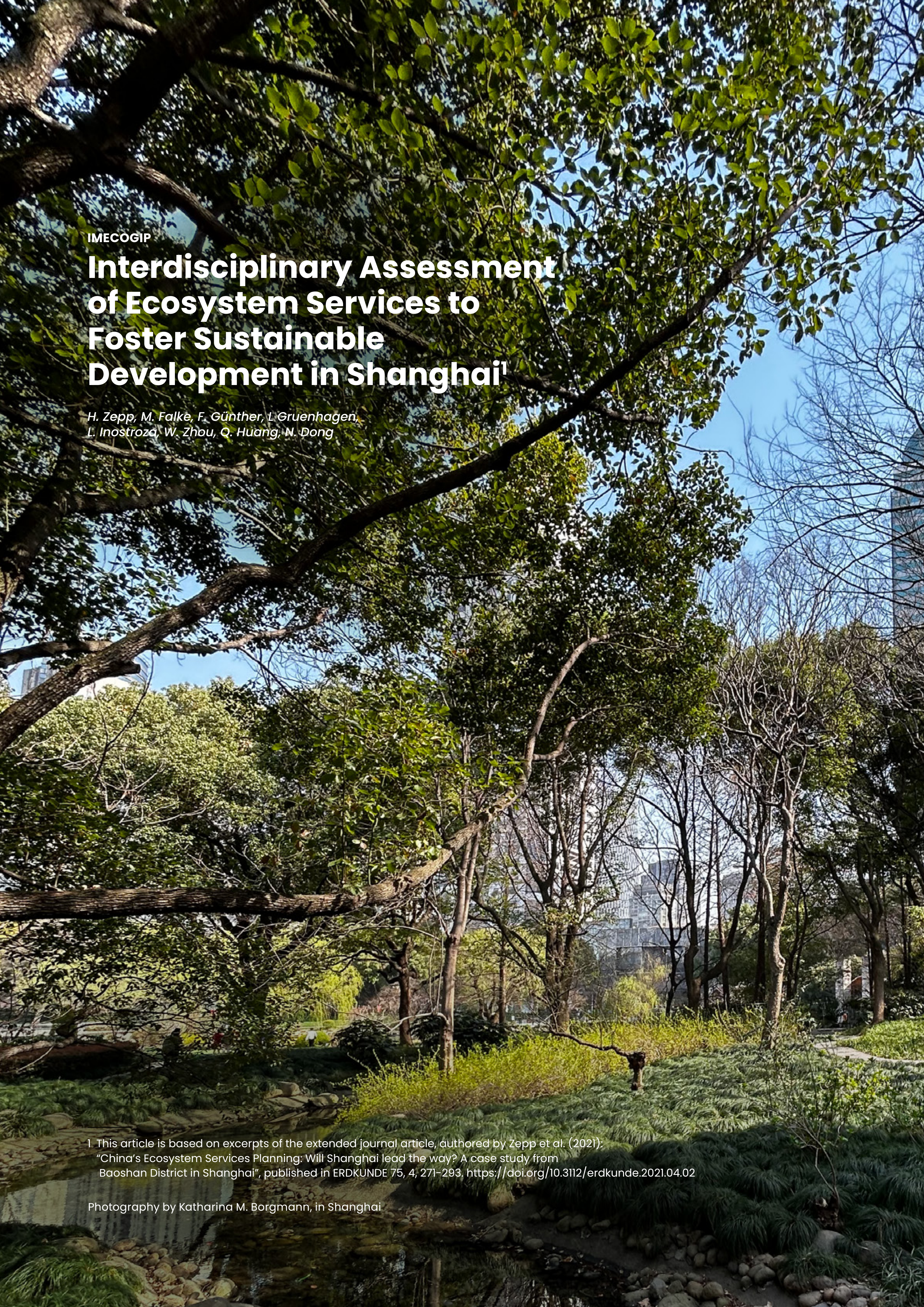


IMECOGIP

Interdisciplinary Assessment of Ecosystem Services to Foster Sustainable Development in Shanghai[1]

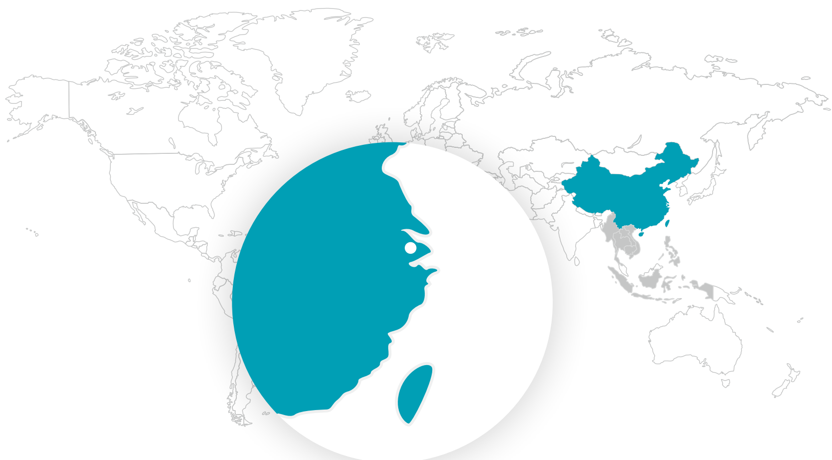
H. Zepp, M. Falke, F. Günther, L. Gruenhagen, L. Inostroza, W. Zhou, Q. Huang, N. Dong

