Exploring local adaptation to small hydropower closure scenarios: evidence from a giant panda nature reserve in Sichuan, China

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Abstract

Given China’s ecological priority principle of nature reserve development, reconciling rural livelihood and ecological conservation is challenging. Although the closure of small hydropower in the nature reserve is an absolute necessity, a minimum requirement for its success is the active participation of local communities. Due to the remote location and historical reasons, some communities in giant panda nature reserves still depend highly on small hydropower for living. There is little guidance on how these vulnerable communities experience the closure of small hydropower and how these grassroots voices could contribute to the local adaptation plan. Hence, a case study using exploratory participatory scenarios analysis in Wawushan giant panda nature reserve was conducted to explore local adaptation strategies. The scenario-building process brought out four possible but diverse future development options and reflected local stakeholders’ corresponding beliefs regarding their adaptation strategies. The study further provided insights into underlying policy options and highlighted the importance of engagement and knowledge exchange between stakeholders to achieve better collaboration and reciprocity for the sustainable development of nature reserves.

1. Introduction

Hydropower development is part of the global clean energy development agenda, through which carbon mitigation goals can be better achieved. However, its advantages in terms of low carbon footprint to a certain degree rely on its location, climate, maintenance, and design (Fearnside 2016, Kuriqi and Jurasz 2022). The hydropower construction could severely impact ecosystem services and biodiversities, such as soil erosion, water quality deterioration, river flow disruption, habitat degradation, and deforestation (Wu et al 2019, Batar et al 2017, Kuriqi et al 2021). In return, the conflict between hydropower production and ecosystem conservation would further affect the survival of local households and their livelihoods standards (Negi and Punetha 2017, Kuriqi et al 2020).

As a kind of renewable and clean energy, hydropower has experienced rapid development in China for more than ten years. As the world’s largest hydropower country, China’s installed hydropower capacity reached 370GW in 2020, accounting for a quarter of the world’s total installed capacity (National energy administration 2020). In southwest China (especially in Sichuan province), abundant water resources and the rapid development of hydropower provide local residents with a stable power supply. In addition, it is also regarded as the most extensive hydropower base and the ‘West-East Power Transmission’ base under the background of the Western Development Policy. Unfortunately, limited local demand and stalled construction of transmission pipelines have led to over-supply in the region. In addition, since the Chinese economy has shifted gear from the previous high-speed growth to medium-high-speed growth, the national power demand growth rate has continued to decline. Hence, Debates on whether China has over-exploiting its hydropower have been raised.
As an essential energy source to serve rural areas, small hydropower (SHP, a single station with an installed capacity under 50 kW) has played a vital role in China’s rural development. In 1983, the state government launched a pilot project to realize rural primary electrification. With the support of central and local policies and funds, more than 40 regional power grids have been built nationwide. Since SHP provided more stable electricity and had lower operating costs per kilowatt-hour (kWh) than wind and solar power, more than 600 counties were powered primarily by SHP at the time. In addition, due to its advantages of on-site development and convenient power supply, SHP was considered an important tool to achieve the goal of poverty alleviation. At its peak, there were more than 47,000 SHPs in 31 provinces and cities in China. However, in the current ‘new normal’ stage of economic development, prohibiting new SHP constructions and optimizing existing SHP capacities are the main ways to upgrade China’s economic structure. It is worth noting that under the principle of ecological priority, SHP approaches to the ecological red line have attracted great concerns.

For the giant panda nature reserves in Sichuan province, the local government encouraged the construction of SHP under the Western Development Strategy and West-to-East electricity transmission project in the 2000s. As villages were not connected to the national power grid, replacing fuelwood with hydropower significantly improved the energy accessibility of local communities (Zhou et al. 2009). However, the high density of SHP development has also caused severe over-exploiting and chaotic management problems. For example, in the main and tributaries of the Dadu River and the Qingyijiang River, nearly 10 SHPs were built within 50 kilometers of the Ya’an section of the Zhonggong River (a tributary of Qingyijiang River); Similarly, 28 running SHPs were built within 34 kilometers of the Xiaoshui River (a tributary of Dadu River). Among the 167 nature reserves in Sichuan province, about 309 SHP projects were in operation. Since the amount of water discharge cannot meet the ecological flow requirements in these areas, the ecological function of the water is seriously affected in nature reserves.

Several pieces of literature have widely recognized the positive environmental and socio-economic benefits of SHP (Anup et al. 2011, Murni et al. 2013). As a more cost-effective solution than traditional fossil fuel generators, SHP provides sufficient electrical energy and improves life quality, especially for those isolated developing communities (Huang et al. 2014). In addition, SHP also provides employment opportunities for locals (Kirchherr and Charles 2016). For some remote regions, SHP reduces poverty, optimizes local energy structure, and protects forests.

While many studies have documented the advantages of SHP development, the bulk of studies has also shown the disadvantages of SHP constructions, especially its longevity performance and profound impact on the ecosystem (Kabalan et al. 2014, Jiang et al. 2016). Hydropower station faces the ‘hydroelectric resource curse’ that may trigger natural disasters (Hancock and Sovacool 2018, Sovacool and Walter 2019). Furthermore, its limited economic and developmental benefits could result in social problems like community resettlement in the long run. Specifically, for giant panda nature reserves in Sichuan, the high density of SHP has caused severe problems such as small regional climate change, earthquakes, hill slides, and dry rivers. SHPs operating in the core and buffer zones of nature reserves also disturb the habitats of the giant panda and other wildlife.

The Chinese government has become more aware of the possible hazards of SHP since 2015. At the national level, a series of regulations to regulate the development of SHP have been issued. In response to national appeals, the Sichuan provincial government has also launched a series of tailor-made regulations for SHP in nature reserves. The promulgation of the ‘Opinions on further strengthening and standardizing the management of hydropower construction’ blew the downsizing horn of SHP. From 2017 to 2019, a series of regulations announced the processes and timetable for the closure of SHPs and clarified the follow-up ecological restoration actions such as water inlet blockage, dam removal, mechanical and electrical equipment dismantlement, and vegetation restoration. Meanwhile, according to the regulation of the ‘Pilot Program of the Giant Panda National Park,’ the local government also emphasized that it will stop approving mining, commercial prospecting, and hydropower projects within the national park.

