Title

Low-Carbon Frontier: Small Hydropower and Logics of Green Development in China

Author

Harlan, Tyler

Publication Date

2017

UNIVERSITY OF CALIFORNIA

Los Angeles

Low-Carbon Frontier:

Small Hydropower and Logics of Green Development in China

A dissertation submitted in partial satisfaction of the
requirements for the degree Doctor of Philosophy
in Geography

by

Tyler Ross Harlan

2017

ABSTRACT OF THE DISSERTATION

Low-Carbon Frontier:
Small Hydropower and Logics of Green Development in China

by

Tyler Ross Harlan
Doctor of Philosophy in Geography
University of California, Los Angeles, 2017
Professor C. Cindy Fan, Chair

The question of how to achieve 'green' development – to maintain economic growth without the trade-offs of ecological degradation or carbon emissions – has long perplexed theorists of development and environmental change. Yet most studies analyze green development as applied to industrialized economies or international aid projects; fewer examine how it is interpreted and implemented in the Global South, especially in resource-rich areas, even as many countries chart their own development path distinct from that of the Global North. This dissertation addresses this issue by examining the political economy and socio-environmental impacts of small hydropower (SHP) in China, the country's most widespread renewable energy technology. At its core, it seeks to explain a seeming paradox: that while the government promotes SHP abroad as a Chinese model of green development, it is actively restricting further SHP expansion at home. Using conceptual and methodological tools from economic geography, political ecology, and development studies, I ‘follow the technology’ from policy design in Beijing, to implementation in China’s southwest Yunnan province, to export abroad through international training workshops in Hangzhou. In doing so, I unearth the logics and politics that shape when, where, and how green development policies and technologies are designed and used, and the economic and environmental consequences that they entail.

Based on fourteen months of fieldwork across six research sites, this dissertation finds that the function of SHP has changed constantly in different times and places, from rural electrification and industrialization, to conservation and national carbon mitigation. I argue that these changes reflect shifting state logics of green development, which have evolved from a focus on rural poverty alleviation to national low-carbon growth. Through new policies and energy subsidies, the state has re-framed rural southwest China as a ‘low-carbon frontier’, generating rapid and uncoordinated growth in SHP construction since the early 2000s. Yet I also found local conflicts between electricity generation and other natural resource uses, such as irrigation, forest conservation, and water storage, which have negatively affected rural livelihoods and agricultural yields. Moreover, while SHP is promoted as a substitute for dirty fuels, I found that it propelled an increase in mineral extraction and deforestation for charcoal production. For these reasons, and because of overcapacity, the state no longer favors SHP as a source of low-carbon value, ceding its position to solar and wind. This has driven SHP firms to new markets abroad, buoyed by state officials eager to tout China as a ‘green’ aid and investment partner. These findings thus contrast with typical accounts of low-carbon transition to highlight the spatial and environmental inequalities that shape renewable energy expansion and green development.

The dissertation of Tyler Harlan is approved.

Judith Carney

Eric Sheppard

Emily Yeh

C. Cindy Fan, Committee Chair

University of California, Los Angeles

2017

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

ATDC	Agricultural Technology Demonstration Center
BRI	Belt and Road Initiative
CDB	China Development Bank
CDM	Clean Development Mechanism
CSPG	China Southern Power Grid
EXIM	Export-Import Bank of China
GHG	Greenhouse Gas
GW	Gigawatt
HRC	Hangzhou Regional Center for Small Hydropower
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt Hour
ICOLD	International Commission on Large Dams
ICSHP	International Center for Small Hydropower
IPCC	Intergovernmental Panel on Climate Change
MW	Megawatt
MWh	Megawatt Hour
MWR	Ministry of Water Resources
NDRC	National Development and Reform Commission
NGO	Non-Governmental Organization
PV	Photovoltaic
SFA	State Forestry Administration

