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Research Article

Different people, different wild: Comparing and mapping wilderness representation in Wuyishan National Park, China

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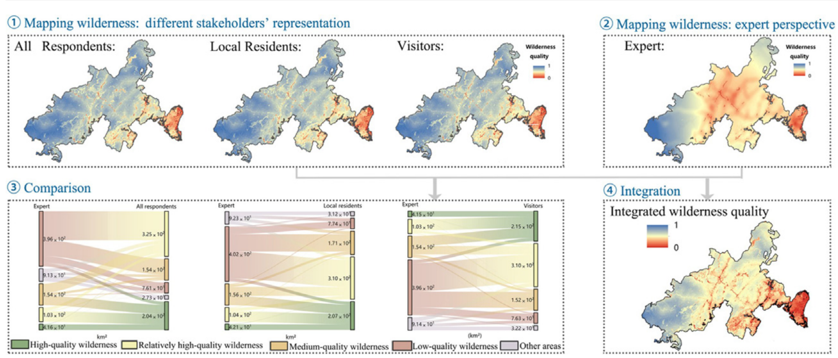
HIGHLIGHTS

- An integrated method of mapping wilderness involving public's perception is proposed.
- Integrated wilderness map allows for more precise identification of wilderness areas.
- The wilderness perception varies significantly amongst the different stakeholder groups.
- 17.41% of high-quality wilderness of the Wuyishan NP is not subject to special protection.

GRAPHICAL ABSTRACT



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ABSTRACT

It is essential to better integrate wilderness representations of different stakeholders into wilderness conservation. The way in which local residents and other stakeholders frame the construction of wilderness of protected areas in developing countries are poorly understood. In these areas, land use policy and decision may lead to conflicts. This study aims to explore existing public wilderness representations using a questionnaire survey (n = 514) administered amongst tourists and other stakeholders in the Wuyishan National Park, in southeast China. The spatial differences in public representations of wilderness across different stakeholder groups were compared against expert knowledge. We found that integrated wilderness representation maps of different stakeholder groups were consistent, namely 'area where wild animals live', 'area with no human influence', 'a barren and lonely area'. However, three sub-representations of the individual stakeholders varied significantly. Moreover, expert-based wilderness mapping did not reflect public representations accurately, and an integrated wilderness quality map considering wilderness representations across both stakeholders and experts can better identify detailed wilderness areas. Our study provides new insights and technical support for future exploration of wilderness conservation and mapping in China and other countries with insufficient awareness of wilderness values and investigations in a regional scale.

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1. Introduction

Wilderness conservation and management has become a central issue in and around protected areas worldwide (Yang et al., 2020) and plays an important role in preserving biodiversity and ecosystem services (Mittermeier et al., 2003; Pimm et al., 2018; Cao et al., 2022a). The concept of wilderness differs according to the setting and issue (Nash, 2014). Generally, wilderness is defined as a natural environment with little or no human activity (Vitousek et al., 2000). However, wilderness is also widely recognized as a social construct that acquire meaning from language and cultures, namely a relative situation across landscapes (Kliskey et al., 2004; Hedblom et al., 2020; Zoderer et al., 2020). The aesthetic, moral, and spiritual values linked to wilderness have been identified in several studies (Mittermeier et al., 2003; Van and Koole, 2006; Pimm et al., 2018; Cao et al., 2022a).

Considering people's various perceptions and attitudes, many studies have pre-selected and assessed wilderness attributes that people's preferences are based on (Vistad and Vorkinn, 2012; Zoderer et al., 2020). Previous studies have mainly focused on the survey of wilderness preferences of recreational users, and the Wilderness Purism Scale is a relevant tool for segmenting visitors into three or four purism groups (Hendee et al., 1968; Stankey, 1973; Vistad and Vorkinn, 2012). Significant differences in wilderness representations owing to different social, cultural and income groups have been found (Palso and Graefe, 2008; Vistad and Vorkinn, 2012). It can be found that visitors labelled 'purist' prefer solitude, remoteness and isolation in wilderness area (Vistad and Vorkinn, 2012). Most survey studies were conducted in national parks and protected areas in the United States and Europe. However, how local residents, employers, and other stakeholders frame constructs of wilderness of protected areas in developing countries, where land use policy and decision may lead to conflicts, are poorly understood (Cao et al., 2022a, 2022b).

Recently, other stakeholder groups of protected areas, including local residents or visitors on wilderness, have been investigated to explore the meaning of wilderness and where it can be found (Carver et al., 2012; Larkin and Beier, 2014; Ólafsdóttir and Beier, 2020; Zoderer et al., 2020). Perceived wilderness and areas designated as wilderness by law were compared, and their agreement and disparity were found (Flanagan and Anderson, 2008; Larkin and Beier, 2014; Zoderer et al., 2020). Wilderness perception mapping based on Stankey's (1973) Purism Scale, wilderness representation mapping based on a mental representation survey (Zoderer et al., 2020), or other participatory mapping may help identify the potential conflict areas between perceived and political wilderness. It is essential to integrate the wilderness representations of the different stakeholders into protected areas conservation (Higham et al., 1999; Flanagan and Anderson, 2008) to improve the efficiency and outcome of conservation efforts. However, existing wilderness conservation policies tend to identify wilderness areas through expert mapping methods using standard or legal definitions without considering the wilderness representation (e.g., Kuiters et al., 2013; Butler and Berglund, 2014; Flannery et al., 2018).

China is regarded as one of the world's 'mega-wild' countries (Watson et al., 2018), where wilderness is widely distributed in national parks and other protected areas. Unlike that in the United States or Europe, wilderness in China is still not designated or conserved by law, which may be attributed to insufficient awareness of wilderness values. Nowadays, China's national park system has been established and developing under the eco-civilization background. Most research at the national scale in China has been carried out based on the multi-criteria evaluation (MCE) models and assessment by 25 experts (Cao et al., 2019). However, current wilderness maps have generally ignored small-scale wilderness areas, especially in the densely populated and accessible areas of China. It is important to identify smaller wilderness areas at the local scale to ensure their protection (Caro et al., 2012), as people residing there often perceive, value, and interact with their local landscape in many different ways. In addition, defining the wilderness zone in a national park is an important direction for the deep reform of China's national park system (Wu et al., 2022). Considering the complexity of land use ownership in the national parks of China, it is essential to map wilderness integrating with different stakeholder group's representation (He et al., 2018).

Wuyishan is one of the first batch of China's national parks and is located in a densely populated area of southeastern China. Taking the Wuyishan as a case study, this study aims to assess the agreement and disparity in wilderness representation amongst different stakeholders. Our findings establish an integrated wilderness map of the national park, building on public representation of wilderness and mapping with expert inputs. Specifically, we put forward the following questions:

(1) What are the spatial differences in public wilderness representation across different groups of stakeholders?
(2) What are the spatial agreement and disparity between public wilderness representation map and expert perspective wilderness quality maps?
(3) Can the integrated wilderness quality map that considers wilderness representations across both stakeholders and experts better identify detailed wilderness areas?

2. Material and methods

To address the aforementioned pivotal issues, our proposed methodology comprises three key stages (Fig. 1): 1) Mapping wilderness: different stakeholders' representation involving the collection, processing, and spatial quantification of wilderness perception data from various stakeholders. 2) Mapping wilderness: expert perspective, employing conventional expert rating methods to score wilderness indicators and determine their corresponding weights, followed by spatial representation. 3) Comparison and integration of different stakeholders' representations and expert perspectives, including the outcomes from the two preceding stages, along with precision validation of the integrated results. Subsequent sections will provide a more detailed exposition of the research methodologies and procedures associated with each of these stages.