Although policy constraints and their implementation on SHP are explicit, there is an evidence gap in how these changes could affect local livelihoods. Literature rarely mentions rural communities’ voices, and their appeals are easily ignored by public discourse. In reality, many people still live in or near giant panda nature reserves, and as an approach to provide income and work opportunities, plenty of them still rely on SHP for a living. Thus, the rectification and shutdown of SHP might significantly affect the local livelihood choices. In order to better understand the adaptive strategies of SHP evolution in rural communities, it is crucial to explore the impact of SHP closure on the environment-energy-livelihood nexus of rural communities and discuss instances where residents’ opinions on the impact of SHP closure. The key questions of this paper are: what kind of local adaptation strategies can be linked to possible future scenarios of SHP closures in giant panda nature reserves? How do government policies support the preferred livelihood choice of local communities? In order to contribute to the existing literature, this paper employs a case study based on participatory scenarios analysis to explore how SHP closure might alter the patterns of local livelihoods and subsequently affect household well-being from stakeholders’ perspectives. This paper aims to address this disjunction and improve the dialogue
between local communities and stakeholders to pursue better policy support. The novelty of this study is that it highlights the important role of future scenarios in exploring the impact of the use of natural resources, livelihoods, and other socio-economic changes on the formulation of solid sustainable development policies.

2. Study areas

This study selected Wawushan Nature Reserve as the study site. Wawushan Nature Reserve belongs to Hongya county, Meishan city, and is located in the southwest corner of Hongya County on the western margin of the Sichuan Basin. It is geographically located at 102°51’ ~ 103°11’ E, 29°25’ ~ 29°43’ N, with a total area of 36,490 hectares and an altitude of 1138 ~ 3269 m. The streams and rivers in reserve are mainly the Zhougong River (Bingling River) water system. The average annual flow rate is 35.3 cubic meters per second, the highest flow rate can reach 2130 cubic meters per second, and the average runoff rate is 1.105 billion cubic meters.

Wawushan Nature Reserve originated from a state-owned forest farm in Hongya county and was launched as a nature reserve in 1993 to protect giant pandas and other rare wild animals. At the initial phase, the Wawushan Nature reserve had 12,000 hectares and seven SHPs. Although SHP had a relatively long operational history in the region, it ushered in a rapid development period since the late 1990s, when the electricity shortage became the main barrier to local economic growth. Since then, SHP has had primary responsibility for daily electricity supply and employment opportunities for residents. However, the high density of SHPs (one SHP in every five kilometers of the river) cut the local river into several independent sections, severely hindered fish migration, and devastated the local environment. Therefore, the call for SHP closure in the Wawushan nature reserve started in 2017 to protect and restore the local ecosystem.

In Wawushan Nature Reserve, there are mainly two towns located in the protected areas: Wawushan town and Gaomiao town. To illustrate the impact of the SHP closure on local households, we choose a village in Wawushan town (Yanyuan) and a village in Gaomiao town (Heishan) as cases. Both villages are located within the buffering zone of Wawushan nature reserve and the Giant Panda National Park (See figure 1). Since most of the local SHP operations are clustered in these two villages, exploring the local adaptation strategies is representative.

2.1. State of hydropower development histories in Yanyuan and Heishan village

In Yanyuan village, the history of SHPs can be traced back to the 1970s, when four SHPs were built with local self-raised funds. In the mid-1990s, Yanyuan village encouraged corporate investment and approved 14 SHP projects invested by firms to improve local welfare and promote local employment. The rewards were positive. Firms annexed the self-funded SHPs and joint-owned them by committing the village as a shareholder by contributing the right of land use. In addition, villagers agreed to have the rights to share the dividends and to work in SHP. During that period, SHP employed more than 60 laborers in the village, covering almost all households in Yanyuan village. However, the closure of SHP to decrease human disturbance to nature reserves was put into real action in 2017. In less than a year, 11 of the 14 SHPs running on the Zhougong River and its branch in Yanyuan village were shut down. All closure SHPs were located in the nature reserve’s core or buffer.
Table 1. Operational status of 14 SHPs in Yanyuan village.

| Name of SHP     | Year of the establishment (Operation date) | Installed capacity | Status at the time of data collection (2019) |
|----------------|--------------------------------------------|--------------------|--------------------------------------------|
| Yanziyuan      | 1998 (2000)                                | 650 KW             | Closed (2018)                              |
| Hanping        | 1998 (1999)                                | 540 KW             | Closed (2018)                              |
| Shuimogou      | 1997 (1998)                                | 1000 KW            | In Operation                               |
| Yanyuan        | 2000 (2008)                                | 1660 KW            | In Operation                               |
| Sanpiaoshuai   | 2004 (2005)                                | 2500 KW            | In Operation                               |
| Dingdanghe     | 2003 (2004)                                | 780 KW             | Closed (2017)                              |
| Huaquipo       | 2001 (2003)                                | 880 KW             | Closed (2017)                              |
| Yangchengqiang | 2000 (2003)                                | 460 KW             | Closed (2018)                              |
| Sanhe First Grade | 2003 (2004)                      | 770 KW             | Closed (2017)                              |
| Dachanghe First Grade | 2000 (2008)                      | 1050 KW            | Closed (2017)                              |
| Dachanghe Second Grade | 2000 (2008)                    | 480 KW             | Closed (2017)                              |
| Sanhe Second Grade | 2007 (2008)                         | 200 KW             | Closed (2017)                              |
| Shimiqiao      | 2005 (2007)                                | 380 KW             | Closed (2017)                              |
| Lianghekou     | 2005 (2006)                                | 630 KW             | Closed (2017)                              |