SHP	Small Hydropower
SLCP	Sloping Land Conversion Program
TVE	Township and Village Enterprise
TWh	Terawatt Hour
UNEP	United Nations Environment Program
UNIDO	United Nations Industrial Development Organization
WCD	World Commission on Dams
YPG	Yunnan Power Grid

A NOTE ON 'GREEN' TERMINOLOGY

What does it mean to call something 'green'? At its most basic, to be 'green' is to be environmentally sustainable, to reduce one's impact on the natural world. Yet such a definition quickly runs into problems. For what does it mean to be 'sustainable'? Does 'green' refer to an improvement in ecological conditions (such as pollution reduction), or merely to technologies or actions that cause minimal ecological harm? How is 'green' performance to be measured, by whom, and at what scale of analysis? And can something that is considered 'green' in one location have negative environmental impacts in another?

These questions are of upmost importance for studies of development and environmental change. Terms like 'green development' are engrained in the global lexicon, used to describe everything from renewable energy generation, to biodiversity conservation, to carbon trading. Like sustainable development, green development is both pervasive and vague, allowing disparate governments, institutions, and interest groups to construct their own definitions and indicators of progress. Some scholars point out that this ambiguity can be useful, because it can facilitate broad agreement on the need to reduce the ecological impacts of growth (Robinson, 2004, p. 374; Williams and Millington, 2004). Yet 'green development' discourse can also be co-opted by powerful actors to promote their own goals, some of which might not be very 'green' at all (see Bernstein, 2002; Sneddon et al., 2006). To use these terms, then, is to contribute to a particular vision of how environmental sustainability is to be defined, enacted, and evaluated, and how it is to be balanced with 'development'.

This dissertation aims to provide a critical geographical account of green development in China. By critical, I mean starting with the recognition that 'green' and 'development' are socially constructed concepts, shaped by power relations and ideologies that serve the interests of particular groups (Adams, 2009; Banerjee, 2003; Lélé, 1991). By geographical, I mean that the social construction of green development is embedded in specific times, places, and scales, which in turn influence how and where actual green development interventions are delivered. And finally, building on longstanding work in economic geography and development studies, I understand development to be a spatially uneven process, one that enriches some regions and people and impoverishes others (Escobar, 1995; Ferguson, 1994; Sheppard, 2011; Smith, 1984). The question is therefore not just *what* counts as 'green' or 'development': it is also about *where* and *for whom*.

Yet while one must recognize the social construction of 'green' terms, it is not possible to avoid using them. As such, in this preface, I put forward basic definitions for some of the terms in this dissertation. These definitions are not meant to preclude critical analysis, but merely to establish a baseline and common understanding for the discussion that follows.

<u>Green development</u> refers to a process of economic development without environmental destruction (Banerjee, 2003, p. 144). It is used widely, ranging from small-scale conservation and poverty alleviation projects to national or international carbon mitigation schemes. Definitions of green development may also include a social equity component (see Giddings et al., 2002). Green development is a favored term in Chinese official discourse (translated as 绿色发展).

<u>Sustainable development</u> is often interchangeable with green development and tends to be used in similar settings (see Adams, 2009). The most often-used definition comes from the 1987 World Commission on Environment and Development, also known as the Brundtland Report, which states that sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (1987, p. 43). This definition presents the three aims of sustainable development as mutually reinforcing:

improvement of human well-being, more equitable distribution of resources, and development that ensures ecological integrity across multiple scales (Sneddon et al., 2006, pp. 255–256)

Green economy is a more recent term that uses a liberal economic language of ‘natural capital’ and ‘ecosystem services’. According to the United Nations Environment Program (UNEP) 2011 report *Towards a Green Economy*, the green economy “is low carbon, resource efficient, and socially inclusive. In a green economy, growth in income and employment should be driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services” (2011, p. 16). This term tends to refer to policies or programs at the regional, national, or international scale.