2.1. Study area

Wuyishan National Park (Fig. 2) has an area of 1,001.41 km^2, with approximately 3,000 residents in Fujian Province. We choose the Wuyishan National Park because of multiple reasons. First, it is one of the first batch of national parks established in China, which aims to preserve the most complete, typical, and largest primary forest ecosystems in the central subtropical zone at the same latitude worldwide. The total wilderness area is 423 km^2 and the wilderness quality grade from Level 3 to Level 8 are 1 km^2, 2 km^2, 9 km^2, 11 km^2, 97 km^2, and 303 km^2, respectively (Cao et al., 2019) (Fig. S1 in Supplementary Material 1). Second, it is a World Cultural and Natural Heritage site, where the diverse natural and cultural elements are highly concentrated and different stakeholders are involved (e.g., residents and visitors), thereby allowing an accurate representation of the opinions from the diverse public. Lastly, at present, the planning of the Wuyishan National Park does not consider the delimitation of wilderness protected areas, and there is a lack of public participation.

2.2. Mapping wilderness: different stakeholders' representation

2.2.1. Data collection and analysis

Inspired by Zoderer et al. (2020), we collected data using a combined qualitative and quantitative approach, followed by reliability, validity, and exploratory factor analyses. To achieve this goal, the following steps were taken.

First, the pre-survey used an open-ended questionnaire administered to 5 wilderness experts and 10 local residents. The list of initial wilderness representation scale items used to determine and map wilderness

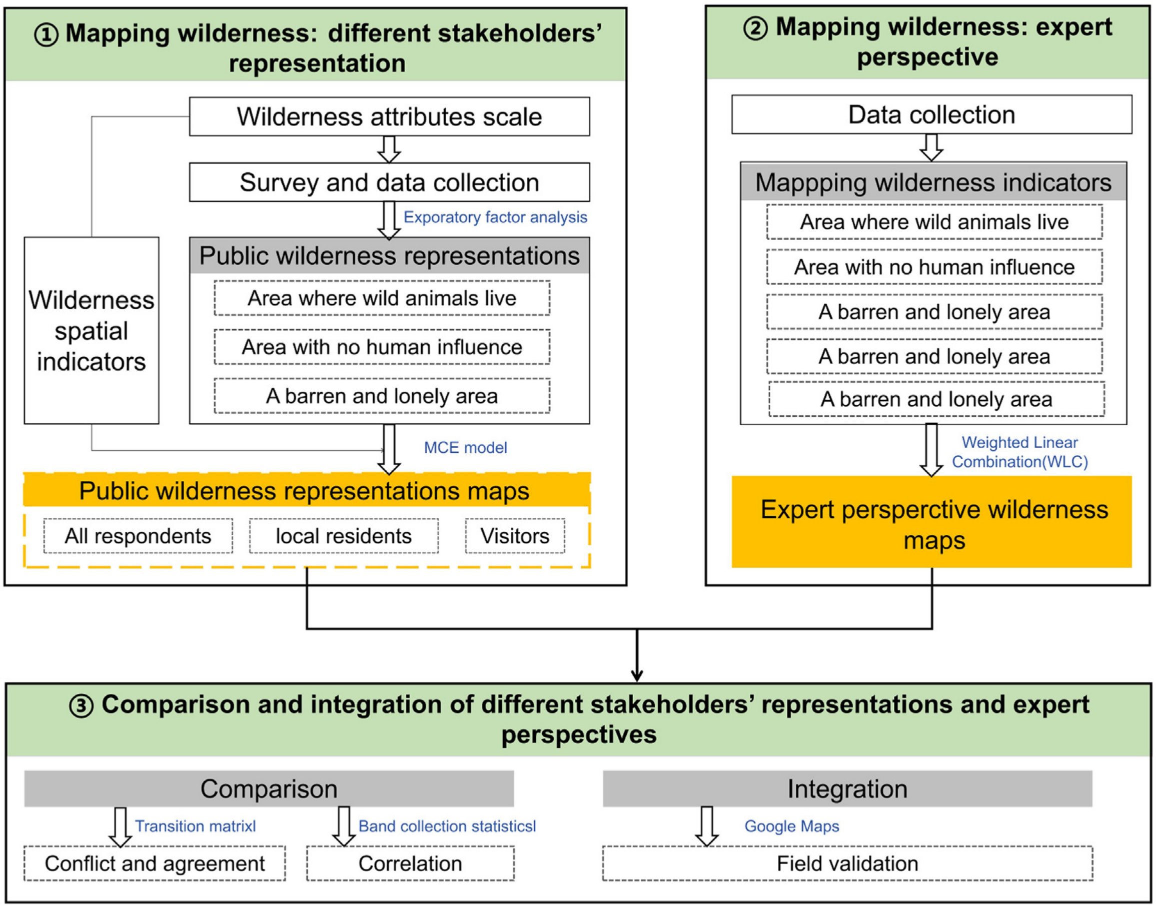

Fig. 1. Research framework of the study.

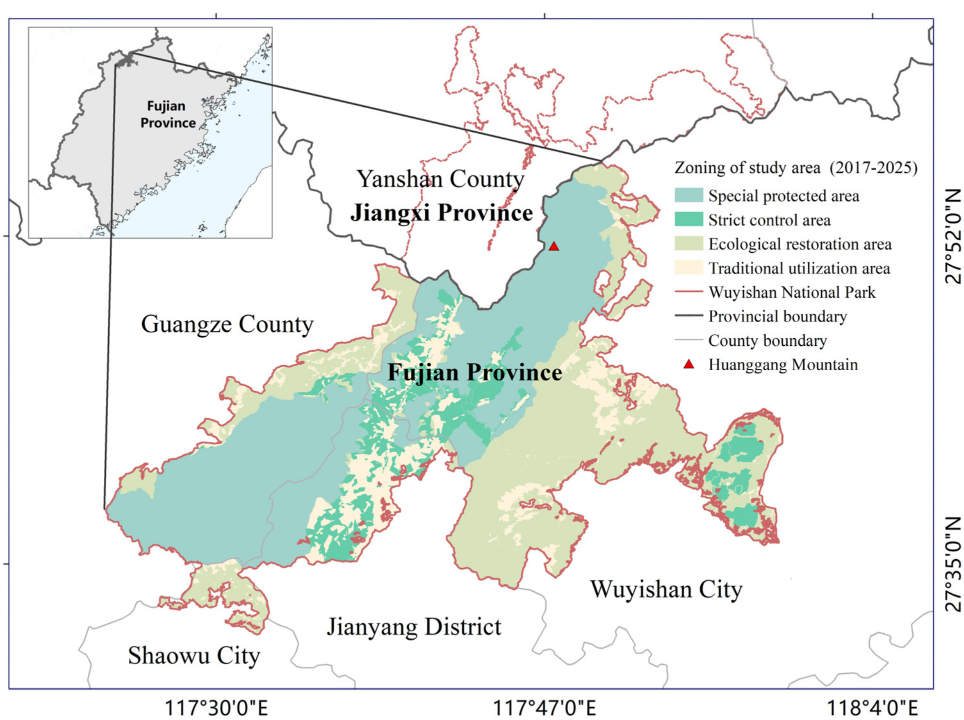

Fig. 2. Location of the Wuyishan National Park.

Table 1
Demographic characteristics of the survey participants (N = 514).

