

Linking the Mountain Futures Action Plan to the Kunming-Montreal Global Biodiversity Framework

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Abstract

Global mountains hold great value to many people, harbor great amounts of biodiversity and provide many ecosystem services. They have not however been well-represented in specific targets under international policy conventions including the UN Sustainable Development Goals and the Convention on Biological Diversity. This paper explores the efforts of one consortium of actors led by the Mountain Futures Initiative, to create and implement an action plan to link research and field projects at the Honghe Innovations Centre for Mountain Futures to targets in the new Kunming-Montreal Global Biodiversity Framework (GBF). This action plan will combine research on agroforestry, soil restoration, ecosystems restoration and connectivity, new green products and supply chains, and more in service of both healthy ecosystem outcomes and lifeways support for local smallholder farmers. Results show that connecting local research goals to GBF targets may leverage more positive outcomes for people and nature.

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Introduction

As one of the most important terrestrial ecosystems, the health of mountains is connected to the health and future well-being of many people on Earth. Mountains cover from 12%–30% of the Earth's terrestrial surface outside of Antarctica (there is debate over how mountains are defined)^[1]. Montane areas are disproportionately rich in mammals, birds and amphibians with 85% of all species in these groups living at higher elevations^[2]. In addition, mountains harbor half of all global biodiversity hotspots and some 17% of protected areas outside Antarctica^[3]. Mountain ecosystems provide an array of critical ecosystem services, exemplified by the fact that some 24% of people on Earth may depend on fresh water originating from the world's 'water towers'^[4]. Globally, approximately half a billion people live in montane ecosystems and food insecurity due to land degradation and climate impacts affects the majority of mountain communities in the developing world^[5].

Mountains provide irreplaceable ecological, cultural and spiritual values for a diversity of peoples^[6]. Yet, despite multiple threats to mountains, they have received little international policy attention relative to their importance^[7]. Since 2015, mountains have been included in the United Nations (UN) Sustainable Development Goals, though work toward these goals is critically behind schedule as of 2023^[8]. There was a flurry of international conferences and reports featuring mountains in 2019–2020 leading to expectations that montane areas would benefit from greater policy action during the 2022 UN conventions for climate and biodiversity. But results have been mixed. At the 27th UN Conference of the Parties (COP 27) on climate, nations agreed to construct an improved Earth observation system that includes updated tracking of the

montane cryosphere. And while there were two mountain-focused side-events at the biodiversity COP 15 in December 2022, montane systems are mentioned only once (as an optional subsidiary indicator) in the new ten-year Kunming-Montreal Global Biodiversity Framework^[9].

These results stand in contrast to recognition among researchers and practitioners of the need for transformative changes given threats to montane social-ecological systems encompassing biodiversity, ecosystem services, human livelihoods, institutions, and governance^[10].

Despite shortfalls in UN-level consideration, and recognizing that the most important factors affecting mountains are national and sub-national conservation and development policies and actions, workers in highlands continue to move forward. One such consortium, the Mountain Futures Initiative, is a research group comprised of the Chinese Academy of Sciences and Chinese Academy of Agricultural Sciences, together with the UN Environment Programme, the UN Food and Agriculture Organization Mountain Partnership, the World Agroforestry Centre, and the International Centre for Integrated Mountain Development. These organizations launched the Mountain Futures Initiative (MFI) in 2016 to enhance the health of mountain ecosystems while supporting sustainable lifeways for highlands dwellers. The MFI is already linked to the Sustainable Development Goals, and the Kunming Declaration vision of 'Ecological Civilization' for the Convention on Biological Diversity.

Mountain Futures delegates participated in COP 15 at a side event that launched a new Mountain Futures Action Plan (hereafter Action Plan), the focus of this paper. This plan, likely the first project-specific framework linked explicitly to multiple targets in the new GBF, is being implemented at the Honghe

Innovations Centre for Mountain Futures, a MFI research site in southern Yunnan province, China. Established in 2019, the Centre covers 672 ha of dry mountain sloping lands and serves as a public-private laboratory where social-ecological projects in support of local livelihoods can be tested^[11]. So far, USD \$10 million dollars have been invested by local, provincial, and national governments along with monies from private donors. Current projects cover a range of experiments: agroforestry fruit and fodder crops; integrating fertilizer use with efficient water management; kapok products produced for sustainable rural-urban market supply chains; innovative biomass production for soil restoration; and more. Expectations are that general lessons learned at Honghe may be scaled up to other mountain areas as appropriate.