Table 2. Operational status of 9 SHPs in Heishan village.

| Name of SHP     | Year of the establishment (Operation date) | Installed capacity | Status at the time of data collection (2019) |
|----------------|--------------------------------------------|--------------------|--------------------------------------------|
| Daheba         | 1994 (1998)                                | 2500 KW            | In Operation                               |
| Caogou         | 1995 (1996)                                | 500 KW             | In Operation                               |
| Yeniuhe        | 1995 (1997)                                | 1150 KW            | Closed (2017)                              |
| Sanji          | 2003 (2005)                                | 630 KW             | In Operation                               |
| Wanghe         | 2003 (2004)                                | 320 KW             | In Operation                               |
| Longshui First Grade | 1995 (1996)                    | 500 KW             | In Operation                               |
| Heishan        | 2002 (2003)                                | 630 KW             | In Operation                               |
| Longshui Second Grade | 1996 (1998)                    | 100 KW             | In Operation                               |
| Lianghe        | 1995 (1996)                                | 680 KW             | Closed (2017)                              |

zone. Only three SHPs are still in operation, but with massive uncertainty in the future. The operation status of 14 SHPs in Yanyuan village is shown in table 1 below.

In Heishan village, the SHP history is relatively shorter. The First self-funded SHP in the village was built in 1995, and firms were simultaneously involved in SHP operations. Villagers were highly involved in developing local SHPs, and more than 50 laborers year⁻¹ were directly employed by SHPs during 1990–2010. The closure process of SHPs in Heishan village is comparatively slow, and only two of nine SHPs were shut down in 2017. However, since Heishan village is within the range of the general control zone of Giant Panda National Park, the closure of the rest would be put on the agenda in the future. The operation status of nine SHPs in Heishan village can be seen in table 2.

2.2. Resource reliance and utilization in Yanyuan and Heishan village

The land area of Yanyuan village is about 26 square kilometers, its altitude is between 1400 and 2000 meters, and the artificial forest area is more than 1333 hectares. There are about 50 households with 210 villagers in Yanyuan village. Traditionally, most local villagers rely on non-timber forest products (NTFP) such as bamboo shoots, honey, and medical herbs for livelihood. Since the 1990s, the establishment of natural reserves and the flourishing SHP operations have significantly improved rural living standards. Encouraged by the local ‘who plant who benefit’ afforestation policy (which aims to motivate locals to plant and manage forests and consequently gain benefits from plantations), more than 50% of villagers participated in afforestation activities. As a reward, logging income has become an important source for villagers. In addition, working in SHPs also provided extra livelihood choices for residents. However, bamboo shoots collection, especially for commercial purposes, has been strictly forbidden since 2017, which cut off one of the major income sources for villagers. Bamboo shoots collection commonly contributed to at least 20,000 RMB income for local households per year, but the collection ban severely impacts local households’ livelihood. Therefore, under the principle of ecological priority, only a few beekeeping activities are allowed in the core zone of reserves for villagers to maintain their income. Figure 2 depicts the current resource utilization status in Yanyuan village.

The land area of Heishan village is about 17 square kilometers, and its forest cover rate reaches about 95%. There are 87 households with 238 villagers living in Heishan village. In the 1970s, the villagers were all herbalists (medicinal herb farmers) who worked for a state-owned factory planting Captis Chinensis. Since the 1980s, the
collective-owned land was assigned to individuals, so villagers planted Cryptomeria fortunei and collected edible bamboo shoots for self-use. Along with improving basic infrastructures in the 1990s, commercial sales of bamboo shoots from the collective-owned forest became the primary household income source. Land loss compensations (about 300 RMB mu\(^{-1}\)) due to the construction of SHP also brought extra money for villagers during that time. For workers employed by local SHP, the average salary was 300–400 RMB month\(^{-1}\). After the 2010s, about 20% of households in Heishan village participated in Coptis deltoidea cultivation. With a steady
relationship with Wawushan Pharmaceutical Company, villagers could sell their dry *Coptis deltoidea* at 1000 RMB kg\(^{-1}\) and dry *Coptis chinensis* at 120 RMB kg\(^{-1}\). Villagers also gained income from logging (Log price 700–800 RMB m\(^{-3}\)) and beekeeping activities. The employment salaries were also raised to 2000–3000 RMB month\(^{-1}\) for local workers. In addition, free electricity was provided by the local SHP, and firewood was rarely used. However, the partial closure of SHP in 2017 significantly lowered local salary standards, and the charge of the electricity fees resulted in the rebounded cases of firewood collections. Heishan village struggled to increase households’ income through agritainment operations and *Coptis deltoidea* cultivations, but the limited...
cultural cultivation technology and the construction ban on any forms of agritainment facilities cut off the rural tourism development opportunities. Figure 3 depicts the current resource utilization in Heishan village.

3. Method

3.1. Participatory scenarios analysis

We conducted a case study using exploratory participatory scenarios analysis to explore possible adaptation behaviors under the circumstance of SHP closure and the stringent environmental regulations in giant panda nature reserves. Two aspects were focused on: (1) how local communities cope with different SHP closure scenarios, (2) how policies support the implementation of SHP closures. To understand community responses to SHP closure, relevant stakeholders (villagers, community leaders, and local governors) designed scenarios to describe hypothetical future scenes based on a set of factors and dynamics that characterize reality (Van Notten et al. 2003). The exploratory participatory analysis aims to identify and discuss the possible future actions and policies to support the concrete settings in the scenarios and to reach a win-win solution for multiple stakeholders (Vervoort et al. 2014).