	Total			Online survey		Offline survey	
	Total	Visitors (n = 197)	Residents (n = 139)	Visitors (n = 168)	Residents (n = 24)	Visitors (n = 29)	Residents (n = 115)
Sex							
Male	251	83	72	68	14	15	58
Female	263	114	67	100	10	14	57
Age, years							
18–30	322	149	61	125	12	24	49
31–50	152	44	54	40	11	4	43
> 50	40	4	24	3	1	1	23
Education							
Junior secondary and below	65	6	49	4	0	2	49
High school	76	9	43	7	3	2	40
Junior college	49	13	18	11	5	2	13
Undergraduate	239	131	24	118	13	13	11
Master and above	85	30	5	28	3	10	2
Do you know about wilderness?							
Yes	249	69	91	56	13	13	78
No	265	128	48	112	11	16	37
Do you think there is wilderness in the Wuyishan National Park?							
Yes	460	165	126	149	20	16	106
No	54	22	13	19	4	3	9

representation was based on 14 items of Zoderer et al. (2020), and was further screened during the pilot study based on consultation with experts and local stakeholders. Based on the pre-survey feedback and limitations of data acquisition, 12 wilderness items were finally adjusted to fit the case context of this study (Table S1 in Supplementary Material 2).

Second, a questionnaire was used to obtain demographic data and wilderness representation data. The questionnaire consisted of population-based information questions (age, sex, residence, knowledge of wilderness) and 12 wilderness representation scale items (Supplementary Material 2, Table S2 in Supplementary Material 3). Survey participants were asked to rate the items based on how well they correspond to their personal wilderness performance. For each item, the respondents had to indicate their agreement or disagreement with the proposed item based on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Because the Corona Virus Disease 2019 broke out from 2021, online (January–May 2021) and offline (January–February 2022) questionnaires were administered to as many stakeholders as possible. The online survey was conducted using the WeChat official accounts of the research group to distribute questionnaires. By introducing the main content and value of this study, different participants were encouraged to fill in the information through the questionnaire link at the end of the article, and information was automatically anonymised. This method was not limited by region and was widely spread in the Wuyishan National Park. Regarding the offline questionnaire, the methods of 'waiting' and 'roaming' based on previous studies (Kliskey and Kearsley, 1993; Flanagan and Anderson, 2008) on wilderness perception mapping were used randomly to contact potential interviewees aged ≥ 18 years in villages around national parks and different scenic spots. We invited them to complete the paper questionnaires, explained the meaning of wilderness when necessary, and encouraged them to distribute the links of the survey to acquaintances, and asked acquaintances to send the links to their acquaintances. 321 valid questionnaires were collected online and 193 offline.

In total, there were 514 respondents, which were divided into three stakeholder groups: (1) all respondents (including visitors, hikers, researchers, local residents, and others, N = 514), (2) local residents (residents living around the Wuyishan National Park, n = 197), and (3) visitors (transient tourists, n = 139). The demographic characteristics of the study participants are listed in Table 1. Validity and reliability of the obtained questionnaire data were analyzed. In terms of validity, all samples have significance ($\rho < 0.05$), that is, 12 items have good differences, and the correlation with the total score of the scale ranged from 0.403** to 0.723**, indicating that the 12 items have good correlation with the scale (Zhang, 1989); in terms of reliability, the Cronbach's α of all respondents, local residents, and visitors in this study ranged from 0.837 to 0.862, indicating that public participation in the questionnaire is highly reliable (Eisinga et al., 2013) (Table S3 in Supplementary Material 4).

Finally, to identify wilderness representations, principal component analysis (PCA) were conducted based on the respondents' ratings of the 12 items. The Bartlett test of sphericity (Chi-square=607.742–2,176.802, df=66, sig.=0) and Kaiser-Meyer-Olkin test (KMO=0.812–0.870 greater than 0.7) of the scale showed that PCA was suitable to be carried out (Table S4 in Supplementary Material 4). Subsequently, to reduce input variable variance, we conducted PCA, utilizing the Kaiser normalization criterion greater than 1 and varimax rotation. Items with loadings lower than 0.4 were eliminated (Zoderer et al., 2020). All of the mentioned procedures were performed using SPSS 27.0. Finally, we assigned names based on key wilderness spatial indicators.

2.2.2. Combination of wilderness spatial indicators through MCE model

To transform the survey results into maps, we followed the GIS approach introduced by Zoderer et al. (2020), which involved quantifying the 12 items on the scale and combining wilderness spatial indicators in the MCE model. Our adaptation of this approach required converting the 12 scale items into corresponding spatial indicators, each comprising a set of quantifiable measures (Table S2 in Supplementary Material 3). While our methodology aligns closely with that of Zoderer et al. (2020), we incorporated a few additional indicators to capture specific aspects of wilderness representation in our study. These unique indicators include 'No other people', which reflects the perception of wilderness as a place that evokes feelings of remoteness and solitude, 'Nature can self-develop' to measure biophysical naturalness, 'No hiking paths & waymarks' to assess the distance to footpath networks, and 'Abandoned Tea Garden'. The primary steps for computing these spatial indicators are detailed in Supplementary Material 5.

Subsequently, we applied the MCE model (Carver et al., 2012) to amalgamate and weigh all the spatial indicators for each wilderness representation based on the relative importance attributed by our survey respondents. It's worth noting that we considered and weighted only those spatial metrics with factor loads exceeding 0.4, in accordance with Stevens (1992) and Zoderer et al. (2020), and these weights were determined by their correlation strength with the PCA component indicated by the factor load. Prior to combining these metrics, we standardized the maps of spatial indicators for each scale item using the linear function in the Fuzzy Membership tool within ArcGIS 10.8. Finally, for each wilderness representation, we integrated and weighted the indicator maps using the Eq. (1).

$$E_i = \sum_{j=i}^{b} Q_{ij} S_{ij} \quad (1)$$

where b is the number of spatial indicators, with a factor load > 0.4; E_i is the overall wilderness mass value of the wilderness representation pixel units; Q is the attribute weight, i.e., the factor load; and S is the standard normalized value of each spatial index map.

According to the 12 maps of wilderness spatial indicators (Fig. S2 in Supplementary Material 5), the wilderness representation map and wilderness representation map classification of different stakeholders were generated, and at the same time, we stacked the three wilderness representations corresponding to each group with equal weight to get the integrated wilderness representation map of this group.

Finally, to allow more accurate comparisons across stakeholders and between differences with expert wilderness quality, the wilderness quality of the wilderness representation map was classified using the natural break classification, which creates the data range according to the Jenks–Caspall algorithm (Jenks and Caspall, 1971). The algorithm is an optimal classification method for improving motif mapping as a communication tool and uses means per range to distribute the data more evenly, thereby minimising the sum of absolute deviations from the class mean (Slocum et al., 2004).

2.3. Mapping wilderness: expert perspective

Based on a previous study on wilderness (Cao et al., 2019), expert perception wilderness mapping was conducted using classical methods. We selected five indicators to identify wilderness quality: biological naturalness (BN), remoteness from settlements (RS), remoteness from roads/railways (RR), settlement density (SD), and roads/railways density (RD). Because the study area was relatively small, compared to the national-scale wilderness mapping data, this study collected more accurate data than national-scale mapping study (Supplementary Material 6). The calculation method was as follows. First, we ranked the natural degree classification of land-use types based on the Chinese mainland wilderness land identification (Supplementary Material 5) (Cao et al., 2019) from 1 to 10, of which 10 is the highest natural degree. Second, the Euclidean distance analysis tool was used to calculate the remoteness of residential areas and roads. The higher the value, the farther away it is from residential areas or roads. Third, kernel density analysis tools were used to calculate the kernel density indicators of settlements and roads/railways. A higher value indicates a higher density of settlements and roads (Supplementary Material 6 for specific calculations). These five indicators can reflect the characteristics of wilderness far away from human activities, with high naturalness and less human interference.

