement of the public into decisional processes, the piloting of substantial co-creation practices, and the launch of platforms facilitating the science-policy-society dialogue (UCLG 2010, Der Graaf and Van Der Brugge 2010, Curran and Hamilton 2012, Perry and

[10] For a thorough institutional analysis of the Lihu case conducted under the same EU project funding this study, see Brombal and Moriggi 2017.

Atherton 2017).[11] Despite being considered a model at home, if compared with experiences abroad the case of Lihu is indicative of the fact that considerable room of improvement remains in China in establishing forms of territorial management fostering comprehensive sustainability.

6. Conclusions

Our work yields significant implications for policy and research. The case of Lihu is representative of positive results achieved in China in overcoming the divide between economic growth and environmental protection, which long characterized the country's policies at both central and local level. However, major efforts should be done to streamline social considerations into integrated territorial management planning processes, in order to avoid social costs that would fall on local residents. Participatory research practices such as those employed for the present study may play an important role in facilitating this transition, creating an arena for co-creation of both planning policies and evaluation tools.

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[11] Climate Change adaptation currently represents a key locus of innovation in this regard, as it both requires holistic approaches and it fosters radical rethinking of human nature-interaction. See Der Graaf and Van Der Brugge 2010.

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Supplementary Materials A

Dimension	Criterion	Attribute	Type	Indicator	Class	Score	Explanatory notes and consulted sources
Environ.	Env1 Environmental quality	Env 1.1 Water environmental quality	Quant.	Water quality grade	Grade I	1,00	This attribute measures water environmental quality according to China's environmental quality standard for surface waters (GB 3838-2002, in SEPA 2002). The standard includes 109 parameters, of which 24 basic parameters and 85 parameters for drinking water sources. For each of the 24 basic parameters, the standard sets thresholds pertinent to each of the six grades into which water quality is evaluated. The grade is attributed on the basis of a 'One-Out-All-Out' (OOAO) principle: the worst grade attained by any of the considered parameters represents the final water quality grade (Deng et al. 2016). Verification sources used to appraise this attribute: Cai et al. 2011, Jiang et al. 2014.
					Grade II	0,75	
					Grade III	0,50	
					Grade IV	0,25	
					Grade V/V+	0,00	
		Env 1.2 Trophic level	Quant.	Trophic Level Index (TLI)	TLI < 30	1,00	The Trophic Level Index (TLI) measures the nutrient status of surface water bodies. It is an important metric of environmental quality, particularly in cases where pollution is mainly generated by non-point sources (agriculture, farming). TLI estimations are based on different parameters: Total Nitrogen (TN), Total Posphorus (TP), Transparency (SD), Chlorophyll-a concentration (Chla), and Chemical Oxygen Demand (COD) (Wang, Liu, and Zhang 2002). In our appraisal, due to incomplete data on COD, we estimated the TLI based on four parameters (TN, TP, SD, and Chla). Classes were defined by taking into account specific conditions of Lihu lake: the highest class (score 1.0) was defined based on natural conditions of the lake, with no appreciable level of man-made pollution. Its value was determined consistently with the earliest available data, collected in 1951 (Wu 1962). Verification sources used to appraise this attribute: Cai et al. 2011, Jiang et al. 2014.
					30≤TLI≤50	1,00	
					50< TLI≤60	0,66	
					60< TLI≤70	0,33	
					TLI 70	0,00	
	Env2 Ecological quality	Env 2.1 Aquatic vegetation coverage	Quant.	Coverage of Submerged Macrophyte Plants (SMP) on the total lake surface	SMP>40%	1,00	Macrophytes are sensitive to changes of water environmental quality. Their coverage is widely used as a measure for ecological quality of shallow lakes (Søndergaard et al. 2010). Classes were defined by taking into account specific conditions of Lihu lake: the highest class (score 1.0) was defined based on natural conditions of the lake, with no appreciable level of man-made pollution. Its value was determined consistently with earliest available data, collected in 1951 (Wu 1962). Verification sources used to appraise this attribute: Jiang et al. 2014.
					20%<SMP≤40%	0,75	
					10%<SMP≤20%	0,50	
					5%<SMP≤10%	0,25	
					SMP<5%	0,00	
		Env 2.2 Biodiversity of macroinvertebrates	Quant.	Macroinvertebrates Shannon diversity index (SI)	SI>4	1,00	Macroinvertebtares are highly sensitive to the ecological integrity of a water body and play an essential role in lacustrine ecosystems. Monitoring the richness of their population is often used as a metric to evaluate the ecological status of a water body (Solimini et al. 2006. See also Blanchet et al. 2008). Classes for this attribute were defined based on the Shannon diversity index, widely used to determine the diversity of animal species in a certain habitat (Li 1985). Verification sources used to appraise this attribute: Shen 2005, Jiang et al. 2014, Li et al. 2015.