Narratives play a central role in constructing exploratory scenarios, as narratives could qualitatively describe how the future might be. In this study, narratives are articulated both by experts’ consultations and communities’ self-constructions. Five steps were implemented to construct the exploratory participatory scenarios. (1) Through the in-depth interviews with local authorities, key stakeholders engaged in SHP closure and significant factors that might impact local lifestyles were identified, and (2) Community-level scenario-building workshops were organized in July 2019 to discuss the most relevant factors or dynamics that affect communities’ natural resource reliability and living standards under the background of SHP closures. (3) Through in-depth discussions with stakeholders, the most plausible future scenarios that capture the perspectives of different institutes were designed, and a storyline characterizing each scenario was developed. In addition, each scenario was assigned a distinctive name. (4) Workshop participants were regathered, and more villagers were invited to the focus group discussion. Scenario narratives were used as a tool to explore local adaptation options. Especially, the participating villagers were asked to vote for the most preferred scenario and explain their choices. For each scenario, participants were asked to provide feedback based on their opinions on what changes would have to be made to meet the scenario requirement, the extent to which the foreseeable uncertainty would affect their daily life, and the ranges of support or policies that would be needed to facilitate the adaptation process to each scenario. (5) We integrated the community perspective policy options into reports and delivered to local and provincial policy-makers to disseminate our investigation results.

Exploratory participatory scenarios workshops are useful platforms for sharing knowledge and opinions. Participants communicate and learn from each other and even change their opinions to reach a consensus on scenario building (Knapp et al. 2017). However, the constructed scenario is a consensus-seeking process, which means that radical and transformative characteristics are often not built-in. Hence, we construct and distinguish scenarios based on the existing factors of stakeholders in the workshop.

3.2. Data collection

The qualitative data collection through in-depth interviews, scenario-building workshops, and focus group discussions were conducted in the Wawushan nature reserve administration and Yanyuan and Heishan villages in July 2019. Although the construction of the integrated scenario with an assessment of climate, socioeconomic, and policy components are widely used at the global level (e.g., Moss et al. 2010, Kebede et al. 2018), the full application of such a framework at the local level was difficult in our case. Especially the climatic component is hard to be tracked over a short period, and a limited landscape in our sample area. We will highlight the socioeconomic-policy dimension that captures local-scale changes in the context of SHP closure. In the sampled village, participant consent was gained for the interviews and workshops. We first organized one workshop by gathering stakeholders’ opinions on what has changed and will change under the background of SHP closure. In Yanyuan village, nine participants (six male and three female) attended the workshop, representing four stakeholder groups: community, SHP, villagers, and government. In Heishan village, 13 participants (12 male and one female) represented similar stakeholder groups. Details of participating stakeholders can be seen in table 3 below. Although the sample size of 9–13 participants per case village is comparatively small, the representativeness of participants and the length of the workshop (more than eight hours of face-to-face communication) could have provided sufficient information to support this study. All participants were given sufficient time to freely express their opinions and discuss their concerns thoroughly during the workshop.
4. Results

4.1. Scenarios design

Workshop participants were invited to think about the context of SHP closures (based on what has happened and what will happen) and to brainstorm the important impacts that SHP closure scenario has or will have on their natural resource reliabilities and daily life. The impacts were then piled into categories based on their similarity under the socio-economic-policy dimensions of change in Yanyuan and Heishan (See figure 4). Yanyuan village’s main concerns are income level, labor employment, restrictions on agritainment management, change of income sources, medical and endowment insurance payment, logging restrictions, and public transportation problems after SHP closure. In Heishan village, the main categories of concerns are income deduction, labor employment, infrastructural maintenance, public transportation issues, insurance payment, security risk, and electricity expenses.

Based on the scenario-building workshop listing key impacts that affect the livelihood conditions, we further arranged a short in-depth discussion with representatives of stakeholders (a community leader, a villager, and a natural reserve manager) to integrate those initial impacts into three sections. Accordingly, we built four plausible future scenarios that could capture possible changes regarding restrictions on sections of natural resource use, livelihood sources, and the degree of basic security in each village. A distinctive name and a storyline that characterizes each scenario were given (See table 4 in Yanyuan Village).

In Yanyuan village, three scenarios were built and named according to the degree of regulatory constraints and supportive actions in the dynamics of SHP closure. Another scenario depicted the current situation. The narrative forms of descriptions are presented below.

4.1.1. Extreme regulatory constraint scenario (S1)

In the extreme regulatory constraint scenario, all 14 SHPs are closed, villagers lose their jobs in SHPs (the major income source), and villages can no longer gain corporate dividends. Due to the stringent environmental regulation on natural resources protection, commercial forest logging, firewood picking, bamboo shooting, and herbal medical collection are comprehensively forbidden. In addition, villagers need to pay their electricity bills, pensions, and medical insurance. Meanwhile, the village road maintenance fees are at their own expense. The loss of the free ride from SHPs also causes inconvenient public transportation in the village.

As described by a villager, ‘I think the village will become more closed, and people will have no job or livelihood choice if they choose to stay… We will lose our income sources, but daily expenses are surging. So, we feel anxious and afraid of this scenario if it happens.’

4.1.2. Partial constraint scenario (S2)

In the partial constraint scenario, all 14 SHPs are closed, but the local government provides ecological governance job positions for villagers to guarantee endowment and medical securities. Environmental regulations are flexible in this case. Commercial forest logging and ecological forest thinning are moderately permitted. Fish culture and medical herbal cultivation are allowed. However, firewood picking is forbidden. In addition, villagers need to pay for electricity use, but the local government shares the expenses on road maintenance. To ease public transport, the government plans to build more bridges to enhance the connectivity of villages.