Assessing the Mountain Futures Action Plan

The Action Plan, like the GBF, is aspirational and ambitious. Its general goals closely follow those in the GBF including: the sustainable use of biodiversity; ecological restoration and ecological health; full and effective participation of indigenous peoples and local communities; and sustainable lifeways change through public education and economic transformation. The Action Plan directly refers to 12 of the 23 specific targets in the GBF; given local conditions, Honghe projects cannot be connected to every GBF target. For example, GBF target 12 (Urban Green and Blue Spaces) is suitable only for densely populated areas, and Target 18 (reducing nature-destroying subsidies) is beyond the political scope and capacity of local managers. However, Action Plan work is already underway on several primary GBF targets including ecological restoration, nature contributions to people, working with business supply chains, and partnering with indigenous and local peoples.

Principles

There are five principles (*in italics*) which set the ambitious tone for the Action Plan.

1. *The principle of precautionary development means that no activity should be undertaken that may have negative impacts on indigenous and local communities.* This is a narrower definition for 'precautionary' than is commonly used (and debated) by conservation scientists and practitioners, and it shows a strong commitment to the health of local peoples in the Honghe area^[12]. The Action Plan calls for *joint ethnoecology research by scientists and indigenous peoples*; here precaution is warranted given the history of how traditional ecological knowledge and Western science have fitfully interacted^[13].

2. *The principle of holistic thinking: There is an inextricable link between biological and cultural diversity. Respect for indigenous ecological civilization and holistic thinking, representing 'Harmony among the heaven, earth and mankind' is recognized.* It is important to state this principle clearly; while this view is increasingly accepted by a majority of conservation practitioners, such a social-ecological systems perspective has been a minority view^[14]. There are multiple ways to respectfully bring biological and cultural views together in a project and yet, so far, there are more academic descriptions of how to co-produce knowledge than examples of active and equitable ways of doing so on the ground^[15].

3. *The principle of secured rights: The health of mountain ecosystems is inextricably linked to the development rights of*

indigenous communities. Their rights to a clean, safe, and healthy environment, traditional knowledge of genetic resources, and mechanisms for access and benefit-sharing should be protected. It is well-known that secure rights to land are critical for indigenous peoples and local communities; safety, access, and benefit-sharing are rendered much more difficult without some form of long-term land tenure security. The GBF has made advances in recognizing the rights of indigenous and local peoples, yet *recognition* does not confer customary or legal land tenure^[16]. National governments almost exclusively control tenure and, in Asia, only 8.7% of indigenous peoples have legally recognized land rights^[17]. In addition to rights, equity is important to securing benefits for indigenous and local peoples. In an inequitable world, respect for local lifeways and alternative knowledge systems is virtually impossible. This may be less of an issue in China at Honghe since project leaders are able to work with and advocate for local peoples, but there can always be room for improvement since free, prior, and informed consent underlie local participation in decision making.

4. *The principle of co-innovation: Mountain farming systems are the cornerstone to building ecological civilization. Indigenous and local communities must be assisted to develop multi-functional products based on traditional farming systems. Urban-rural innovation links across cultures and regions should be established, and the self-development capacity of local communities must be supported.* Indigenous and local peoples in global mountains (and elsewhere) are in a state of flux due to increasing land use degradation, climate impacts, and socio-economic pressures. They are subject to shifts between traditional lifeways and state support^[18], benefits and costs of increasing links into global supply chains^[19], and multiple stresses on local food systems: reduced farm income and security, aging farm workers, outmigration for cash labor, and more^[20]. Research at Honghe is well-positioned to explore innovative solutions to these issues. Project work is underway with a focus on what are often described as essential solutions to highlands food systems issues including: building partnerships with local smallholder farmers, establishing functional green product/market supply chains, working to reform water and waste management in agriculture, and experimenting with public/private partnerships^[21]. Study site location comes with benefits and costs; though China has lagged somewhat behind in creating national-level sustainable agriculture policies^[22], the mix of top-down mandates and bottom-up implementation creates room for innovation^[23]. In some ways, Honghe's county-level location is ideal for project leaders to experiment with food systems knowledge co-production^[24] (see below for specific actions).