1 This article is based on excerpts of the extended journal article, authored by Zepp et al. (2021): "China's Ecosystem Services Planning: Will Shanghai lead the way? A case study from Baoshan District in Shanghai", published in ERDKUNDE 75, 4, 271–293, https://doi.org/10.3112/erdkunde.2021.04.02

Photography by Katharina M. Borgmann, in Shanghai

Ecosystem services (ES) are a fundamental component of well-being and sustainable urban development with tremendous potential to enhance urban planning. In this activity report from the IMECOGIP project, we focused on the Shanghai Baoshan district Master Plan as a case study, and analyzed it under the lenses of ES supply using the matrix approach. We ascertained the supply of ES as delineated in the ecological network plan for 2035, and developed an evaluation framework based on CICES v5.1 and two expert workshops. Our approach used an integrated preliminary ES-assessment, and evaluated the consequences for the supply of ES in Baoshan district, which is adaptable to varying urban geographies. The results of our assessment show that, if realized as planned, the district will increase the overall supply of ES, especially regulating and cultural services that play an important role within GI on the urban level. In general, the land use plans should include fine-grained information within building blocks to allow for even better assessing of the spatial structure of ES supply.

中文（简体）
生态系统服务（ES）是福祉和城市可持续发展的基本组成部分，在提升城市规划工作方面具有巨大潜力。在 IMECOGIP 项目工作报告中，我们以上海宝山区总体规划为研究案例，在生态系统服务供给视角下对其进行了矩阵分析。我们根据当地2035 年生态网络规划确定了生态系统服务的供给内容，并在 CICES v5.1 和两次专家研讨会的基础上建立了评估框架。我们的方法综合了基础性的生态系统评估，并对宝山区生态系统供给水平的实施影响进行了评估，该方法适用于变化中的城市地理特点。我们的评估结果表明，如果按规划实施，宝山区生态系统服务总供给量得到提升，尤其是在城市层面的绿色基础设施中发挥重要的调节服务和文化服务功能。总体而言，土地利用规划应包括建筑区块内的细粒度信息数据，以便更好地评估生态系统服务供给下的空间结构。



Shanghai, China

Figure 1: Ecological network Plan from the Shanghai Master Plan 2017-2035 (redrawn from Shanghai Urban Planning and Land Resource Administration Bureau 2018, 66)

1. Introduction

However sustainable development may be defined, constitutive parts touch on the ecological, economical and social dimensions. Ecosystem services (ES) build on the interaction between people and ecological systems. In times of ecological crises, the value of the ecological base for societies and their economies striving to follow sustainable development paths receive more and more attention. Ecosystem services, understood as the benefits humans gain from nature, are sometimes expressed in terms of monetary values, which expresses their relation to economic considerations. The challenges of economic valuation are immense because the priorities in rating the benefits are diverse among individuals, social groups and more so between cultural spheres. The project "Implementation of the ecosystem services framework in Green Infrastructure Planning for resilient urban development in the Ruhr and in Chinese megacities" (IMECOGIP) therefore aims at assessing and quantification of ecosystem services on a non-monetary base in two different societal contexts, in Shanghai, China, and in the Ruhr Metropolis, Germany.

The broad approach to ecosystem services implies that knowledge from different disciplines is needed. In a series of Sino-German workshops, the IMECOGIP project gathered specialists from ecology, social sciences, and planning as well as from planning practice to exercise a matrix-based assessment of ecosystem services in Shanghai and the Ruhr Metropolis. In this contribution, we present the method and its application to the present and tentative, anticipated future as laid out in the Master Plan for the Baoshan District.

2. Study Area and Methods

2.1. Study Area and Planning Framework

Shanghai's Baoshan district is situated in northern Shanghai (Fig. 1). It is one of sixteen districts in Shanghai, covering an area of 425 km² and is home for roughly 2.2 million people (Shanghai Municipal People's Government 2022). Being a part of the Yangtze delta, flat terrain and high groundwater table prevail. The Huangpu River forms the southeastern border of the district, which is well known for its steel industries along the Changjiang (Yangtze) River in the north and the southeast. Small-scale industrial plots locate alongside and south of the Shanghai outer ring road as well as in central Baoshan, whereas the large industrial plots of state-owned enterprises, notably the Baosteel Group, are in the eastern and northeastern parts. Peri-urban land use with scattered village structures dominate in the northwestern parts of Baoshan. However, urban tissue occupies two-thirds of the district. Baoshan is in the process of urban transformation. The retreat of heavy industries offers chances for a comprehensive spatial reorganisation of land uses.