As demonstrated by a village officer, ‘I believe almost all villagers know the importance of natural resources and wildlife protections, however, our life quality matters too, we love the village we live in, and we hope to have livelihood choices to make our life better.’ One SHP representative added, ‘SHP closure causes annually 40 000 RMB income loss for us. Since we do not have any other skills, re-relying on nature resources seems to be the only choice’.

| Stakeholders | YY village | No. of participants | HS village | No. of participants |
|--------------|------------|---------------------|------------|---------------------|
| Community    | Village Party Secretary | 1                    | Village Party Secretary | 1                    |
|              | Village officers       | 2                    | Village officers       | 3                    |
| SHP          | SHP representatives    | 3                    | SHP representatives    | 3                    |
| Villager     | Villager representatives | 2                  | Villager representatives | 3                    |
| Government   | Manager of the nature reserve | 1          | Manager of the nature reserve | 3                    |
4.1.3. Supportive scenario (S3)

In the supportive scenario, all 14 SHPs are closed, local government provides job positions in ecological governance for villagers. The local government agrees to redeem the commercial forests with logging bans from villagers. Meanwhile, proper bamboo shoot collection, fish culture, and medical herbal cultivation are permitted, and beekeeping in the general control zone of the national park is allowed. In addition, villagers have subsidies on electricity use, and the government is responsible for road maintenance. Villagers are further allowed to gain incomes from agritainment activities moderately.

As a villager and a SHP representative described, ‘If the government gives us more livelihood choices and protects our property rights of forest land use, we would be very grateful. We would have been willing to decrease the disturbance to nature, but we also need compensations or subsidies for our efforts.’
Table 4. Scenario-building in Yanyuan Village.

| Regulations on SHP closure          | Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
|------------------------------------|---------------------------------------------|---------------------------------|--------------------------|---------------------------------|
| Commercial forest logging          | All closed (no dividend)                    | All closed                      | All closed               | 3 running SHP                   |
| Ecological forest thinning         | Banned                                      | Moderately allowed              | Government redeems       | Limited                         |
| Bamboo shoot digging               | Banned                                      | Moderately allowed              | Allowed                  | Banned                          |
| Medical herbal collecting/planting| Banned                                      | Planting allowed                | Planting allowed         | Moderately allowed              |
| Firewood collecting                | Banned                                      | Allowed                         | Allowed                  | Allowed, but only log residues  |
| Fish culture                       | Banned                                      | Moderately allowed              | Allowed                  | Moderately allowed              |
| Beekeeping                         | Banned                                      | Allowed                         | In general control zone of the national park | Moderately allowed |
| Possibilities of livelihood sources|                                             |                                 |                          |                                 |
| Job from SHP                       | No                                          | No                              | No                       | A few                           |
| Job positions in ecological governance | No                                          | Yes                             | Yes                      | No                              |
| Other job opportunities            | No for 50+ year-old                         | A few                           | Some                    | No for 50+ year-old             |
| Income from natural resources      | No                                          | Yes                             | Yes                      | Limited                         |
| Agritainment activities            | Banned                                      | Banned                          | Moderately allowed       | Banned                          |
| Pay for electricity                | Private                                      | Private                         | Government provides subsidies | Private |
| Pay for endowment                  | Private                                      | Shared by government            | Shared by government     | Private                          |
| Pay for medical insurance          | Private                                      | Shared by government            | Shared by government     | Private                          |
| Pay for road maintenance fees      | Private                                      | Shared by government            | Government               | Private                          |
| Public transportation              | Paid                                         | Government build bridges        | Government build bridges | Freeride                         |
4.1.4. Current condition scenario (S4)
The current condition is that three of 14 SHPs are still running, but many laborers lose their job and stay at home. Only a few amounts of commercial forest are permitted to be cut down, but commercial bamboo shoot sales are forbidden. Firewood picking is allowed, but only within a range of logging residues. Villagers must pay for electricity, endowment, and medical insurance alone. The road maintenance fees are also at their expense.

As the village party secretary described, ‘the current condition is not good, our villagers lost the dependences that we used to rely on, and we need to find more ways to live. However, we have little support now and feel anxious about the uncertain future.’

In Heishan village, three similar scenarios were built and named according to the degree of regulatory constraints and supportive actions in the dynamics of SHP closure. Another scenario also depicted the current situation (See table 5. in Heishan Village).

The narrative form of scenario descriptions is presented below.

4.1.5. Extreme regulatory constraint scenario (S1)
In an extreme regulatory constraint scenario, all nine SHPs are closed. Forest-related activities such as commercial forest logging, bamboo shoots, and herbal medical collection are strictly prohibited. In addition, agritainment activities are strictly regulated, and expansion of existing operations is not allowed.

As described by a village officer, ‘under this scenario, we will lose all our income sources, and do not know what to do in the future.’

4.1.6. Partial constraint scenario (S2)
In the partial constraint scenario, three SHPs (Caogou SHP, Sanji SHP, and Longshui First Grade SHP) are operating to provide electricity for the village. Bamboo shoots and herbal medical collection are moderately allowed in private forests, but the logging quota on commercial forests is strictly limited. *Coptis Chinensis* and *Coptis deltoidea* cultivations are encouraged, but the expansion of agritainment activities is under a strict approval process. The government has renovated basic infrastructures such as roads, parking plots, and sewage and garbage treatment systems. In addition, ecologically friendly products and forest therapy activities are permitted.

As described by a nature reserve manager, ‘*Coptis deltoidea* cultivation is vital for local livelihoods, but relevant cultivation techniques are desperately needed… SHP's closure in the core zone is necessary, but the ones outside or on the edge of nature reserve deserve further consideration.’

4.1.7. Supportive scenario (S3)
In the supportive scenario, all but two closed SHPs are running, which means that many villagers can still have jobs from SHPs. Bamboo shoots and medical herbas collection in a proper manner are permitted, and the logging quota of commercial forests can meet basic requirements. Subsidies standards on the ecological forest are increased. Cultivations of *Coptis Chinensis* and *Coptis deltoidea* are encouraged, and the commercial use of ecological products made from *Coptis deltoidea* (tea, toothpaste, face mask) is promoted and branded to look for market opportunities. Agritainment and forest therapy activities are permitted in an appropriate scale and manner. Basic infrastructure conditions in the village are improved.