5. *The principle of green and low-carbon development: There is a strong synergy between biodiversity and green, low carbon development. Biodiversity mainstreaming and urban consumer behaviors are critical to conserve biological diversity in global mountains. Based on values of indigenous people, everything is interconnected, and cross-generation cultural heritage and cross-cultural cooperation and exchanges should be strengthened to support a green and carbon-neutral community of shared life.* Two keys to green and low-carbon development are how to best insert biodiversity values and accounting into mainstream government decision making from local to global levels^[25] while also influencing consumers to make greener choices in their purchasing decisions, especially around food^[26]. In

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addition, indigenous people who are mountain smallholder farmers need solutions that support their lifeways. At Honghe, researchers are implementing projects that can deliver co-benefits around sustainably produced agricultural goods that benefit local farmers and that can fit into green(er) supply chains linked to urban markets^[27].

Mountain Futures Actions

The Action Plan focuses on four areas with 15 specific actions including:

A. Scientific exploration: Use an ecosystem-based approach and transdisciplinary research to explore mountain futures.

1. *Collect data related to biological and cultural diversity in mountain ecosystems to fill gaps between local project design/needs and national/GBF targets.* There are many biological, ecological, and cultural data gaps in mountain social-ecological systems. A key at Honghe (and elsewhere) is to work with local partners to identify/prioritize knowledge gaps; for example, there exist biocultural metrics that can be used to map culturally significant species^[28]. In a world of many gaps and few resources, such tools can help to set priorities that are critical to success. Researchers at Honghe can also review the draft GBF monitoring framework to look for other metrics to use to help fill data gaps^[29].

2. *Evaluate impacts of global change (including climate change) on endemic, endangered species, and economic plants, and connect local monitoring to national/GBF quantitative measures.* Enhanced warming is occurring at regional scales in mountains^[30] and agriculture on steeper slopes is being impacted^[31]. However, linking local monitoring at Honghe to GBF quantitative measures around climate change will be delayed since COP 15 Parties have not yet finalized a monitoring framework. There will be no final monitoring metrics until 2024; in the meantime, researchers at Honghe can gain ideas from several of the draft climate metrics under GBF consideration.

3. *Define the keystone role of fungi in global mountains to develop soil solutions and create holistic conservation strategies that address climate change, biodiversity loss and food security.* Fungi play fundamental roles in montane ecosystems but global, regional, and local states of knowledge on these organisms are poorly developed^[32,33]. At Honghe, work is being done to explore how mushrooms can play key roles in enhancing soil development^[34,35] using innovative growing techniques. In lands needing ecological restoration at Honghe, one important research question is the proportionate roles that fungal networks vs. species diversity play in enhancing soil restoration^[36].

4. *Employ ecosystem-based management to emphasize interconnections of multiple species, and the role of microbes in ecosystem functioning and human health such as COVID and SARs.* As with fungi, little is known about the role of microbes in ecosystem functioning in mountains^[37]. The limited soil microbial work from drylands mountains in China shows that there is much diversity across elevation, latitude, slope, and soils^[38]. Creating soil restoration experiments that search for how microbial biomass and species composition may that influence how to build soils faster on degraded sites is an ongoing focus at Honghe^[39]. Little is known about links between microbial function and human health in mountain lands.

B. Ecological restoration: Use a landscape approach and agroforestry systems for ecological restoration.

1. *Identify critical areas from global mountains including tropical savannah, high altitude lakes and wetlands, tropical mountains, degraded karst landscapes and mining sites.* The International Centre for Mountain Futures will be established in partnership with the Belt and Road Green Development International Alliance. Linked to the ecological restoration target in the GBF, the process of identifying critical global areas for restoration in mountains is in early stages^[40]. Studies have been completed on various aspects of restoration in montane degraded karst ecosystems^[41] but less is known about other critical ecosystems. Given rapidly expanding global infrastructure, more research linked to large development initiatives will create new opportunities to identify both threatened lands and ways to manage development to limit impacts on people and nature.

2. *Design using a landscape approach and agroforestry systems for restoration around protected areas with corridors that maintain local agricultural and other practices and highlighting projects that protect waters.* So far, planning for corridors between protected areas has not often attempted to address multiple benefits including supporting local agriculture and water management. This is now changing as the GBF has incorporated the goal of conserving 30% of global lands and waters by 2030 and embraced Other Effective Area-based Conservation Measures (OECM) lands (where biodiversity is conserved, though not as a primary goal). Some research is focused on how much land for conservation should be incorporated into farms, agroforestry projects, and corridors^[42], and this can be explored at Honghe. Agroforestry is also being experimented with at Honghe as a tool for ecological restoration^[43]. Agroforestry has been shown to generally conserve biodiversity^[44] and increase carbon sequestration on croplands^[45] yielding benefits for smallholders.