The Shanghai Master Plan (Shanghai Urban Planning and Land Resource Administration Bureau 2018) represents the mandatory planning framework, which the district government of Baoshan must implement accordingly. The *'Comprehensive Plan and General Land-Use Plan of Baoshan District* 2017-2035' was issued in March 2019 (Baoshan District People's Government 2019). It zones ecological spaces as well as permanent cropland areas and delineates urban development boundaries. Baoshan intends to cut the share of industrial land by half, from 34.4% to 17.2%. At the same time, the proportion of residential land shall increase from 21.4% to 25.3%, green space from 9.2% to 16.8%, and public facilities from 6.2% to 9.2% (Baoshan District People's Government 2019, 43).

2.2. Methods

2.2.1. Present and Future Land Use and Land Cover

Our assessment of ES provision is based on present and prospective land use/land cover (LULC) patches, for which a matching classification for both points in time was elaborated. As part of project activities, we mapped the LULC of Baoshan district in the year 2017 using a three-step approach combining visual interpretation, spatial overlay analysis and object based-classification (Antrop and Eetvelde 2000; Cadenasso et al. 2007; Shao and Wu 2008; Zhou et al. 2014). We overlaid Planet and Pleiades multispectral satellite images with a spatial resolution of 3 m and 0.5 m respectively, from August and September 2017. To cross-check and verify urban street networks, waterways, and public facilities, we used Open Street Map (© OpenStreetMap-contributors). We distinguished 18 LULC-classes (Table 1, Column 1), including areas that could not be classified adequately.

Baoshan LULC 2017	**Baoshan LULC 2035**	**Workshop LULC assessment**
residential urban > 80% sealed		residential urban > 80% sealed
residential urban 80-30% sealed	residential area	residential urban 80-30% sealed
residential urban < 30% sealed		residential urban < 30% sealed
residential rural		residential rural
green area	green area	urban green areas (parks)
basic farmland	basic farmland protection area	agricultural land
greenhouses		greenhouses
agroforestry area	agroforestry area	agroforestry
		forest
water bodies	water bodies	water bodies
water bodies (river)	water bodies (river)	water bodies (river)

Baoshan LULC 2017	Baoshan LULC 2035	Workshop LULC assessment
commercial area	commercial area	commercial area
industrial area and warehouses	industrial area and warehouses	industrial area and warehouses
	industrial R&D area	
sports & recreational area	sports and recreational area	sports and recreational area
educational, cultural and welfare area	educational, cultural and welfare are	educational, cultural and welfare are
municipal infrastructure	municipal infrastructure	municipal infrastructure
transportation facilities	transportation facilities	transportation facilities
unclear	strategic empty space	land reserved for development or under construction
under construction	land reserved for development	
	construction area for other land use	

Table 1: Land use/land cover (LULC) classifications used in Master Plans and harmonized for ES assessments. (1) Baoshan LULC 2017 is the classification we used in our own analysis of the present state. It is more detailed than (2) Baoshan LULC (General Land-Use Plan). To be able to assess and compare ES for both years, we prepared the (3) Workshop LULC assessment.

The *'Comprehensive Plan and General Land-Use Plan of Baoshan District 2017-2035'* establishes only 16 LULC classes, (Column 2 in Table 1). The Plan does not allow for subdivisions of residential areas. To resolve the mismatch between class designations of Column 1 and 2, we aggregated the 2017 categories ('unclear', 'under construction') and 2035 categories (*'strategic empty space', 'land reserved for development*' and *'construction area for other land use*') to 'land reserved for development or under construction' (Column 3). Industrial R&D area was subsumed in the category 'industrial area and warehouses' and greenhouses in 'agricultural land'. Ultimately, we performed a spatial overlay for 2017 and 2035 LULC patches to calculate the LULC change in GIS (©ArcGIS 10.5.1).