Green economic value, unlike the terms defined above, has its roots in eco-Marxism and Marxist political economy. O’Connor (1998) and Smith (1984), for example, argued that capitalism transformed human/environment relations by extending Marx’s exchange-value form to the raw material of nature, thus incorporating it into circuits of capital. A contemporary example of this phenomenon is the use of the term ‘natural capital’, which refers to the economic value of natural entities such as streams, forests, and coastline. This dissertation uses green economic value to refer to both the monetary value embedded in ‘natural capital’ and to the monetary value produced through green commercial activity, such as renewable energy generation or managed landscapes.

Green industry, according to the United Nations Industrial Development Organization (UNIDO), is industry that is low-carbon, resource efficient, and environmentally benign (2010). This dissertation broadens this definition somewhat, describing a green industry as commercially-oriented firms that generate economic value through environmental activities (such as renewable electricity generation). Here, I leave open the possibility that green industries might not be ‘green’ at all, even though they are involved in sectors that are part of the green economy (see above).

ACKNOWLEDGEMENTS

It is difficult to convey my gratitude to the many scholars, colleagues, and friends who helped bring this dissertation to fruition. Research and writing can sometimes feel solitary, especially when the final product is many years in the distance. The extraordinary wealth of support that I have experienced has made this process bearable, and quite often enjoyable. I hope I can repay even a small amount of this debt as a future scholar and teacher.

My dissertation committee deserves immense credit for guiding me through many years of research, fieldwork, and writing. I am indebted to my committee chair, Cindy Fan, for her commitment and deep investment in my dissertation research and academic career. She taught me to state the essence of an argument, defend claims with evidence, and position myself as a scholar. Her ability to balance research, mentorship, and the responsibilities of a Vice-Provost role is a model for my career. Eric Sheppard, who arrived at UCLA the year I started this research, spent many hours helping me work through difficult arguments and enable this dissertation to speak to them. I hope to emulate even a small measure of his scholarly commitment to social justice and generosity to students and colleagues. Judy Carney offered sage advice on research design and the importance of coupled social and ecological analysis; her pioneering work in political ecology is an inspiration. And Emily Yeh gave far more of her time and experience than could reasonably be expected of an external committee member, including meeting up while in Yunnan. I would never have embarked on this research if not for her scholarly example.

I am fortunate to be surrounded by so many smart, collegial, and generous colleagues in the UCLA Department of Geography. I entered the program with an outstanding cohort of geographers, with whom I shared hours of long discussion, innumerable edits to proposal and paper drafts, and many happy hours at the pub. Dylan Connor, Katie Glover, Sara Hughes, and

Kate Willis will remain close friends and role models long after graduation. Across campus, C.K. Lee in the Department of Sociology offered timely critiques that were turning points in my research, and Susanna Hecht gave me the early encouragement I needed to delve into environmental research. And outside of campus, I would never have completed the thesis if not for the many trail miles logged with good friends in the mountains, from summers on the Sierra High Route, to Tuesday morning time trials in Temescal Canyon.

I owe a great deal to the many partners, colleagues, and friends in China who generously gave of their time and expertise. In Beijing, Tang Xiaoyang of Tsinghua University took me under his wing as a Fulbright scholar and provided crucial advice and introductions as my project developed. Ren Peng of the Global Environmental Institute taught me the basics of environmental policy and NGO work in China; our friendship (and Mustang racing) is one of the best gifts this dissertation has given me. Xu Jintao of Beijing University shared his deep knowledge of forest reforms and survey design. In Hangzhou, Zhang Xu and Liu Xin warmly welcomed me into the world of small hydropower consulting and training; I will never forget their hospitality to a foreign researcher. They are public servants in every sense, and their work has a far-reaching impact that I can only seek to emulate.