Using ArcGIS10.8, the linear function in Fuzzy Membership tool was used to normalise the evaluation results of each indicator and unify the values into 0–1. According to Cao et al. (2019) experts' scoring on the weights of each indicator, each indicator was superimposed, and the wilderness quality index perceived by experts in the study area was calculated. According to the wilderness quality index (Cao et al., 2019), the wilderness was divided into five classifications (Table 2) ranging from other areas to high-quality wildness.

2.4. Comparison and integration of different stakeholders' representations and expert perspectives

To better illustrate the differences between different stakeholders' representation and expert perspectives, we quantitatively compared the different stakeholders' integrated wilderness representation map with wilderness quality map of expert perspectives. First, we counted the areas of different types of wilderness quality between expert perspective and different stakeholders' representation wilderness maps; based on the method of land use transfer matrix (Gao and Cheng, 2020), we quantified the conflict and agreement area between the expert perspective wilderness quality classification and different stakeholders' wilderness representative maps classification using Origin Pro (2022) (Origin Lab Corporation, Northampton, MA, USA). Here, we analysed the conflict between the two spatial pixel scales and the conflict areas of each classification.

Table 2
Classification of expert perspective wilderness quality.

Wilderness quality	Basis of classification (Wilderness quality index)
High-quality wilderness	0.601–1.000
Relatively high-quality wilderness	0.451–0.600
Medium-quality wilderness	0.401–0.450
Low-quality wilderness	0.351–0.400
Other areas	0.258–0.350

Second, in ArcGIS10.8, the Band Collection Statistics tool was used to generate the covariance and correlation statistics to further evaluate the correlation covariance of different stakeholders' representation and expert perspective. The covariance was calculated using Eq. (2).

$$\mathrm{Cov}_{ij} = \frac{\sum_{K=1}^{N} \left(Z_{ik-\mu i}\right)\left(Z_{jk-\mu j}\right)}{N-1} \quad (2)$$

where Z is the value of a cell; i, j are layers of a stack; μ is the mean of a layer; N is the number of cells; and k denotes a particular cell. A correlation coefficient was then calculated using Eq. (3).

$$\mathrm{Corr}_{ij} = \frac{\mathrm{Cov}_{ij}}{\delta_i \delta_j} \quad (3)$$

where i, j are layers of a stack; Cov is the covariance between layers i and j; and δ represents standard deviation.

This analysis was repeated for the combination of different stakeholders' representations and expert perspectives.

Finally, we drew a map that integrates the publics and experts' understanding of wilderness. According to Eq. (4), the wilderness representation maps of all respondents and experts were superimposed to obtain a comprehensive wilderness mass index map.

$$I = \sum_{i=1}^{N} e_i \quad (4)$$

where I is the integrated wilderness quality index; N is the number of indicators, which was set to 2 in this study; and e_i is the single indicator score.

3. Results

3.1. Wilderness representation maps of different stakeholders

Three identical wilderness representations (characteristic root > 1) in all respondents, local residents, and visitors were revealed by PCA. To facilitate the interpretation of the results, we named the identified representations based on their main spatial indicators as follows: 'area where wild animals live' (Wilderness Representation of all respondents 1, WRAR1, local residents 1, WRLR1, visitors 1, WRV1); 'area with no human influence' (Wilderness Representation of all respondents 2, WRAR2, local residents 2, WRLR2, visitors 2, WRV2); and 'a barren and lonely area' (Wilderness Representation of all respondents 3, WRAR3, local residents 3, WRLR3, visitors 3, WRV3). Although the factor loads of the 12 items of the same wilderness represented by different stakeholders were all different, the distribution of items with factor loads > 0.4 was highly consistent; therefore, they were named similarly (Table 3).

We compared the integrated wilderness representation maps of all respondents, local residents, and visitors and the three wilderness representation maps. Overall, little difference was shown amongst all respondents, local residents, and visitors in the integrated wilderness representation map. However, there are significant differences in the map coverage of the three sub-wilderness representatives, and their comparison is helpful to determine the local agreement and disparity patterns for land planning and conflict management (Fig. 3).

According to the first representation of the three groups (WRAR1, WRLR1, WRV1), wilderness representation is a habitat where wildlife lives, an area where nature can develop itself, and an area sufficiently large and unexplored. However, compared with WRAR1 and WRV1, WRLR1 suggested that large carnivore's habitat is not essential for wilderness, and areas where small wildlife live is an important determinant of wilderness. These areas are located in the southwest of the study area around the Huangkeng forest farm in Jianyang District, Gankeng forest farm in Guangze County in the west, Feicui Valley, Shibazhai village and Pikeng in the middle, and Maocaogang and Baishaling in the northeast. These areas are low in altitude and low relief areas and located close to surrounding villages but still maintain relatively natural and original characteristics.

The second representation of the three groups (WRAR2, WRLR2, WRV2) was characterized by the most stringent attributes. An area considered as wilderness pertains to no signs of human activity, including settlers and man-made facilities, such as railways, roads, water systems, and even hiking trails. Moreover, this representation shows that the density of vegetation affects the perception of wilderness quality.

The third representation of the three groups (WRAR3, WRLR3, WRV3) describes the wilderness as a barren and lonely area, where people can feel distant and lonely, including abandoned tea gardens and wasteland. However, unlike WRLR3, WRLR3's high-quality wilderness patches are more integrated and gathered, mainly located in Yanggangling and Longjingkeng in the southwest of the study area, Tongmu Village in the middle, and Huanggang Mountain in the northeast. The high-quality wilderness areas perceived by WRV3 are mostly located in areas with low human activity density, characterized by large areas and high altitude, including wasteland and abandoned tea gardens. These are mainly distributed in the southwest border area between Guangze County National Park and Raoping Village and from the west entrance in the middle to Huanggang Mountain in the northeast (Table 3, Fig. 3).

3.2. Expert perspective wilderness quality map

The expert perspective wilderness quality map was weighted (BN [0.226]) RS [0.189], RR [0.189], SD [0.198] and RD [0.198]) by combining the five wilderness indicators (Fig. S3 in Supplementary Material 6), and the wilderness quality was divided into five classifications. Here, the highest quality wilderness was concentrated at a high altitude in the southwest and north-east of the study area (Fig. 4(a)), which is far from areas with human impacts and has a high level of biophysical naturalness. The coverage of high-quality wilderness areas accounted for 4.7%, whereas that of low-quality wilderness areas accounted for 45.98%, mainly situated in lower altitude in the central part of the Wuyishan (Fig. 4(b)).

3.3. Comparison and integration

3.3.1. Comparison with expert perspectives

Overall, the conflict area (yellow) occupies a large area in the central and northeastern parts of the study area, whereas the agreement

Table 3
PCA results.