2.2.2. Assessment of (Prospective) Ecosystem Services

We applied the 'Common International Classification of Ecosystem Services' v5.1 (CICES) in our assessment (Haines-Young and Potschin 2018). The CICES framework represents a sophisticated and peer-reviewed classification system used in recent European (Zepp et al. 2016; Tammi et al. 2017; Sutherland et al. 2018; Zepp 2018; Elliot et al. 2019) and Chinese (Yang et al. 2015; Cheng et al. 2019; Liu et al. 2020) ES studies. During an initial workshop held in October 2019, out of 90 ES listed in CICES v5.1, the principal investigators and Chinese partners, supported by their respective team, preselected the most relevant ES for large metropolitan areas. Thereafter, we invited experts from regional planning, municipalities, and universities to an assessment workshop. Seventeen scientists and professionals from practice assessed the ES significance of each LULC class listed in Table 1, Column 3. All experts who finally contributed to the assessment held academic degrees in urban or environmental planning (n = 5), landscape architecture (n = 3), environmental science (n = 7), economics (n = 1), and social science (n = 1), and were already familiar with the concept of ES. In the workshop, we explained in detail the different LULC classes, both orally and using supporting photos, to prepare the individual work phase. The organizers asked the participants to rate the potential ES provision of each LULC in numbers from zero (no contribution) to five (maximum contribution), as done by Montoya-Tangarife et al. (2017) and Mukul et al. (2017). The assessment took place on-site during the afternoon of the same day. We calculated means, and to express the degree of consensus between the participants, we looked at the variability of ratings. The procedure is adapted to the matrix approach, originally suggested by Burkhard et al. (2012). Additionally, Jacobs et al. (2015) performed a knowledge-based survey among experts. Data are fuzzy in the case of LULC in general land use plans. With the matrix approach, we covered all major LULC classes (n = 18) presently found in the Baoshan District, approximating China's system of current land use classification (Chen and Zhou 2007; Guo et al. 2018). We included different degrees of imperviousness for urban residential areas to better explore ES by type of urban-dwelling structure. For the expected LULC 2035, we estimated the building density for new residential areas based on recently built neighbourhoods.

Prior to estimating the effect of land use changes on ES provision, we performed a minimum-maximum standardisation according to Mouchet et al. (2017). For each mean rating of ESs, we subtracted the minimum mean rating of ESs occurring in any LULC and then divided by the difference between the maximum and the minimum values, i.e., the range of mean ES ratings in any LULC

$$(1) \qquad ESs = \frac{ES - MIN(ES)}{MAX(ES) - MIN(ES)}$$

with ESs standardised ES
ES mean rating of ES
MIN(ES), MAX(ES) minimum and maximum of mean ratings of ESs occurring in any LULC

For each combination of LULC and ES, the result is a dimensionless and comparable indicator, ranging from zero to one (Mouchet et al. 2017).

The standardisation attributes equal importance to all ES and are area-specific.

For each ES, we calculated an area-weighted ES significance ESs_w (Equation 1) for both 2017 and 2035. The change in area-weighted significance is ESC according to Equation (2). To express the relative change of area weighted ES significance, we calculated a handy ESs_C*-Index* (Equation 3). We subtract the value of 100 to accentuate differences between the 2017 and 2035 results. An increase in ES significance results in a positive index, while negative values indicate a deterioration of the situation.

$$(2) \qquad ESs_w = \sum_{LULC=1}^{n} \left(ESs_{LULC} \times \frac{A_{LULC}}{A_t} \right)$$

$$(3) \qquad ESs_C = ESs_{w;\,2035} - ESs_{w;\,2017}$$

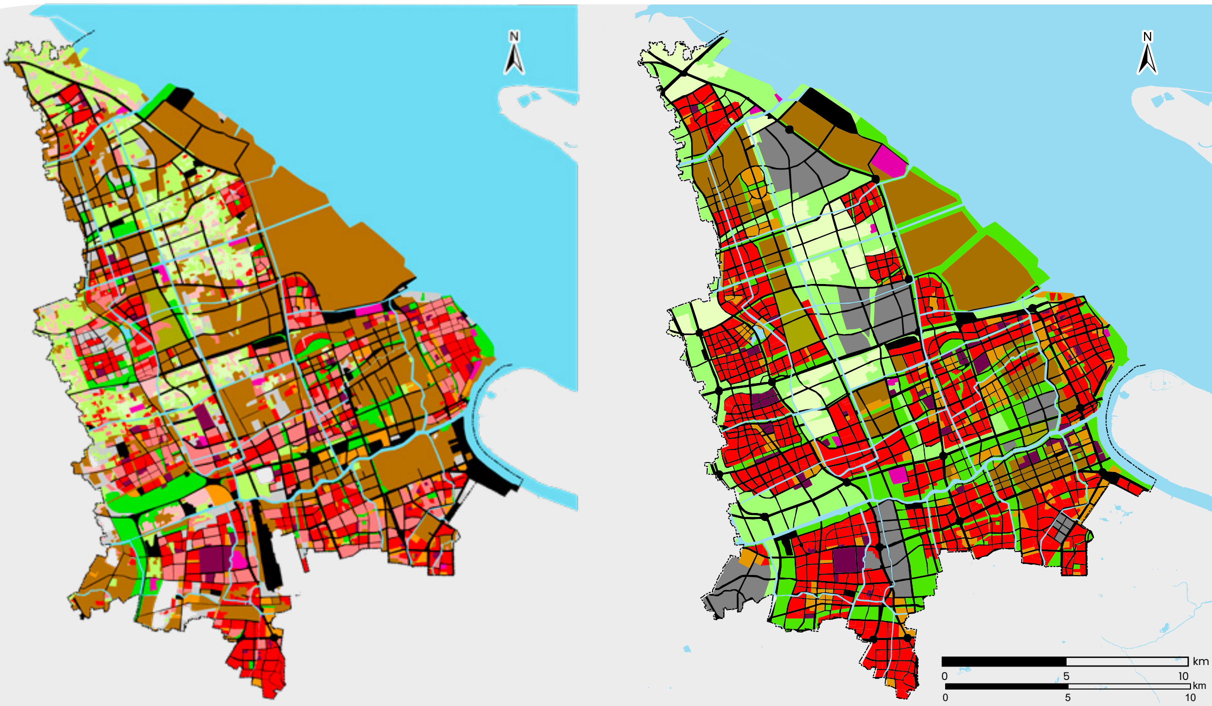
$$(4) \qquad ESs_C\text{-}Index = (ESs_C \times 100) - 100$$