In Yunnan, Xu Rui of Yunnan Normal University was a wonderful project partner. His research on small-scale renewable energy challenged me to be solutions-focused in my work. My research assistant, Li Jienan, is a scholar far beyond his years; I learned much from his ability to quickly build rapport and get to the essence of an interview. My four survey assistants, the 'Dream Team', would put most of us PhD students to shame with their efficiency. I miss our dinners in the town square after a long day of data collection. My partnership with Yunnan Normal University was only possible thanks to He Jun, who I continuously looked to for validation and advice. Our

friendship will continue to bring me back to Yunnan. At the Yunnan Academy of Forestry, Ma Jianzhong provided office space, plenty of tea, and much conversation about the possibilities and obstacles of environmental research in China. The Kunming Institute of Botany welcomed me as a visiting scholar with a desk and good company, many of whom are now spread throughout the world. Ou Xiaokun convinced me to shift my project and inspired me to work in Xinping county. And of course, I thank the many government officials, investors, resource managers, and farmers who graciously shared their insights and experience with me.

I received generous financial assistance for this research through the Fulbright U.S. Student Program, the Henry Luce Foundation–ACLS Program in China Studies Predissertation Fellowship, the UCLA International Institute Fieldwork Fellowship, the UCLA Center for Chinese Studies Duthie-Secchia Fellowship for Research on Contemporary China, and a fieldwork grant from the Energy and Environment Specialty Group of the American Association of Geographers. I am grateful to Thomas Hennig for allowing me to reproduce figures from our co-authored manuscript; it is a pleasure working with such a knowledgeable and generous scholar.

This dissertation has been a long journey. My wife Andrea has been with me at every stage: encouraging, cajoling, and putting up with my long absences. I’m so lucky to have such a smart, caring, and supportive partner. And to my parents and siblings: you continue to inspire me.

VITA

Tyler Harlan
Department of Geography **|** University of California, Los Angeles

Education

PhD Candidate	Geography, University of California, Los Angeles, Expected 2017 Dissertation: *Low-Carbon Frontier: Small Hydropower and Logics of Green Development in China*
MPhil	Resource Management and Geography, University of Melbourne, 2009 Thesis: *Entrepreneurship and Development in Urumqi, Xinjiang Uyghur Autonomous Region*
BA	Anthropology & Asian Studies, *summa cum laude*, Vanderbilt University, 2006

Publications

2017	Shades of green energy: Geographies of small hydropower in Yunnan, China and the challenges of over-development. [with Thomas Hennig]. Forthcoming in *Global Environmental Change*.
2017	A ‘green’ development model: Transnational model-making in China’s small hydropower training programmes. *Area Development and Policy* 2 (3): 251-271.
2016	Fringe existence: Uyghur entrepreneurs and ethnic relations in urban Xinjiang. In Hillman, B. and Davis, G., eds., *Ethnic Conflict and Protest in Tibet and Xinjiang: Unrest in China’s West*. New York: Columbia University Press, pp. 179-200.
2012	New Uyghur corporate entrepreneurs in Urumqi, China. *Central Asian Survey* 31 (2), 175-191. [with Michael Webber]
2009	Private sector development in Xinjiang, China: A comparison between Uyghur and Han. *Espace Populations Sociétés* 2009/3, 407-418.

Fellowships, Grants, and Awards

2017	Dissertation Year Fellowship, UCLA

	American Association of Geographers (AAG) Energy and Environment Specialty Group Earl Cook Student Paper Award
	AAG China Geography Specialty Group Student Paper Award
	AAG Asian Geography Specialty Group Student Paper Award
	AAG Energy and Environment Specialty Group Fieldwork Award
	AAG Asian Geography Specialty Group East Asia Travel Award
	UCLA Political Sociology and the Global South Conference Best Paper Award
	UCLA International Institute ‘Going Global’ Conference Best Paper Award
	Institute of Australian Geographers Outstanding Student Presentation
	Institute of Australian Geographers Postgraduate Travel Grant
	Regional Studies Association Travel Grant
2016	UCLA Duthie-Secchia Fellowship for Research on Contemporary China
	UCLA Collegium of University Teaching Fellows Award
	NSF International Geographical Union Travel Grant
	Economic Geography Summer Institute, U. of Kentucky
2015	United States Fulbright Fellowship, IIE
	Henry Luce / ACLS Program in China Studies Predissertation Fellowship
	UCLA Hiroshi Wagatsuma Graduate Fellowship
2014	UCLA Graduate Research Mentorship Fellowship
	Foreign Language and Area Studies Fellowship in Chinese, Academic Year
	UCLA International Institute Fieldwork Fellowship
	UCLA Affiliates Graduate Fellowship (and 2013)
2013	U.S. State Department Critical Language Scholarship in Chinese
	UCLA Graduate Summer Research Mentorship Fellowship
	UCLA International Institute Recruitment Fellowship
2007-08	Australia International Postgraduate Research Scholarship
2006	Rotary International Kirchner Scholarship
	Southeastern Conference H. Boyd McWhorter Student-Athlete Scholarship
	John T. and Lizzie Allen McGill Award for Leadership, Vanderbilt University
	Scholar-Athlete of the Year, Vanderbilt University (and 2005)