As described by the village party secretary, ‘*Coptis deltoidea* cultivation and its ecological processing products are unique in our village, we would like to make efforts to develop and sell these products, and we would also have ambitions to build a brand for this. We certainly hope that the rest of the SHPs could remain, but we value more cooperation with the academic institute and firms to develop our *Coptis deltoidea* products. We bet that will be the future for our village in the post-SHP era.’

4.1.8. Current condition scenario (S4)
Currently, seven out of nine SHPs are still running. Villagers can dig bamboo shoots, collect medical herbal, and have beekeeping activities relatively free. Logging quotas are restricted and cannot meet the basic requirement. Cultivations of *Coptis Chinensis* and *Coptis deltoidea* are permitted, but the rotation period for *Coptis deltoidea* reaches 30–50 years, which seriously impacts its production efficiency and commercial sale return. There are 16 running agritainment facilities in the village, and expanding their operational scales is still possible. However, no parking plot limited the village’s tourist reception capacity. In addition, the narrow road (only 3.5m in width) and the simple sewage and garbage treatment facilities lowered villagers’ sense of happiness. Villagers shared the garbage disposal fees with the local government (villagers pay 12 RMB/person/year, and the government bears the rest).

As described by a SHP representative, ‘currently, we still highly rely on SHPs incomes. We want to participate in *Coptis deltoidea* cultivation, but unfortunately, we do not have corresponding techniques. We
Table 5. Scenario-building in Heishan village.

| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
|-------------------|----------------------|----------------------------------------|----------------|
|                   |                      |                                        | Road           |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
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| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
| Regulations on SHP | Natural resource use | Possibilities for livelihood improvement | Infrastructure |
| Extreme regulatory constraint scenario (S1) | Partial constraint scenario (S2) | Supportive scenario (S3) | Current condition scenario (S4) |
hope that the academic institutes could help us shorten the time of land re-cultivation and improve our operational efficiency’.

4.2. Local adaptation strategies and policy actions
The scenarios designed above served as a tool for further discussion within the community. A Focus group was arranged to collect villagers’ opinions on adaptation strategies for each scenario. According to the most preferred scenario vote, the supportive scenario (S3) is the best choice for both YanYuan and Heishan villages. Although feedback on adaptation strategies under each scenario showed its diversity, their fundamental needs and appeals are sharp and clear. (see table 6).

In Yanyuan and Heishan villages, under extreme regulatory constraint scenario (S1) and current scenario (S4), local communities may rely only on government conservation subsidies and possible ‘mercy’ policies on natural resources use. It is hard for villagers to imagine how to improve their life quality and well-being under these scenarios, but only to think about how to maintain the minimum living standards. As one village party secretary said: ‘nowadays, mainly elderly people are living here, and if policy becomes stringent, we hope that the government will provide medical care and basic infrastructure support to ease our daily life. The younger generation would wish to have opportunities in fish culture or medical herbal cultivations. If no hopes, more migrations would happen in scenarios S1 and S4, and the village will disappear soon.’

Villagers’ potential adaptation strategies are active in the partial constraint scenario (S2). In Yanyuan village, villagers are willing to learn more knowledge and techniques for competent job positions in ecological governance. Villagers are also motivated to manage their commercial and ecological forests and are willing to expand their fish culture and herbal medical cultivation areas properly. Similarly, in Heishan village, villagers would like to bet their livelihoods on community-co-managed Coptis deltoidea cultivation. Villagers would also have a strong incentive to improve the management quality of agritainment to increase their income. From a policy interventions perspective, both villages advocate increased electricity subsidies, improved public facilities maintenance, and preserved traditional environment and culture as key government- and reserve-led actions for communities’ adaptations.

As the most desirable supportive scenario (S3), both villages believe it is the best case where major households could benefit. Under this scenario, in Yanyuan village, villagers are motivated to improve their skills to fit themselves into the ecological governance position better. The villagers also actively pledged that they prefer to properly control the scale of bamboo shoots collection, medical herbal cultivation, fish culture, beekeeping, and agritainment management to maintain sustainable development. In Heishan village, villagers are willing to accept any form of technical training on Coptis deltoidea cultivation and invest in industrial processing facilities for bamboo shoots and other eco-products to extract adding values. Both villages emphasize that governmental institutions should carry out a unified plan on agritainment activities in terms of sewage and garbage treatment and road construction to reach sustainable development goals. Furthermore, co-founding with research institutes and companies is perceived as an effective way to promote the Coptis deltoidea cultivation and solve the local surplus labor problem. Protecting surrounding water and soil quality emphasizes its importance in guaranteeing the quality of Coptis deltoidea products. In addition, tourism is also seen as an active adaptation strategy by managers of natural reserves, and speed up the construction of the popular science and recreational zone of the giant panda national park is expected.

5. Discussion
Given the ecological priority principle in China, reconciling rural livelihood and ecological conservation is challenging, especially in nature reserves. Taking a SHP closure event in a giant panda nature reserve as the research target, this study attempts to explain the local community’s response to SHP closure and examines the micro-livelihood adaptation strategies faced by rural communities under different future development scenarios in the future. The case study creates four scenarios to demonstrate rural communities’ opinions on varying degrees of natural resource use constraints. Rather than portraying the communities as homogenous entities with shared interests and norms, this study argues that the coping strategies of residents vary according to the stringency of regulations and the perceptions of different members of the local community about the benefits and costs of SHP closure. This study helps to understand the uncertainties and diversities of adaptation policy-making in the post-SHP era.