with ESsw area weighted ES significance
n number of LULC
ESs_{LULC} ES significance of LULC class
A_{LULC} area covered by LULC class
At total area (Baoshan district)
ESs_C change of area weighted significance
ESs_C-*Index* Index expressing relative ESC

3. Results

3.1. Land Use/Land Cover Change

The maps of Figure 2 formed the base to assess the supply of ES in 2017 and 2035, the anticipated state. The largest LULCC (change between Columns 1 and 2 of Table 1) is attributed to the transformation of industrial land. According to the plan, a total of 198 industrial plots are in need of consolidation and rehabilitation (Baoshan District People's Government 2019, 56). Our calculations show (Fig. 3) that the share of industrial land in the Baoshan District would decrease from 30.7% in 2017 to approximately 11.7% in 2035, of which 3.2% would be transformed into *"industrial R&D areas"*. Although the amount of residential area showed a marginal increase from 20.8% to 21.1%, our analysis showed that this change would also imply an increase from 18.6% to 21.1% in urban residential area, presumably



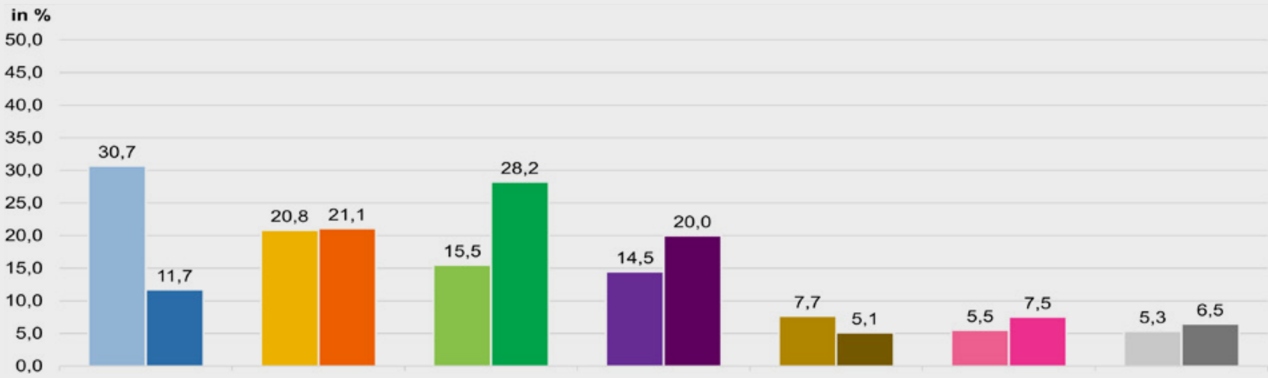
Land Use Land Cover 2017

- agroforestry area
- basic farmland
- commercial area
- educational, cultural and welfare area
- green area
- industrial area and warehouses
- municipal infrastructure
- residential rural area
- residential urban <30% sealed
- residential urban >80% sealed
- residential urban 80-30% sealed
- sports & recreational area
- transportation facilities
- under construction
- water bodies

Land Use Land Cover 2035

- agroforestry area
- basic farmland protection area
- commercial area
- educational, cultural and welfare area
- green area
- industrial area and warehouses
- municipal infrastructure
- residential area
- sports & recreational area
- transportation facilities landuse
- land reserved for development
- water bodies

Figure 2: Land use land cover in 2017 (based on satellite interpretation and existing maps) and for 2035 according to the 'Comprehensive Plan and General Land-Use Plan of Baoshan District 2017-2035' (Baoshan District People's Government 2019).



Land Use

- Commercial and industrial areas
- Residental area
- Green Inrastructure(green area, agroforestry and water bodies)
- Transportation and freight facilities
- Cultivated agricultural land
- Municipal infrastructure and commercial areas
- Land reserved for development or under construction

Figure 3: Prospective land use change between 2017 and 2035 for the Baoshan District, Shanghai. Calculation based on Figure 2.

multistoried buildings, at the expense of rural residential land (villages). Green Infrastructure (GI) would represent the largest net gain (from 15.5% to 28.2%). LULC for transportation and freight facilities is also foreseen to increase by approximately one-third, primarily due to the widening of narrow, rural streets to multilane streets for cars and motorbikes. Cultivated agricultural land is planned to shrink from 7.7% to 5.1%.