CHAPTER 1

Introduction: On the Low-Carbon Frontier

1.1 Renewable energy on China's frontier

In the last decade, China has built renewable energy installations at a rate matched nowhere else in the world. Between 2006 and 2016, the country added 258 gigawatts (GW) of renewable energy capacity, and now boasts 15% of all systems installed worldwide[1]. In the wake of the 2017 U.S. withdrawal from the Paris Climate Agreement, President Xi Jinping declared China's intent to lead the world in renewable energy, with plans to spend US$380 billion on new systems by 2020 (Forsythe, 2017). The government also announced a proposal to invest in renewable energy in other countries through the Belt and Road Initiative (BRI), an overarching strategy for promoting regional economic integration in the Asia-Pacific region (Xu, 2017). Despite these investments, though, China's economy is still largely comprised of energy-intensive and export-oriented manufacturing, creating toxic levels of air, soil, and water pollution. The national pivot to renewable energy is therefore both an economic strategy and an environmental imperative: what the national 13th Five Year Plan (2016-2020), in its first paragraph, calls 'green development' (NDRC, 2016a, p. 1).

In China's southwest Yunnan province, far from Beijing, renewable energy installations are being constructed near villages only recently connected to the national grid. Yunnan is part of a loose grouping of provinces and autonomous regions known as 'western China', which cover more than half of the national territory (see Fig. 1.1). Western China looms large in the national consciousness, as a land of vast mountains and deserts, unruly ethnic minority groups, and natural

---

[1] China had approx. 300 GW of renewable energy installed capacity (not including large hydropower) at the end of 2016; the total global installed capacity was approx. 2,000 GW at the end of 2016 (China Electricity Council, 2016; REN21, 2006, p. 5).

resource wealth. It has long been viewed in Chinese society as economically and socially backward, a 'frontier' in need of development through state intervention. The region contains much of China's forests and grasslands, and suffers from deforestation and land degradation, problems that the state blames on poverty-stricken farmers (Sun et al., 2006; Xu, 2006). As a result, since the late 1990s, the state has invested in major poverty alleviation and 'ecological construction' initiatives in western China that incentivize farmers to conserve forests, including by replacing fuelwood use with electricity powered by small-scale renewable energy. But because western China is rich in resources – particularly rare earths, nonferrous metals, and large hydropower – the state has also ramped up mineral extraction and energy generation to supply economies in the eastern provinces. New renewable energy installations offer a way to achieve both goals: of conservation-based rural development in western China, and of low-carbon electricity generation for eastern China. The 'frontier', then, is at the center of China's green development transformation.