The analysis of the four alternative scenarios in two parallel villages shows that local communities least welcome the extremely strict regulations from S1. S1 can lead to very high governance costs, as conservation subsidies or resettlement compensations are almost the only way to maintain the basic living of residents. Villagers would have passive emotions and behaviors when dealing with such an extreme situation. A partial constraint scenario (S2) is acceptable, but residents would need more natural resource utilization (i.e.,
| Yanyuan Village | S1 | None | •Subsidies: Minimum standard of living | None |
|----------------|----|------|--------------------------------------|------|
|                | S2 | •Self-improvement: Knowledge and techniques | •Safeguard: Medical care; Education opportunities | |
|                |    | •Diversification: Managing commercial and ecological forests; Developing fish culture; Planting medical herbal | •Subsidies: Electricity consumption | |
|                | S3 | •Diversification: Developing fish culture; Planting medical herbal; Beekeeping; Operating agritainment | •Safeguard: Electricity equipment maintenance; Sharing medical insurance fees | |
|                |    | •Management and planning: Unified planning on agritainment activities | •Subsidies: Increase subsidy standards for ecological forest | |
|                |    | •Physical infrastructure: Building sewage and garbage treatment facilities; Widening village road | •Management and planning: Ecological governance positions | |
|                | S4 | None | None | |
| Heishan Village | S1 | None | •Subsidies: Certain levels of SHP income | |
|                | S2 | •Diversification: Improving the management quality of agritainment; Developing tourism cooperative | •Safeguard: Co-sharing medical and endowment insurance | |
|                |    | •Subsidies: Electricity consumption | •Subsidies: Electricity consumption | |
|                | S3 | •Self-improvement: Knowledge and techniques | •Physical infrastructure: Public facilities maintenance | |
|                |    | •Diversification: *Coptis deltoidea* cultivation; Industrial processing of bamboo shoots and other local products | •Safeguard: Endowment insurance | |
|                |    | •Management and planning: Control the tourist volume | •Capacity building: Training | |
|                | S4 | None | •Capacity building: Found research based on *Coptis deltoidea* cultivation | |
|                |    | •Physical infrastructure: Maintaining 4 SHPs for free power; Widening the road; Construction of parking lot; Improving sewage treatment facilities; Medical care station | •Management and planning: Protect the traditional village in terms of its environment, culture, etc. | |
|                |    | •Management and planning: Speed up the construction of popular science and recreational zone; Restrict the use of water and soil resources surrounding *Coptis deltoidea* cultivation base | •Policy: Protect the traditional village in terms of its environment, culture, etc. | |
|                |    | None | None | |
herbal medical planting, fish culture) and basic living security (i.e., electricity consumption subsidies, medical insurances) to maintain a normal self-sufficiency life operate. Supportive regulations (S3) are the most welcomed, and residents could expect more long-lasting incomes through agritainment management, cultivation cooperation, infrastructural improvement, and natural education.

While unsurprisingly, S3 is the best choice and the most desired future for residents, it is still worth discussing the means and obstacles to achieving this scenario. Yanyuan residents in S3 expect the government to redeem their commercial forests as compensation. With current policies, this is not yet a feasible way for political discussion. However, converting these commercial forests into ecological forests and raising the subsidy standards for ecological forests may be attractive. In addition, reopening the harvesting of commercial forests under a certain quota is also a way to solve the problem. Heishan residents want to pay more attention to the prospect of herbal medical cultivation and agritainment in S3. From a policy-making perspective, cultivation and scientific research collaborations could be supported and encouraged, but the obstacle is the technical challenges of how to shorten the land restoration period without harming the surrounding natural environment. Moreover, the moderate development of agritainment is always an effective way to maintain and increase residents’ income. Policy-making can also try to regulate villagers’ agritainment operations by implementing a concession mechanism in the giant panda national park.

Further comparing Yanyuan and Heishan villages, it is interesting that the two villages have significantly different expectations for the next step in SHP closure moves. For Yanyuan Village, due to its closer location to the core protected area, all SHPs are expected to be closed by villagers. However, due to its high dependence on natural resources, the villagers would rather focus on passive livelihood adaptation strategies, such as subsidies, resettlements, and government basic living guarantees. For Heishan Village, since some of their SHPs are not operating in the core protection area of the Giant Panda Nature Reserve, the villagers are optimistic about keeping the rest SHPs in operation. Villagers hope positively to take the initiative to transform their livelihoods through technical support and infrastructure guarantees from the government. Therefore, when making policy choices, we call for the inclusion of local natural resource conditions and the values and abilities of villagers. For areas with high resource use restrictions, high monitoring costs should be paid at all costs to achieve ecological goals; supportive policies with minor regulatory costs are more welcome for areas with resource utilization possibilities. Therefore, flexible policy design and effective implementation at the local level is an important means to balance protection and development in nature reserves effectively.

From a broader perspective, future scenarios are not static, and changes in scenarios may be influenced by external factors such as labor migration and urbanization. Although our scenario design could capture some exciting and uncertain perspectives on local adaptation strategies and policy decision-making, it may still be limited without considering the macro context. It needs to be indicated that the scenarios represent mainly the underlying values within a specific society (Ernst et al. 2018). Therefore, future research can improve in three aspects. First, there needs to be a broader discussion of the optimal scenario (Cairns et al. 2017, Nygren 2019), as it is the most meaningful and motivating scenario for residents. Second, although scenario construction has strengths in decision support, it has weaknesses such as ambiguity in illuminating solutions. Radical visions should be emphasized more during the scenario design process to ensure viable long-term adaptation options. In addition, broader themes and contexts need to be assessed to discover new pathways to inspire participants’ full ranges of future awareness and optimize scenario design. Third, multiple rounds of scenario development with different participant groups are recommended to provide sufficient insights on a specific topic to improve scenario quality.