Though LULCC would include the conversion of rural residential area (10%) and agricultural land (7.5%) to create the ecological corridors, the intended LULCC implies a substantial conversion of formerly sealed land to GI accounting for more than 52 km². We evaluate the implications for the supply of ES in the following section.

3.2 ES Assessment Matrix

Table 2 shows the significance of ES on a scale from zero to five, expressed as the arithmetic mean of the experts' evaluation. The LULC classes are according to Column 3 in Table 1. Urban green areas, forests, and bodies of water exhibit the highest scores. Regulating services reveal the highest significance for most of the LULC classes

In a metropolitan context, cultural ES can play, a more important role than provisioning and regulating ES according to the experts' opinions. This is especially the case for 'educational", "sports and recreational" LULC and for "urban green areas". With a view of provisioning ES, we noticed that almost all LULC-based maximum values stem from the section of abiotic ES (surface and groundwater used as a material), while biotic ES (aquatic and reared animals for nutritional purpose) delivered almost nosignificant levels (close to one) or were even rated as irrelevant (close to zero). The lowest mean ratings were assigned to transportation (0.67), commercial areas (0.80), and industrial areas and warehouses (0.86). Forests, urban green areas, and sports and recreational areas exhibit the highest contrasts between ES. There is a strong

Ecosystem Service \ Land Use / Land Cover	Residential / Urban / >80 sealed	Residential / Urban / 30-80 sealed	Residential / Urban / < 30 sealed	Residential / Rural	Urban Green Areas (parks)	Agricultural Land	Greenhouses	Agroforestry	Forest	Water Bodies (river)	Water Bodies	Commercial Area	Industrial Area and Warehouses	Sport and Recreational Area	Educational, Cultural and Welfare Area	Transportation Facilities	Municipal Infrastructure	Land reserved for Development/ Under Construction
Animals reared for nutritional purposes	0.2	0.2	0.6	1.5	1.1	1.8	1.6	1.9	1.3	2.1	1.1	0.3	0.3	0.2	0.5	0.2	0.3	0.1
Animals reared by in-situ aquaculture for nutritional purposes	0.2	0.3	0.4	0.9	0.9	0.6	0.4	1.1	0.8	3.8	3.0	0.5	0.5	0.2	0.4	0.1	0.3	0.3
Surface water used as a material (non-drinking purposes)	1.9	2.7	2.7	2.9	2.9	2.4	2.3	3.0	3.2	3.3	3.1	1.7	1.6	1.3	2.0	0.8	1.9	2.6
Ground water (and subsurface) used as a material (non-drinking purposes)	1.6	2.1	2.5	2.6	2.9	2.9	2.6	3.0	4.7	2.5	1.9	1.2	1.1	1.5	1.5	0.7	1.4	2.2
Hydrological cycle and water flow regulation (including flood control)	1.4	1.6	2.1	2.3	3.8	3.1	2.5	3.8	4.5	3.8	2.8	0.8	0.8	1.0	1.3	0.8	1.1	1.4
Pollination (or 'gamete' dispersal in a marine context)	1.3	1.7	2.1	2.5	3.8	3.3	2.8	4.2	4.5	2.3	1.7	0.6	0.7	1.1	1.2	0.7	0.9	1.5
Maintaining nursery populations and habitats (including gene pool protection)	0.8	1.1	1.6	2.0	3.6	2.7	2.6	3.7	4.3	3.4	2.1	0.5	0.5	0.8	1.1	0.4	0.7	1.2
Decomposition and fixing processes and their effect on soil quality	0.8	0.9	1.5	2.1	3.9	3.1	3.1	3.5	4.8	1.9	1.2	0.3	0.4	0.9	0.8	0.3	0.5	0.9
Regulation of the chemical condition of freshwaters by living processes	1.0	1.1	1.3	1.6	2.5	2.3	1.9	2.5	4.0	4.5	3.2	0.6	0.9	0.7	0.8	0.5	1.3	1.0
Regulation of temperature and humidity, including ventilation and transpiration	2.1	2.2	2.5	2.5	3.8	2.9	2.6	3.5	3.5	3.8	3.0	1.4	1.8	1.9	1.7	1.5	1.6	2.3
Characteristics of living systems that enable activities promoting health (actice)	1.6	1.7	2.1	2.4	4.6	2.3	2.3	3.7	4.3	4.0	2.4	1.2	1.1	3.3	2.3	0.9	1.3	1.9
Characteristics of living systems that enable activities promoting health (observational)	1.5	1.6	2.4	2.8	4.3	2.4	2.4	3.3	4.0	4.1	2.5	0.8	0.8	2.4	1.8	1.0	1.6	1.7
Characteristics of living systems that enable scientific investigation	1.0	1.1	1.3	1.1	4.0	2.4	2.5	3.2	4.8	4.1	2.1	0.5	0.9	1.2	1.8	0.7	1.0	1.0
Characteristics of living systems that enable education and training	1.0	1.1	1.3	1.2	4.1	2.3	2.4	3.3	4.7	4.1	2.2	0.6	0.8	1.9	2.6	0.6	1.4	1.0
Characteristics of living systems that enable aesthetic experiences	1.3	1.4	1.9	2.1	4.6	2.4	2.1	3.7	4.8	4.6	2.9	0.9	0.9	1.5	1.9	0.8	1.3	1.5
Maximum Provisioning Service	1.9	2.7	2.7	2.9	2.9	2.9	2.6	3.0	4.7	3.8	3.1	1.7	1.6	1.5	2.0	0.8	1.9	2.6
Maximum Regulating Service	2.1	2.2	2.5	2.5	3.9	3.3	3.1	4.2	4.8	4.5	3.2	1.4	1.8	1.9	1.7	1.5	1.6	2.3
Maximum Cultural Service	1.6	1.7	2.4	2.8	4.6	2.4	2.5	3.7	4.8	4.6	2.9	1.2	1.1	3.3	2.6	1.0	1.6	1.9
Contrast	1.9	2.5	2.3	2.0	3.7	2.7	2.7	3.1	4.0	2.7	2.1	1.4	1.5	3.1	2.2	1.4	1.6	2.5