					3<SI≤4	0,75	
					3<SI≤2	0,50	
					2<SI≤1	0,25	
					SI<1	0,00	
	Env3 Water treatment	Env 3.1 Wastewater treatment	Quant.	Domestic wastewater treated (TWW) on the total discharged	TWW≥90%	1,00	This attribute measures progress made in wastewater treatment during the period of implementation of Lihu's IWM program (on the relevance of this specific for Lihu's IWM, see CNAEC 2008, Jiangsu sheng huanjing baohu ting 2008, China Environment News 2011). The attribute compares the amount of domestic wastewater generated in Binhu district−the largest administrative subdivision of Lihu lake basin−with the capacity of wastewater treatment plants in operation. Verification sources used to appraise this attribute: Survey Office of the State Statistics Bureau 2003, Table 0723, Survey Office of the State Statistics Bureau 2012, Table 0723. Jiangsu Province n.d.
					80%≥TWW<90%	0,90	
					70%≥TWW<80%	0,80	
					60%≥TWW<70%	0,70	
					50%≥TWW<60%	0,60	
					40%≥TWW<50%	0,50	
					30%≥TWW<40%	0,40	
					20%≥TWW<30%	0,30	
					10%≥TWW<20%	0,20	
					0%>TWW<10%	0,10	
	Env4 Land use	Env 4.1 Land consumption	Quant.	Coverage of built-up area (BUA) on the total land surface of the basin	≤20%	1,00	Land consumption refers to "the conversion of open space or farmland to residential, commercial, office, or other developed land uses" (CMAP 2016). Changes in land use imply wide-ranging environmental consequences, including biodiversity loss, change in hydrology and soil degradation, impact on greenhouse gases emissions (Pileri 2015). Land use is closely associated with environmental quality of lake basins. Therefore the expansion of built-up areas is of particular concern at this regard (Huang et al. 2013). Classes for this attribute were based on an evaluation framework applied in China (Beijing), proposing an optimal coverage of built-up areas equal to 20% of the city's outer greenbelt (Lia et al. 2005). Verification sources used to appraise this attribute: Landsat TM 2002-12.
					20%<BUA≤30%	0,80	
					30%>BUA≤40%	0,60	
					40%>BUA≤50%	0,40	
					50%>BUA≤60%	0,20	
					60%>BUA≤70%	0,10	
					>70%	0,00	
Social	Soc1 Green space	Soc 1.1 Public green space	Quant.	Sqm of public green space (GS) per capita	>30	1,00	Public green space consists of green areas accessible to the public within the urban area of a city. Therefore, it does not include space used for private purposes and/or not accessible by the public (such as private gardens, cultivated plots of land). Urban public green spaces are one of the major determinants of liveability of urban spaces. Classes were defined by triangulating international standards and evidence relevant to public green spaces in medium-sized cities worldwide (Fuller 2009, EC 2011, ISTAT 2014). Verification sources used to appraise this attribute: Wuxi shi tongji ju 2003, 2013a.
					15≥GS<30	0,75	
					9≥GS<15	0,50	
					5≥GS<9	0,25	
					GS<5	0,10	
	Soc2 Housing	Soc 2.1 Affordability of housing	Quant.	Ratio of average house price (HP) to income	HP≤3	1,00	Urban renewal projects impact on housing affordability, often triggering phenomena of gentrification. This indicator measures housing affordability by comparing average house prices to average incomes in the area of the lake basin (Binhu district). Housing prices were estimated by assuming an average housing space of 100 sq meters per family (EIU 2014). Classes were defined by taking into consideration international standards and adjusted to enhance relevance to the Chinese case, as well as sensitivity (Cox 2014, 2016, Demographia 2016). Verification sources used to appraise this attribute: WB 2003, Binhu qu 2013, Wuxi ribao 2014.
					3>HP≤5	0,66	
					5>HP≤10	0,33	
					HP>10	0,00	
	Soc3 Public participation	Soc 3.1 Participation process	Qual.	Procedures of public participation	Citizen juries, ballots, delegated decisions	1,00	This attribute is based on the assumption that different procedural forms of participation imply different degrees of public influence in decision-making (Arnstein 1969, Brombal et al. 2017). Citizens juries, ballots and delegation of decisions are meant as empowering techniques, as they lay the basis for an active involvement of the public in the decision-making process. Citizens advisory committees and participatory decision-making refer to collaborative forms of participation, where the public is included in the design of possible alternatives and solutions. At a lower level of involvement, channels such as workshops and deliberative polling allow citizens to air their concerns and aspirations. Public comments and surveys fall into the category of consultation, in which citizens are asked to provide with feedback only. Finally, tools such as fact sheets, web sites and open houses are understood as informative means of participation, as they merely keep citizens informed over decision-making process (Arnstein 1969, Brombal et al. 2017, Schroeder 2013). Verification sources used to appraise this attribute: Jiangsu Wuxi Basin Urban Environment Project Office 2003, Wuxi shi zhengfu 2005, Wuxi lihu fengjingqu 2012, Wuxi shi tongji ju 2013b, FDG #150816.
					Citizen advisory committees, participatory decision making	0,75	
					Focus groups, workshops, deliberative polling	0,50	
					Surveys, public meetings, platforms for public comment	0,25	
					Information provision through fact sheets, web sites, open houses	0,10	