Scale items	All respondents			Local residents			Visitors		
	Factor loading			Factor loading			Factor loading		
	WRAR1	WRAR2	WRAR3	WRLR1	WRLR2	WRLR3	WRV1	WRV2	WRV3
Wilderness is a place where nature can renew and restore itself	**0.747**	0.161	−0.055	**0.690**	0.176	0.054	**0.756**	0.104	0.121
Wilderness is where wild animals like deer, horses, antelopes, and hares live	**0.798**	0.174	0.035	**0.859**	0.093	0.093	**0.817**	0.206	0.021
The wilderness is extensive	**0.692**	0.040	0.355	**0.771**	0.171	0.100	**0.561**	0.023	**0.572**
Wilderness is unexplored land	**0.629**	0.306	0.193	**0.566**	0.321	0.179	**0.631**	0.102	0.397
Wilderness is where large carnivores like leopards, tigers, bears, and wolves live	**0.656**	0.337	0.086	0.351	0.111	**0.583**	**0.692**	0.393	−0.039
Wilderness is an impassable area due to dense vegetation	0.252	**0.649**	0.287	0.252	**0.548**	0.357	0.051	**0.646**	0.316
The wilderness is where there is no mechanical traffic	0.165	**0.827**	0.144	0.100	**0.870**	0.138	0.111	**0.809**	0.160
Wilderness is where there are no man-made facilities such as settlements, railways, roads, water systems, etc.	0.208	**0.807**	0.163	0.122	**0.828**	0.294	0.197	**0.780**	0.116
Wilderness is a place where there are no hiking trails	0.243	**0.606**	0.202	0.261	**0.593**	0.060	0.255	**0.685**	0.086
The wilderness is a place that makes you feel far away and alone	0.249	0.227	**0.685**	0.047	0.311	**0.771**	0.132	0.108	**0.734**
Wilderness is a place that is difficult for people to access because of the steepness of the terrain	0.343	0.251	**0.553**	0.378	0.196	**0.640**	0.265	0.240	**0.657**
Wilderness refers to abandoned tea plantations or wasteland	−0.129	0.234	**0.792**	−0.060	0.088	**0.662**	−0.299	0.326	**0.643**
Characteristic root	2.940	2.557	1.746	2.636	2.497	2.073	2.725	2.566	2.069
Explanation of variance (%)	24.498	21.305	14.552	21.966	20.807	17.277	22.711	21.381	17.243

Note: All wilderness attributes that are unique to one wilderness representation (factor loading greater than 0.4 are in bold). WRAR1/2/3, all respondents wilderness representation 1/2/3; WRLR1/2/3, local residents' wilderness representation 1/2/3; WRV1/2/3, visitors' wilderness representation 1/2/3.

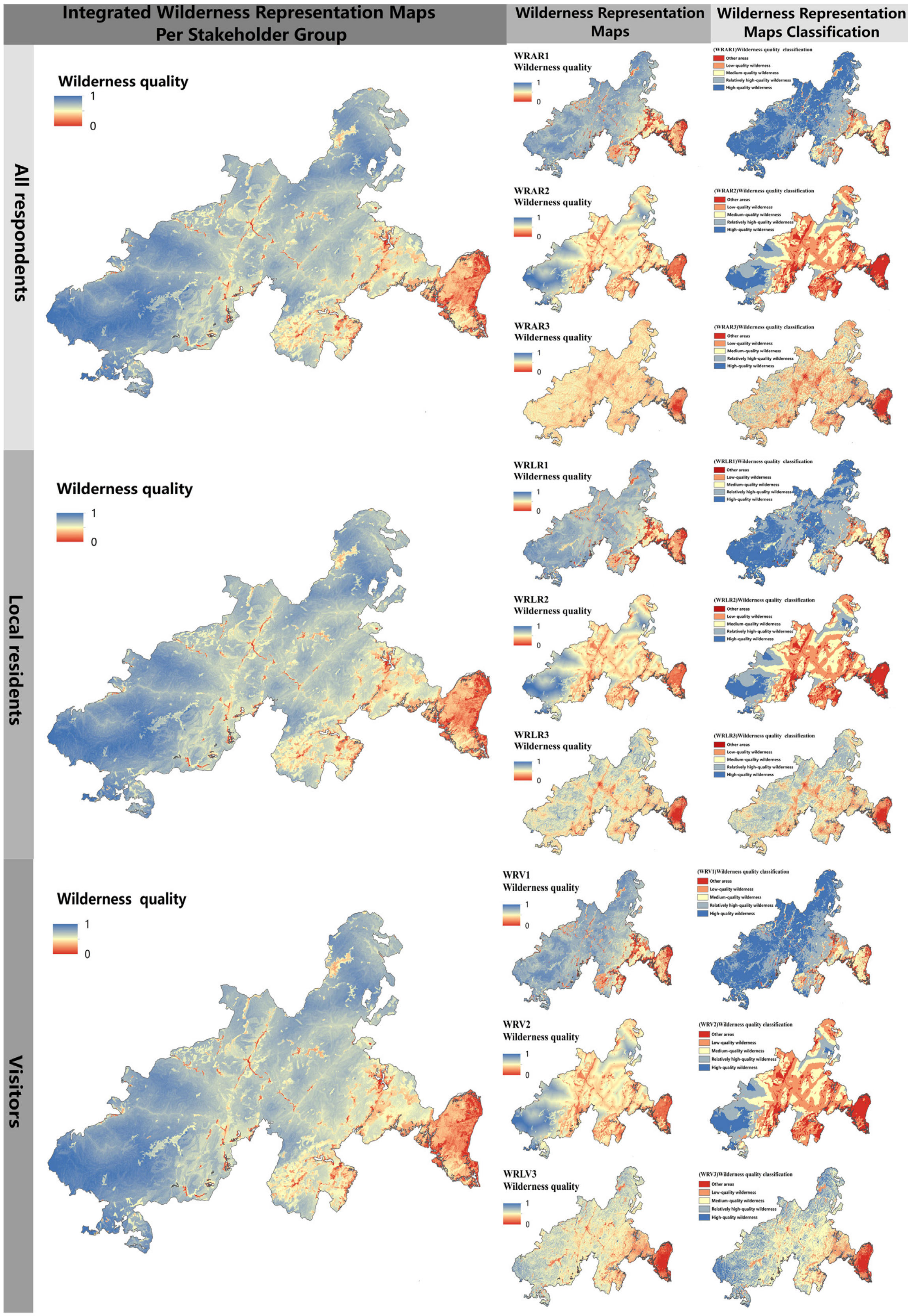

Fig. 3. Wilderness representation maps. Integrated wilderness representation maps per stakeholder group (first column), wilderness representation maps (second column) and wilderness representation maps classification (third column) for all respondents, local residents and visitors. WRAR1/2/3, all respondents wilderness representation 1/2/3; WRLR1/2/3, local residents' wilderness representation 1/2/3; WRV1/2/3, visitors' wilderness representation 1/2/3. 0–1 indicates the lowest to highest wilderness quality area for each representation group.

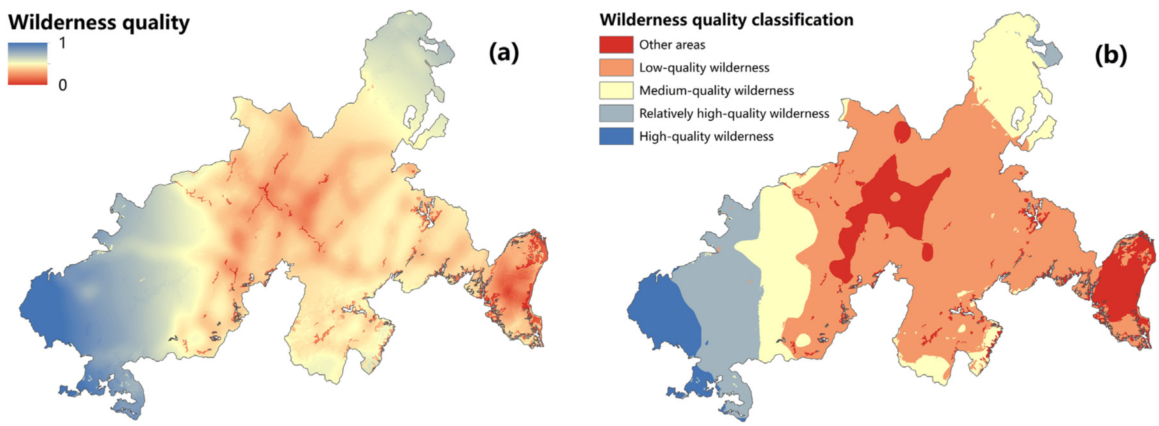

Fig. 4. (a) Wilderness quality map of expert perspectives and (b) their quality classification. 0–1 indicates the lowest to highest wilderness quality area according to expert.