Table 2: Graded significance of ES (derived from CICES 5.1) by LULC class for Shanghai. Calculations based on results of an expert workshop held in 10/2019. Contrast (bottom row) is the range between highest and lowest ratings.

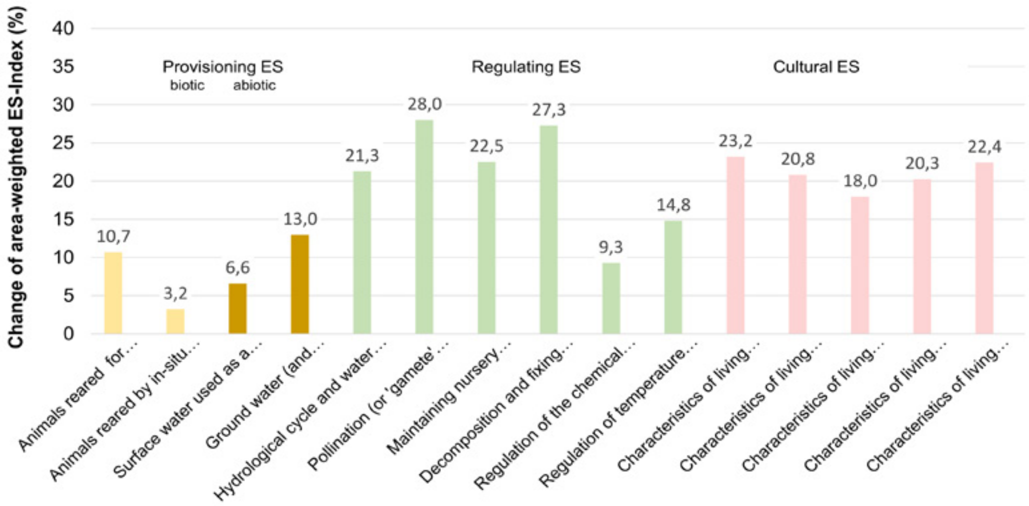


Figure 4: Change of area-weighted ES-Indices between 2017 and 2035. The index visualizes relative changes to compare the effects on single ES. It does not depict absolute increase of decrease of ES provision.

contrast with nearly all regulating and cultural services. The same is true for urban green areas. Sports and recreational areas provide respectable cultural services, which is the cause for the considerable contrast to ES with suitability.

3.3 Hypothetical Changes in ES Provision 2017-2035 in Terms of Contributing Areas

Assuming the prospective LULC changes are implemented, ES provisioning in the Baoshan district will increase in terms of areas. The area-weighted changes of ES supplies would be strengthened by 10% to 28% in comparison to 2017 (Fig. 4), depending on the ES considered. Again, provisioning services such as animals reared by in-situ aquacultures (CICES 1.1.4.1, +3.2%) and surface water used as a material (4.2.1.2, +6.6%) represent the smallest net gain in the supply of ES due to the lack of explicitly added blue infrastructure apart from ditches and ponds in agroforestry and urban green areas. Contrary to that, regulating ES exhibit the largest increase in the supply of ES, especially pollination (CICES 2.2.2.1, +28%) and decomposing and fixing processes and their effect on soil quality (2.2.4.2, +27.3%). Besides this, the planned LULCC will considerably strengthen cultural ES (CICES 3.1.1.1 to 3.2.2.4, +18% to 23.2%).