		Soc 3.2 Participation scope	Qual.	Scenarios of lake basin remediation and renewal considered in participation processes	Public is consulted on ≥ 2 scenarios, including zero option	1,00	This attribute measures the scope of public participation. From a normative perspective, participation should allow local communities to be consulted over different project/program/policy scenarios, leaving space also to radical criticism. Therefore, the highest class (1,00) reflect a situation in which also a "zero option" is considered in the participation process. The second highest class (0,75) refers to situations in which the public is given the possibility to contribute substantially to decision making, by proposing and discussing different project/program/policy scenarios based on socioeconomic aspirations and cultural values. The next lower class (0,50) makes reference to consultations allowing the public to influence aspects of a project/program/policy such as location, dimensions, and timing of implementation. With mitigation measures (0,25) we make reference to both socioeconomic aspects (e.g. compensation for land requisition) and environmental aspects (Arnstein 1969, Brombal et al. 2017, Schroeder 2013). Verification sources: Jiangsu Wuxi Basin Urban Environment Project Office 2003, Wuxi shi huanjing kexueyuan 2005, Jiangsu sheng huanjing baohu ting 2008, Wuxi lihu fengjingqu 2012, Wuxi shi tongji ju 2013b, FDG #150816.
					Public is consulted on ≥ 2 scenarios, NOT including zero option	0,75	
					Public is consulted on a single scenario. Space left for adjustments in planning	0,50	
					Public is consulted only on measures to mitigate impacts	0,25	
					Public is not consulted	0,00	
	Soc4 Relocation	Soc 4.1 Residents' relocation	Qual.	Modes of relocation	No relocation	1,00	One of the major social impacts of environmental remediation and urban renewal projects is the relocation of those living and working in affected areas. Change in land use, establishment of ecological buffer zones, hydraulic infrastructures and real estate development often result in displacement of local communities, with negative socio-economic and cultural consequences. Classes for this attribute are based on international best practices for sustainable relocation (see in particular Chand et al. 2016). The highest class was defined based on the assumption that the optimal solution would be avoiding relocation *tout-court*, ensuring social and cultural continuity of local communities. Verification sources used to appraise this attribute: Jiangsu Wuxi Basin Urban Environment Project Office 2003, WB 2003, Jiangsu sheng huanjing baohu ting 2008, Wuxi shi tongji ju 2013b, Key informant interview #150918 (relocated peasant).
					In situ relocation, preserving access to sources of traditional livelihoods	0,75	
					In situ relocation, NOT preserving access to sources of traditional livelihoods	0,50	
					Relocation within the lake basin	0,25	
					Relocation outside of the lake basin	0,00	
		Soc 4.2 Reemployment	Qual.	Measures for reemployment of relocated residents	Preexisting employment preserved	1,00	Relocation implies consequences in terms of access to the labour market. Remediation and redevelopment of urban and fringe areas often impact the availability and accessibility of jobs, potentially hampering job-access of those living in communities directly affected by the project/programme/policy at hand. Classes for this attribute are based on international best practices for sustainable relocation (see in particular Chand et al. 2016). The optimal solution is identified in ensuring continuous access to pre-existing job opportunities, consistent with working skills available locally. Other classes were defined based on possible practices to ease negative consequences in terms of access to jobs and to ensure the utilisation of skills available among local communities. Verification sources used to appraise this attribute: Jiangsu Wuxi Basin Urban Environment Project Office 2003, WB 2003, Jiangsu sheng huanjing baohu ting 2008, Wuxi shi tongji ju 2013b, Key informant interview #150918 (relocated peasant).