Table 4
Conflict and agreement area statistics between expert perspective maps and wilderness representative maps of different stakeholders (km^2).

Expert	Other areas			Low-quality wilderness			Medium-quality wilderness			Relatively high-quality wilderness			High-quality wilderness		
Public	All respondents	Local residents	Visitors	All respondents	Local residents	Visitors	All respondents	Local residents	Visitors	All respondents	Local residents	Visitors	All respondents	Local residents	Visitors
Other areas	21.38	24.30	25.14	24.63	22.37	20.58	18.59	22.89	17.55	26.67	22.72	28.06	0.05	0.05	0.03
low-quality wilderness	5.48	6.37	6.55	46.07	49.13	48.68	114.00	123.73	114.33	208.50	197.16	203.21	22.14	22.16	23.33
Medium-quality wilderness	0.46	0.47	0.52	4.93	5.40	6.46	16.50	17.01	15.00	65.90	65.35	60.20	66.45	68.05	72.03
Relatively high-quality wilderness	0.02	0.03	0.01	0.42	0.44	0.54	4.37	4.27	4.57	22.22	22.94	17.42	75.67	76.41	80.15
High-quality wilderness	0.00	0.00	0.00	0.02	0.02	0.02	0.37	0.39	0.57	1.88	1.85	0.96	39.37	39.88	39.95

Note: Yellow represents conflict, whereas blue represents agreement.

Table 5
Descriptive and correlation statistics of different stakeholders' representation and expert perspectives.

	All respondents	Local residents	Visitors
Descriptive statistics			
Mean cell value	0.6428	0.6497	0.6701
Standard deviation	0.1172	0.1181	0.1285
Maximum cell value	1	1	1
Minimum cell value	0	0	0
Correlation statistics			
Expert	0.4579	0.4663	0.4664

area (blue) is mainly concentrated in the southwest, south, and southeast parts of the study area (Fig. 5(a), (c), (e)). The conflicting areas of views between experts and all stakeholders, local residents, and visitors are 640.55 km^2, 640.13 km^2, and 639.67 km^2, respectively. The agreement areas of views are 145.54 km^2, 153.26 km^2, and 142.97 km^2, respectively. The detailed areas of different wilderness qualities are shown in Fig. 5(b), (d), (f) and Table 4.

We validated the above results using descriptive and correlated statistical analysis, utilizing GIS 10.8's Band Collection Statistics tool, between experts and the groups of all respondents, local residents, and visitors. The correlations between expert perception of wilderness maps and all responses, local residents, and visitors' wilderness representation maps were weak, ranging from 0.4579 to 0.4664 (Table 5), indicating a poor fit between expert and public perspectives. In addition, high-quality wilderness, which is consistent with the views of all respondents, should be the key protected area in the future wilderness planning process of the Wuyishan National Park, because the ecological value of this area is important, and it has no conflict between expert perspective and public representation.

3.3.2. Integration with expert perspectives

To further consider public wilderness perspectives, this study proposed an integration map that overlays the representation wilderness maps of all respondents with that of expert perspectives (Fig. 6(a)). The integrated wilderness quality was divided into five categories according to the natural break classification, and approximately 201 km^2 of high-quality wilderness was extracted, of which 82.59% (166 km^2) was within the Wuyishan National Park Special Protection Area and 17.41% (35 km^2) was outside the Special Protection Area (Fig. 6(b)).

In addition, we compared the accuracy of the integrated wilderness quality map (Fig. 7(b)), the expert perspective wilderness quality map (Fig. 7(c)), and scope of the Wuyishan National Park extracted from a Chinese wilderness quality map based on Cao et al. (2019) (Fig. 7(d)). Wilderness maps incorporating public representation were more accurate. We found that large-scale wilderness map could only faintly distinguish wilderness from non-wilderness, owing to insufficient data accuracy, and could not accurately identify the spatial distribution and quality variation in wilderness at the regional scale (Fig. 7(d)). Even if more accurate data were used, it would still be difficult to capture the nuances of local wilderness quality (Fig. 7(c)). An integrated wilderness map incorporating public representation (Fig. 7(b)) could more accurately reflect the detailed differences between wilderness and non-