Connectivity and water management co-benefits are also being given impetus from the new GBF targets. For example, water for Honghe comes from a protected area at a considerable distance uphill from the research site and there are other conservation lands in the vicinity. This provides opportunities to design and implement a corridor/waters system from the ground up working with local partners. There has been some work done on the role of tree crops in corridor design^[46]; research identifying corridors and barriers to their implementation has also been done in southwestern China, and this work may be helpful in the design of local study site projects^[47].

3. *Link carbon sequestration and biodiversity enhancement to identify where multiple wins are located while protecting local agriculture/biodiversity/waters/carbon sequestration.* Southwest China has the largest potential of any region in the country for increasing carbon storage through forest restoration^[48]. Building soil biodiversity^[49], plant litter^[50], and understanding carbon implications of managed transitions between ecosystem types^[51] are crucial to restoring ecosystem functioning and carbon storage. All such projects at Honghe should attempt to include empirical monitoring to track outcomes and ecosystem change over time^[52].

4. *Explore innovative biotechnology for biodegradation of plastics and accelerated restoration.* Given the ubiquity of plastics around the world and challenges in recycling and repurposing these materials, much research is organized around discovering how to render these materials useful^[53].

Multiple solutions are being explored: biotechnological and microbial degradation^[54,55], biomass feedstocks^[56], algae^[57], and various biodegradable/compostable compounds^[58]. All of these methods can be explored at Honghe. Especially exciting is experimental upcycling of fruit and vegetable wastes that can be made into starch-based bioplastics^[59].

C. Indigenous wisdom: Apply ethnobiological approach for developing culture and community-based solutions.

1. *Strengthen research on medicinal ethnobotany, establish the Traditional Medicinal Botanical Gardens such as Himalaya Tibetan Medicine Botanic Garden, and carry out cross-cultural exchanges and cooperation for integrated One Health or EcoHealth.* Linking traditional and scientific knowledge continues to be challenging work. One way to make these connections is through focusing on the human health benefits of traditional knowledge and Honghe researchers have already established a public demonstration garden of medicinal plants. Honghe project leaders are long-term participants in global efforts to spotlight ecosystem benefits in the One Health and Ecohealth Initiatives, yet these initiatives are not well-established in Asia^[60]. At COP 15, health links to biodiversity were featured for the first time, however, no explicit health goals or targets were included in the GBF^[61].

2. *Conduct ethnoecological surveys based on traditional ecological knowledge, that help define what local OECMs might look like following the GBF definition, and (in China) encourage scientific and traditional knowledge development to support implementation of the Ecological Red Line system.* As mentioned in B.2 above, OECM lands are going to transform biodiversity conservation. But incorporating these lands into an effective global protected areas network will be challenging^[62]. Standards for what counts as OECM, who decides, and how to monitor projects to measure outcomes have not been specified in the GBF, and this will likely lead to misapplied accounting of the value of these lands for conservation^[63]. Workers at Honghe cannot 'follow GBF definitions' since they as yet do not exist. It is well-known that indigenous peoples often manage land for conservation better than global standards^[64]; given this, it is probably best for Honghe researchers to begin defining OECM lands by first working with local peoples and then linking in to GBF standards when these are finalized.

In China, a rough equivalent to OECM lands at the country-level is the central government's Ecological Red Line System (ERL)^[65]. Active since 2014, ERLs are the most comprehensive attempt in the world to manage lands for no net loss of biodiversity, ecosystem services, and other benefits. As with OECMs, implementation of ERLs will be key; the system is not yet fully functional. Since ERL implementation occurs at local and regional levels in China, Honghe researchers should design projects that fit into county and provincial –level-plans. To do this, methodologies to identify gaps in ERLs in mountains in Sichuan^[66] and the protected area system in southwest China^[67] may be of use.

3. *Protect cultural landscapes and Globally Important Agricultural/Natural Heritage Systems. Based on existing heritage systems such as the Honghe Hani Rice Terraces, foster exchange and cooperation to strengthen eco-circular agriculture.* The Honghe Hani Rice Terraces, one of the most famous Globally Important Agricultural/Natural Heritage Sites, provide a landscape-level link to projects at the Honghe. The rice terraces are well-studied; they remain intact but face pressures from an

increase in agricultural chemical inputs^[68], lack of benefit sharing between farmers and those who gain direct benefits from tourism^[69], and lack of input from farmers in local decision making^[70]. Researchers at Honghe are reaching out to farmers and leaders in the rice terraces to share results from work at the Innovations Centre that may be pertinent to solving problems at Hani. Two promising developments that may be useful in building cooperation with Hani farmers are that, in general in China, younger farmers are more open to innovative sustainable agricultural methods than older generations^[71], and farmer cooperatives appear better able to embrace green farming solutions than individual growers^[72].