4. Interdisciplinary and Cross-Cultural Aspects

Ratings between the experts varied, which might be attributed to their disciplinary background. As the workshop ratings were done anonymously, we cannot back trace possible disciplinary biases. The variability increases with decreasing ES significance (Fig. 5a), i.e., the consensus between the experts was higher in the case of LULC, which was rated as providing a higher ES supply. As the data are not normally distributed and no confidence interval can be visualized, Figure 5a depicts the ranges of variabilities that cover 75% of the lowermost variabilities within the five classes of ES significance. This confirms that the experts unanimously rated the strong ES performance of the various LULC systems. The scattergram of the standard deviations as a function of the five significance classes (shown by Fig. 5b) reveals that good agreements occur when mean ratings exceeded 3.5. On the other hand, the dome-shaped distribution illustrates that LULC with irrelevant (insignificant) ES performance (ratings of less than one) was unanimously rated to be low by the experts. Q3 of standard deviations in the ES significance classes 0-1, > 1-2, > 2-3, > 3-4, and > 4-5 are 1.0, 1.5, 1.7, 1.5, and 1.3, respectively.

The accuracy of the assessment is likely to vary for those LULC that are of intermediate value for the provision of services. The bias between experts of various fields is small when it comes to low or high ecosystem services provision. This finding is corroborated by Roche and Campagne (2019, 1) who concluded that "using expert knowledge through the matrix approach yields results very close to those from quantitative proxies or biophysical models for the evaluation of ES at the regional level, particularly when there is a need to evaluate many ES or in a data scarce region."

Spyra et al. (2019b) saw the challenges of developing a cohesive understanding among actors. Yet, in this contribution we could show that that a preliminary assessment of ecosystem services is possible in an interdisciplinary team of experts. On the whole, the results encourage that experts from various disciplines already have und can develop even more a common understanding of ecosystem services after interdisciplinary discussions.

In addition to what Albert et al. (2020) call the knowledge-to-action gap, we have to point to the extra challenges of literal translation of planning terms between culture areas. The ES-concept had been designed in Western science world. Only recently it trickles penetrates planning cultures around the globe. Even in German planning system, it is not yet being used operationally in planning authorities and consulting. When Spyra et al. (2019b) attested to the potential of the ES concept to become the new Esperanto in planning processes, the hurdle to effectively implement this concept in countries with different cultural and linguistic backgrounds, as in China, should not be overlooked.

From our project experience, it is also clear that another problem becomes more important when the planning areas become fine-grained, regardless of the cultural background. The often fuzzy description of planned land use and land cover hinders the transition from the preliminary matrix approach to more sophisticated models to quantify ecosystem services.

Figure 5a

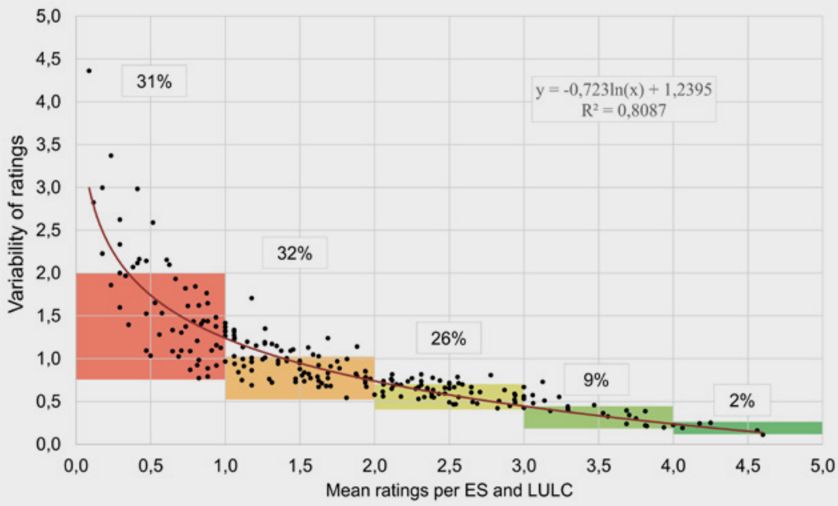


Figure 5b

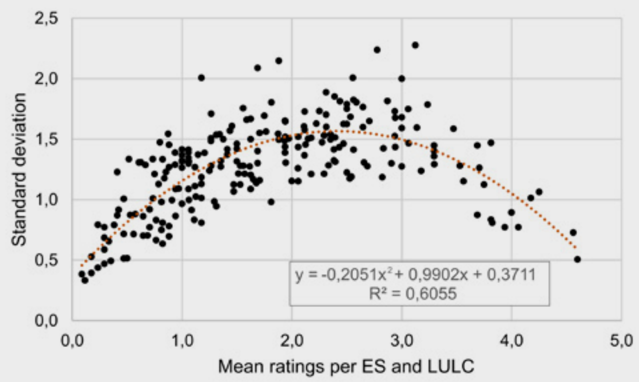


Figure 5: a) Variability of the ratings as a function of mean ratings per ES and LULC. Shaded areas visualize the intervals comprising 75% of the lowermost variabilities of each significance class. Colors are the same as in Table 2. Percentages refer to the proportion of all ratings within each significance class. b) Standard deviation as a function of mean ratings per ES and LULC. Regression lines for illustration only.