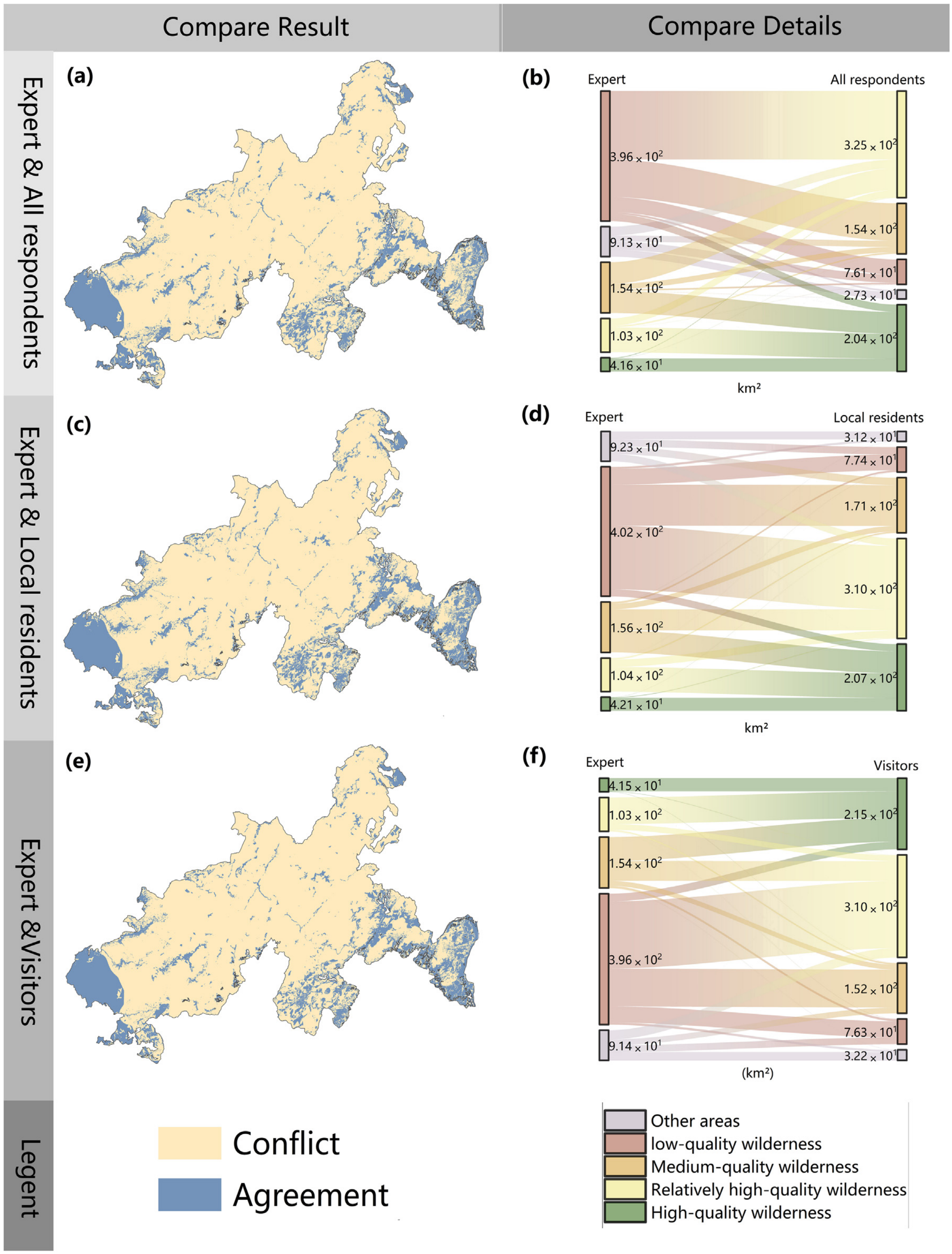

Fig. 5. Expert-perceived conflict and agreement of wilderness maps with wilderness representation maps of different stakeholders. (a), (c), and (e) show the comparison results, and (b), (d), and (f) show the corresponding comparison details.

wilderness. For example, we found that the integrated wilderness map clearly depicted the subtle contours of wilderness and non-wilderness at the Zhumugang that were ignored in Fig. 7(b) but obscured in Fig. 7(a). This illustrates that the inclusion of public representation of wilderness maps greatly improves the accuracy of the spatial distribution of specific scale wilderness and validates the need and feasibility of wilderness mapping research at the protected area scale, which is important for more accurate wilderness inventory and wilderness conservation decisions in the future, especially in the national parks of developing countries.

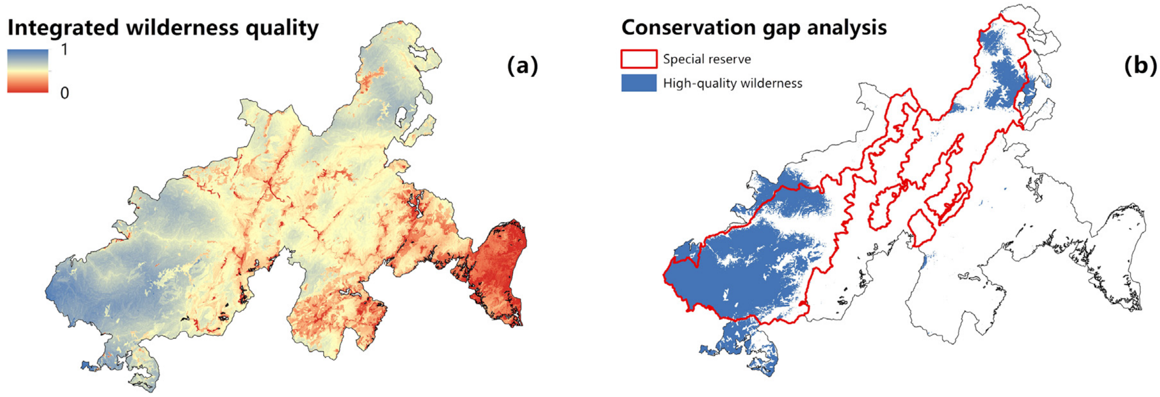

Fig. 6. (a) Integrated wilderness quality map and (b) conservation gap analysis.

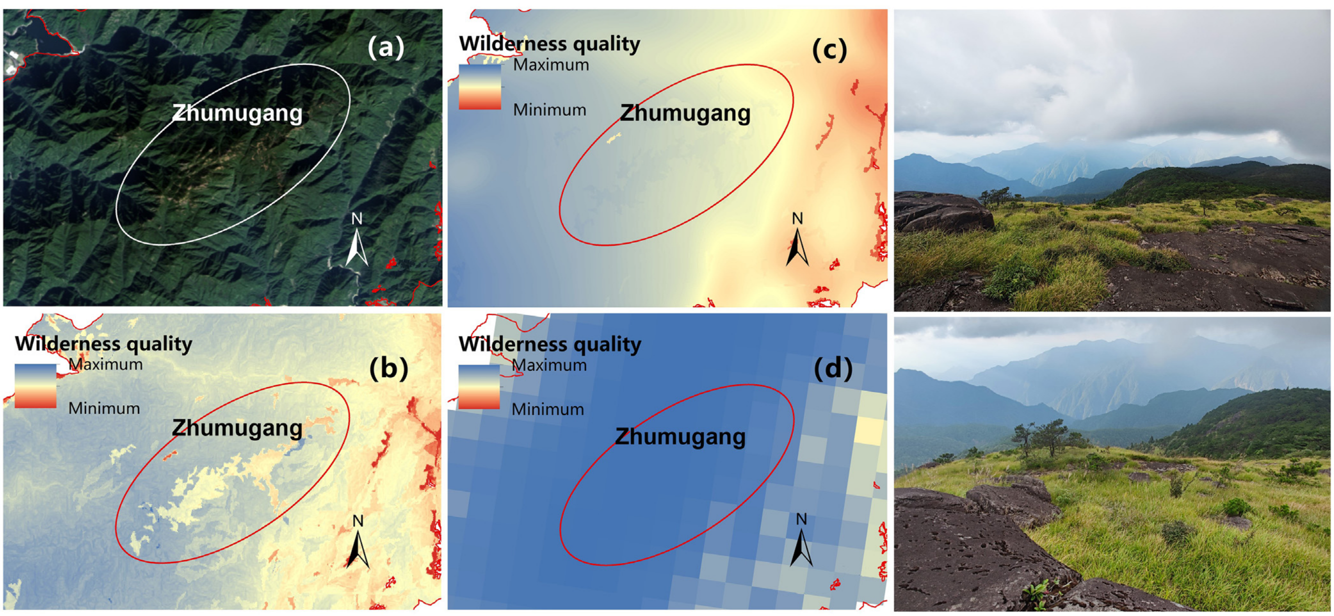

Fig. 7. Validation using Google Maps and field study. (a) Google map of the Zhumugang, (b) integrated wilderness quality map, (c) expert perspective wilderness quality map, and (d) a Chinese wilderness quality map based on Cao et al. (2019).

4. Discussion

4.1. Is there consistency in wilderness representation amongst different stakeholders?

Our results showed a stable consistency in wilderness representations of different stakeholders. Empirical studies showed that wilderness has no agreement on the physical reality; however, it exists in different places, depending on the socio-cultural environment that they live in and their personal history and experiences (Bertolas, 1998; Ewert, 1998; Habron, 1998; Higham et al., 2000; Vistad et al., 2012). There is a seemingly endless diversity in the public (Bauer and von Atzigen, 2019). A recent exploratory study (Zoderer et al., 2020) showed that countless individual wilderness definitions can be reduced to a limited number of shared wilderness representations, namely ‘area with no human impact’,‘remote and large area’, and ‘area where nature can self-develop’.

In our study, PCA analysis of combined data from local residents and visitors (detailed in Table S5, Supplementary Material 4) identified these three wilderness representations. These representations are consistent and strong across diverse social populations. Although there are differences in naming, factor loadings, and attribute when compared to Zoderer et al. (2020), the core essence of these wilderness representation points remains fundamentally similar. Our findings, along with the exploratory study by Zoderer et al. (2020), tentatively suggest enduring stability in these representations across socio-cultural backgrounds. Nevertheless, it is imperative to acknowledge that our study was conducted with a limited number of surveyed participants. A more comprehensive examination with an increased number of stakeholders is warranted to further validate the consistency and stability of these representations across diverse contexts.