From the perspective of policy inspiration, with the gradual improvement of protection policies in China, more and more land will be included in the protected areas. However, China has about 47,000 SHPs, and the closure of whom to maintain the ecological health of river basins is an essential policy requirement. The closure of SHPs would undoubtedly have a massive impact on the lives of rural households. For locals, compensation, resettlement, and alternative livelihoods are directly related to their fundamental interests. Under the brand effect of the Giant Panda National Park, the scenarios concerned in this paper has relatively high alternative livelihood choices for local residents. They have received extensive policy attention during their livelihood transition process. In contrast, for vast mountainous areas in other parts of China, the subsequent impact of similar policy changes on local livelihoods could be vast and catastrophic. Therefore, based on this research, we call for more policy scenario research at the local level to understand the residents’ basic needs and formulate and implement policies according to local conditions by thoroughly combing the individual abilities, local governing capacities, and national policy orientations. Furthermore, we call for policy implementation neither rigid nor variable at different levels to avoid stakeholder conflicts. We also hope this research could provide experience and enlightenment for other developing countries with similar situations to implement such ecological and economic coordinated policies smoothly and effectively.
6. Conclusion

This study unpacks the local community’s diverse views and possible coping strategies for SHP closure. It highlights the need to broaden the understandings of local communities on how they identify themselves as beneficiaries or victims and further explore how these grass-roots forces could promote the inclusive development of nature reserves, as it is of importance to include these views within the broader context of social justice (Sen 2009). The hypothetical scenario setting at the Wawushan nature reserve could partly reflect the broader socio-political scenario of nature reserves in China, although the theme of policy change/evolution might differ. This study provides further insights into the underlying policy options to better serve the local community development. Hopefully, the rural policies could be re-oriented in favor of local residents to increase their well-being and promote social equity. We believe that more engagement and knowledge exchange between different stakeholders through participatory approaches would be highly appreciated to achieve the appropriate collaboration and reciprocity to promote the long-term efficient and sustainable development of the rural community in nature reserves.

Data availability statement

The data that support the findings of this study are available upon reasonable request from the authors.

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Appendix A

| Table A1. Policy constraints on SHP development in Sichuan province (In chronological order). |
|-----------------------------------------------|
| Regulation |
| Notice on Further Strengthening the Supervision and Management of Activities Related to the Development and Construction of Nature Reserves |
| Ministry of Ecology and Environment (2015) No. 57 |
| Policy in brief |
| • Strengthening the supervision and management of activities involving the development and construction of nature reserves |
| • Investigating activities that violate laws and regulations, such as illegal hydropower/wind stations in the core and buffer zone of nature reserves |
| • Shutting down or demolishing those stations within due time. |
| • Ecological restoration shall be implemented. |
| Remarks |
| General statements, no detailed instructions, and guidelines |

| Regulation |
| Opinions on further strengthening and standardizing the management of hydropower construction |
| The People’s Government of Sichuan Province (2016) No. 47 |
| Policy in brief |
| • Stopping the construction approvals of SHP projects completely. |
| • Hydropower is not allowed in the nature reserve to protect the ecological environment. |
| Remarks |
| Explicitly stopping the SHP projects |

| Regulation |
| Plan for problem rectification in Sichuan Nature Reserves |
| General office of Sichuan provincial Party Committee (2017) No. 44 |
| Policy in brief |
| • SHP illegally constructed in the core and buffer zone shall stop its operation immediately. |
| • Ecological restoration shall be done before December 31, 2017. |
| Remarks |
| Specifying the areas where SHP should be shut down. |
### Table A1. (Continued.)

| Regulation                                                                 | Year of launch | Policy in brief                                                                                                                                                                                                                                                                                                                                 | Remarks                                                                 |
|---------------------------------------------------------------------------|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| Minutes of the Meeting of the Leading Group for Environmental Protection Inspection of Sichuan Forestry Administration | Sichuan Forestry Administration, (2017) | • Preexisting SHP should be withdrawn from the core and buffer zone within due time.  
• Supervising and urging the completion of rectification of ecological and environmental problems in the nature reserve and planning the on-site verifications.                                                                                       | Mentions ecological restoration deadlines.                              |
| Work plan for rectification of small hydropower problems in Nature Reserves in Sichuan | Sichuan Provincial Development and Reform Commission (2017) No. 438 | • Completing the demolition of SHP by the end of 2017 and implementing ecological restoration in the core and buffer zone.  
• Completing the rectification of environmental problems before middle 2018 in the experimental zone.                                                                                                           | Giving detailed guidelines on ecological restoration.                  |
| Notice of ‘Work Plan for Rectification of Small Hydropower Problems in Nature Reserves in Sichuan (Revision)’ | Sichuan Provincial Development and Reform Commission (2018) No. 421 | • Listing the SHP problems and implementing the rectification in nature reserves.                                                                                                                                                                                                                                     | Setting detailed deadlines by zones in nature reserves.                 |
| Notice of the rectification of SHP in core and buffer zone of nature reserves | Sichuan Provincial Development and Reform Commission (2018) No. 745 | • Speeding up the rectification and reform process following the regulatory requirements and standards.                                                                                                                                                                                                              | Urging the rectification process.                                      |
| Rectification plan for the feedback from the central fifth environmental protection inspection team | Sichuan provincial Party Committee (2018) No. 223 | • Solving the prominent environmental problems.                                                                                                                                                                                                                                                                                        | Reiterating the importance of the ecological environment               |
| Minutes of the consultation meeting on issues related to the rectification of small hydropower stations in nature reserves in Sichuan province | Sichuan Provincial Development and Reform Commission (2018) No. 2 | • Establishing the long-term management mechanism.  
• Continuing to improve the quality of the ecological environment and strengthen the Yangtze River’s ecological barrier.                                                                                                                                                      | Clarity the deadline for rectification tasks of SHP demolition          |
| Measures for the Rectification under the Supervision of Ecological Environmental Protection in Sichuan Province | Department of Ecology and Environment of Sichuan Province (2019) No. 140 | • Completing the rectification task of SHP problems by the end of December 2019.  
• Completing the rectification activities according to the rectification plan and the list of rectification tasks.                                                                                                                                           | Completing SHP rectification process                                    |

### Appendix B. List of acronyms

| Acronym | Definition |
|---------|------------|
| SHP     | Small Hydropower |
| MW      | Million Watts |
| KW      | Kilowatt |
| kWh     | Kilowatt-Hour |
| NTFP    | Non-Timber Forest Products |
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