					Targeted measures for reemployment, consistent with skills of affected people	0,75	
					Targeted measures for reemployment, inconsistent with skills of affected people	0,50	
					Non-targeted measures. Working opportunities offered in areas affected by relocation	0,25	
					No measures for reemployment	0,00	
Econ.	Eco1 Environmental management funding	Eco 1.1 Funding sources for environmental management	Qual.	Number of different sources of funding	≥5	1,00	Diversification of funding sources is key to sustainable financing of environmental and territorial management. Classes for this attribute were identified based on different typologies of funding sources, as categorised in relevant literature (Panayotou 1998, IUCN 2002, Emerton et al. 2006, Azevedo et al. 2012, Cellini et al. 2015). Sources include the following: (1) public sector (including loans from multilateral organisations); (2) private sector; (3) PPIs; (4) Income generation activities; (5) Trust funds participated by society at large. Other forms of funding are considered inly for the highest class (≥5). Funding refers to both activities of lake basin remediation and recurrent costs for long-term maintenance. Verification sources used to appraise this attribute: Wuxi shi fazhan gaige weiyuanhui 2009, Wuxi lihu fengjingqu 2012, Wuxi shi zhengfu 2013, Key informant interview #150917 (party official).
					4	0,75	
					3	0,50	
					2	0,25	
					1	0,10	
		Eco 1.2 Participation of the non-public sector in funding environmental management	Quant.	Share of environmental management funding (EMF) covered by non public sources	EMF≥50%	1,00	This attribute measures the contribution of non-public resources to the environmental maintenance of the Lihu lake. Classes were defined based on published literature and on regulatory documents enacted by local authorities (Panayotou 1998, IUCN 2002; Emerton et al. 2006, OECD 2006, Jiangsu sheng huanjing baohu ting 2008, Azevedo et al. 2012). In 2008 the provincial government set the objective of diversifying funding sources for Lihu's environmental management, while maintaining the leading role of the public sector (Jiangsu sheng 2008). The highest class was therefore set at a value lower or equal to 50% of the total funding for environmental management. Verification sources used to appraise this attribute: Wuxi shi fazhan gaige weiyuanhui 2009, Wuxi lihu fengjingqu 2012, Wuxi shi zhengfu 2013, Key informant interview #150917 (party official).
					40%≥EMF<50%	0,80	
					30%≥EMF<40%	0,60	
					20%≥EMF<30%	0,40	
					10%≥EMF<20%	0,20	
					0%≥EMF<10%	0,10	
					EMF=0%	0,00	
	Eco2 Economic growth	Eco 2.1 Per capita GDP	Quant.	