4.2. Why do experts and public have discrepancy views about wilderness?

Our study comprehensively incorporates diverse Wilderness Representations (WR) from various stakeholders, including experts, local residents, and visitors. This inclusivity acknowledges that different groups may prioritize and perceive distinct facets of Wilderness Quality (WQ). While experts often emphasize technical or ecological aspects, the general public tends to focus more on the personal or familiar elements of wilderness.

In fact, this difference between expert perspective and non-professional is echoed in landscape-related literature (Barr and Kliskey, 2014; Watson et al., 2015; Bauer et al., 2018) and other areas (Blok et al., 2008; Castan Broto, 2012; Weng, 2015). This mismatch may indicate a fundamental defect in the early planning of the Wuyishan National Park. Even if the zoning planning of national park was completed, the importance of preserving wilderness and the value given by the public to the wilderness were not considered. Preventing further depletion of future biodiversity depends on the ongoing and collective efforts of a range of stakeholders and institutions. The public value of more field experience must be appropriately considered (Dryzek, 2013; Niedziaokowski et al., 2018), as the public will eventually experience new developments (de Groot, 2006; Nassauer, 1997; Seddon, 1986; Vouligny et al., 2009).

The several mismatches noted in our results may be attributed to the fact that expert-perceived wilderness quality is not evident to non-professionals. For example, experts assume that certain attributes (e.g., naturalness and lack of human influence) have been summarised (presence of wildlife habitat, abandonment of agriculture, or no previous use by humans), without noticing the differences in the interpretation of these attributes in different representations. However, there may be fundamental divergence in what experts and the public value; for example, although expert wilderness assessments are based on naturalness and less human influence, while the public may focus more on the familiar regions (Eiter, 2010). It is clear from our results that there is a great consistency between the public and expert views of the highest-quality wilderness, and the wilderness map that combines expert with public views was the most accurate.

Although this study highlights the important contribution of public participation, experts also continue to play an important role. These findings suggest that there is a strong need to consider both public representation and expert perspective as supplements rather than substitutes; each is necessary and insufficient. Moreover, there should be better communication between experts and the public. Experts can explain to the public why some values or areas are considered important from a technical point of view, and they can also listen to the opinions of communities living in these landscapes and incorporate them into the assessment. This conclusion echoes the conclusions of de Groot et al. (2014), who found great potential for social learning by using the methods that make public values more visible and those seeking to become familiar with non-professional and experts when developing a shared vision. Although there is no designated wilderness protected area in national parks, our findings can provide useful information for future wilderness planning in the Wuyishan National Park, particularly in balancing the views of the experts and public landscape planning.

4.3. Implications for national park planning and management

Thus far, the relevant theoretical research and political practice of China's national parks remain in the exploratory stage. For the development of national parks system, considering the public view is significant, and the demarcation and management of wilderness land will involve different stakeholders (Cole et al., 1997). Public acceptance and support are important for the establishment and long-term protection of wilderness areas (Hirschnitz et al., 2011). The integrated wilderness map of 'public wisdom' obtained through public participation can add different perspectives and improve the scientific nature of national park management and accuracy of expert decision-making (Clark et al., 2003).

Our study offers several suggestions for the planning and management of the Wuyishan National Park. First, in terms of spatial optimisation of the landscape, we suggest that the approximately 201 km^2 of high-quality wilderness extracted from the integrated wilderness quality may be used as a key reference area for the future designation of the Wuyishan High Quality Wilderness protected areas, as this area has a low probability of conflicting stakeholders and is considered relatively high-quality wilderness with rich biodiversity (Menzel and Teng, 2010; Lamarque et al., 2011; Fagerholm et al., 2012). For the wilderness areas that have been included in the Special Protection Area (166 km^2), they should be highlighted in the management zoning, and more scientific and refined management measures should be developed to strengthen the intensity and permanence of the protection of these wilderness areas. For the other parts of the high-quality wilderness located outside the Special Protection Area, they can be used as a basis for extending the current Special Protection Area by linking small areas of wilderness into a wilderness network (Cao et al., 2020).

Second, in terms of wilderness zoning optimisation, the wilderness areas identified in this study can be divided into different areas to meet the needs of different populations, for example, a natural development core (e.g., WRAR2) and several surrounding buffers that allow different degrees of entertainment and low-intensity land use (e.g., WRAR1 and WRAR3). Furthermore, the probability of wilderness designation was particularly low in the middle of the study area. However, in terms of visitor needs, these areas can offer new opportunities to experience wilderness qualities closer to home, such as wilderness nature education courses, recreation, exploration, and healing. Moreover, when labelling an area as 'wilderness', whether it harms areas that exclude any human activity (e.g., WRAR2) should be considered. Although wilderness maps can be an important reference for the design and management of such reserves, the needs and preferences of all stakeholders should be considered whenever possible as part of the participatory process. In many ways, integrated wilderness quality map can help planners meet the growing need for wilderness experiences while alleviating environmental damage and protecting loneliness and remoteness.

Third, in policy optimization, we revealed agreement and disparity between wilderness representation maps of different stakeholders, as well as conflict and agreement with expert perspective wilderness maps, which is useful for landscape planning and management. In particular, the generated wilderness map can be used as a decision support tool to assess the impact of the planned infrastructure development in the early stages of the planning process. For example, WRAR1, WRLR1, and WRV1 believe that opening a new campsite can affect wilderness quality far beyond its actual location, whereas the same project may only affect WRAR3, WRLR3, WRLR3, and WRV3 at the site if it causes new disturbance and overcrowding.

4.4. Limitations

Despite its contributions, this study has limitations. First, a small number of respondents ($N = 514$) due to COVID-19 and regional factors may have influenced the comparative analysis of wilderness mapping. Differing classification methods between groups further impact the results. Future efforts should aim to broaden representation using internet-based technologies and conduct multi-case studies to explore differences in public wilderness representation. Second, integrated wilderness maps inadequately represent stakeholder groups, potentially concealing conflicts arising from differing perceptions of wild areas. Addressing uniform weighting issues and employing customized weighting in future studies can reduce conflicts, requiring deeper collaboration, and open communication. The third limitation involves language restrictions. Using the equivalent term in Chinese may lead to deviations in data collection. Further studies are needed to assess cross-cultural differences in wilderness performance and understand the impact of language choices.

5. Conclusions

This study not only provides novel insights and technical support for future wilderness conservation and mapping efforts in China but also has wider implications. It offers a unique perspective on how cultural diversity influences wilderness representations, a phenomenon that extends beyond the Wuyishan to a global context. Recognizing the importance of public participation and the various public interactions with, definitions of wilderness carries broad significance for conservation. It emphasizes the necessity of adaptive and inclusive strategies that consider cultural contexts. These insights are relevant for the management of protected areas and sustainable tourism on a global scale, where the challenge of balancing environmental preservation with diverse human needs is prevalent. Additionally, the cross-cultural aspect of this research fosters international collaboration, enriching the global dialogue on human-nature relationships and the preservation of our natural heritage.

Ethical statement

Ethical approval was not required for this study since human participants were ensured following local legislation and institutional requirements. All proceeds of this research were carried out following the Helsinki Declaration principles of human subject investigation. Participation in this survey was anonymous and voluntary, assuring consent of prospective respondents before participation. Data accumulated for this research was treated confidentially.

Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.geosus.2023.12.002.

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