4. *Support participatory technology development for biological conservation and livelihood development including biological-based local handicrafts and intangible cultural heritage.* China has one of the best national policy frameworks to protect intangible cultural heritage^[73]. However, under pressures from mass tourism and the fact that definitions of what is culturally 'intangible' and 'valuable' are inherently subjective, these policies have been challenging to implement on the ground^[74]. There are three groups that researchers at Honghe will need to engage with to shape successful work here: local people, government officials, and tourists. Some work has been done in China linking heritage protection with national parks and agricultural lands, and this may be helpful to conducting research in the Honghe area^[75].

D. Future living: Use public engagement to encourage behavior change for interconnections for all life.

1. *Promote integration of biodiversity-centered science, arts and culture, intercultural communication, and south-south collaboration.* Project leaders at Honghe recognized long ago that the construction of 'ecological civilization' requires equal attention to ecology and social dynamics. In China and the Honghe area, intercultural communication for sustaining arts and culture must navigate gaps between traditions and pressures from tourism commodification^[76]. One promising way to do this is through using multimedia to create innovative ways to present local art and culture to visitors^[77]. Recognizing benefits for women in cultural production of crafts can also become a tool for local peoples' empowerment^[78].

2. *Establish an International Centre of Savannah Natural Fiber, support the China model of ecological poverty alleviation, develop indicators and certification (ethical trade, low carbon, biodiversity, quality of life) for mountain products using green supply chains.* In mountains, poverty alleviation is linked to sustainable farming, biodiversity protection, climate adaptation, and supply chains that leave a lower ecological footprint on people and nature. Researchers at Honghe are establishing supply chains between smallholders and new markets for their products. This work often begins with assisting smallholders to connect with nearby urban consumers to purchase sustainably-grown products^[79]. Or it may start with finding partners in cities who wish to establish Community-Supported Agriculture markets^[80]. An ongoing question is how far up supply chains and away from small farm study sites should one go to account for life cycle impacts^[81]. Eco-certifications, improved product labelling, and understanding how Chinese consumers make decisions can help to accomplish this^[82].

3. *Develop local circular agricultural systems and promote regional projects that demonstrate a biomass-based circular*

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economy and reduced petroleum-based plastic pollution while protecting high-plateau lakes, mountain watersheds and river systems. As the environmental footprint of global food systems continues to grow, many countries are searching for answers to questions around sustainable food production and consumption. Circular agriculture, agroecology, and climate-smart regenerative agriculture are all aimed at solving food systems problems^[83]. China has been implementing a national plan for circular agriculture since 2015 and, while evidence-based results are slow to accumulate, the country is moving forward^[84]. Biomass-based actions are one entry point into circular agriculture that are being experimented with at Honghe. Biomass substitutes for chemical fertilizers^[85], bioactive compounds to produce animal feed and reduce food waste^[86], and insects as animal foods^[87] are being employed and there are many win-win solutions to discover. And using a social-ecological framework for circular agriculture in a world where food systems are often inefficient and inequitable requires that the social aspects of food be accounted for^[88].

Conclusions

As the GBF and other UN frameworks to protect biodiversity are enacted, new studies reveal the ongoing unravelling of nature: in 2023, attaining Paris target climate goals is becoming implausible^[89], global cryosphere losses are mounting^[90], water management is becoming more challenging as stream flows around the world are in severe decline^[91], and the number of hungry people has been growing since 2015^[92]. Yet field work to solve local, regional, and global problems will continue at Honghe and in multiple communities and research sites around the world. The vision of the Mountain Futures Action Plan is ambitious in linking so many local threads of social-ecological systems together, while also seeking connections to the GBF. But this is what is required to implement transformative changes necessary to meet the challenges of the Anthropocene^[93]. From smallholder farmers to urban consumers and from montane agricultural lands to highlands protected areas, interdisciplinary values and actions that connect people with nature are required to move the world toward a sustainable future.

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Conflict of interest

The authors declare that they have no conflict of interest.

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