Ratio of the per capita GDP in the lake basin to Wuxi city's average	GDP≥1,35	1,00	This attribute measures the relative economic development in the area of the Lihu lake basin *vis-a-vis* the overall situation of Wuxi city. Classes were defined based on a negative to positive scenario, ranging from a situation in which the per capita GDP in the lake basin is sensibly inferior to the city's per capita GDP (lowest class), to a situation in which it is sensibly higher (highest class). This approach was preferred to the utilization of classes employing absolute values because of the necessity to adjust to local conditions our appraisal of the economic benefit brought about by Lihu's IWM and urban renewal (Wuxi shi 2005, Frey, Gleave and Dawson 2014, Chung 2015, Wu 2015). Classes were defined by means of expert judgment (cfr. the methodological section of the paper, par. 3.4). Verification sources used to appraise this attribute: Survey Office of the State Statistics Bureau 2003, Tables 2-3c, 7-10c, 0723-4, 0723-8, 0723-12, Survey Office of the State Statistics Bureau 2012, Tables 0113, 0111 0201, 0203, 0204, 0723.
					1,10≥ GDP<1,35	0,75	
					0,90≥ GDP<1,10	0,50	
					0,75≥ GDP<0,90	0,25	
					GDP<0,70	0,10	
		Eco 2.2 Employment	Quant.	Ratio of the employment rate (ER) in the lake basin to Wuxi city's average	ER≥1,35	1,00	This attribute measures the relative employment level in the area of the Lihu lake basin *vis-a-vis* the overall situation in Wuxi city. Classes were defined based on a negative to positive scenario, ranging from a situation in which employment level in the lake basin is sensibly inferior to the city's overall employment level (lowest class), to a situation in which it is sensibly higher (highest class). This approach was preferred to the utilization of classes employing absolute values because of the necessity to adjust our appraisal to local conditions (Wuxi shi 2005, Wu 2015). Classes were defined by means of expert judgment (cfr. the methodological section of the paper, par. 3.4). Verification sources used to appraise this attribute: State Statistics bureau 2003, tables 2-3c, 7-10c, 0723-4, 0723-8, 0723-12, State Statistics bureau 2012, tables 0113, 0111 0201, 0203, 0204, 0723.
					1,10≥ER<1,35	0,75	
					0,90≥ER<1,10	0,50	
					0,75≥ER<0,90	0,25	
					ER<0,70	0,10	
	Eco3 Recreational value	Eco 3.1 Ecotourism	Quant.	Share of revenues from ecotourism (ET) on the total of Wuxi city's tourism revenues	ET>15,0%	1,00	This attribute is based on the share of tourism revenues generated by the exploitation of natural attractions. It has been chosen as a proxy to measure the contribution of the Lihu lake basin to Wuxi's tourism development, since most of naturalistic touristic attractions are located within the lake basin and/or in its surroundings. The lowest class was defined by triangulating historical data with interviews, showing a steep decrease in revenues from tourism activities (<10% of the total) in years with poor environmental conditions (Jiangsu sheng 2008, Wuxi shi tongjiju 2011, Key informant interview #150917). Classes were defined by means of expert judgment (cfr. the methodological section of the paper, par. 3.4). Verification sources used to appraise this attribute: Wuxi shi tongjiju 2011.
					12,5%≥ET<15,0%	0,66	
					10,0%≥ET<12,5%	0,33	
					ET<10,0%	0,00	
	Eco4 Hedonic value	Eco 4.1 Market value of real estate properties	Quant.	Ratio of prices per sqm of properties (PP) in the lake basin to Wuxi city's average	PP≥1,35	1,00	This attribute measures the relative value of newly built properties in the Lihu basin, compared with the average values of Wuxi city. It is used as a proxy to appraise the influence of Lihu's IWM and urban renewal on the value of properties (Poor, Pessagno, and Paul 2007, Troy and Morgan 2008). Classes were defined by means of expert judgment (cfr. the methodological section of the paper, par. 3.4). Verification sources used to appraise this attribute: Wuxi ribao 2014, Sina.com 2013, Sou fang 2015.
					1,10≥PP<1,35	0,75	
					0,90≥PP< 1,10	0,50	
					0,75≥ PP<0,90	0,25	
					GDP<0,70	0,10	

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