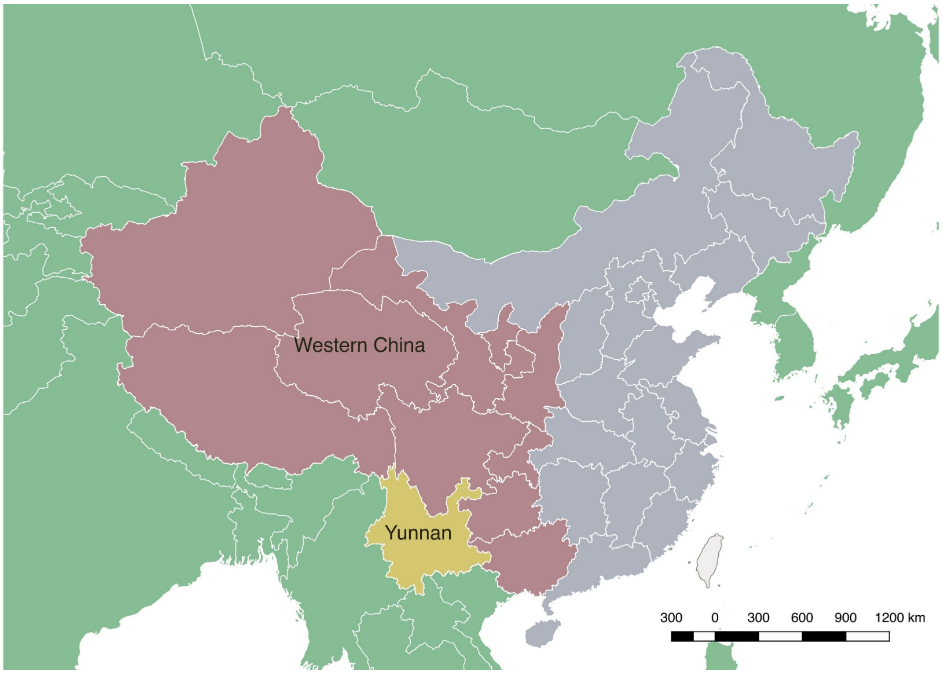


Fig. 1.1: *Yunnan and western China*

This dissertation explores the geography of China's green development through the lens of renewable energy. Its main claim is that renewable energy systems do not necessarily produce environmental and economic benefits for all. They are shaped by the priorities of and struggles between state, private sector, and community actors at different times, spaces, and scales. These struggles are not just about the impacts of renewable energy on local resource use, livelihoods, and economies. They are also about the green development function that renewable energy is supposed to serve, and the regions and people that are meant to be its main beneficiaries. Put simply, renewable energy is a key arena of struggle and negotiation over different 'green' and 'development' priorities. This dissertation investigates how these priorities differ over time, space, and scale in China, as well as their consequences for communities and regions on resource frontiers.

Yet, this dissertation does not merely conclude that geography shapes green development and its outcomes on the frontier. It also examines how certain types and uses of renewable energy – and by extension, certain ideas about green development – become engrained in policy and packaged as a model for others. I call this packaging of technologies, policies, and practices an act of green model-making, in which different groups and places vie to define their own visions of green development and how they should be achieved. Much of this green model-making occurs in a domestic context, but Chinese state and private actors also promote renewable energy to other countries as an example that can be followed. By tracing the path of renewable energy from policy, to implementation, to export as a model, this dissertation also aims to link the struggles over green development on resource frontiers to China's growing influence in the global green economy.

1.2 The low-carbon frontier

I focus on the 'frontier' in this dissertation as both the site of renewable energy and as a broader framework for parsing the geography of green development. In China and elsewhere, the frontier tends to have a dual meaning. On one hand, it is understood as suffering from a lack of development; a place that lags behind more economically dynamic regions. On the other hand, it is believed to be a land of opportunity, of resource wealth that promises great riches to those who can extract it (Woodworth, 2017). While these definitions of the frontier have some basis in reality – such as low population density, or the presence of mineral deposits – they are also discursive constructs that legitimize certain development policies and investments. In western China, these have included state subsidies for poverty alleviation programs alongside investments in resource extraction – interventions that are framed as both frontier development and as part of national development. This frontier is not stuck in one place; it can shift to new regions when land becomes settled and 'developed', when certain resources are depleted, or when new technologies render some frontier-based economic activities obsolete (Barbier, 2005). Such dynamics often lead to 'boom and bust' cycles that upend local economies, livelihoods, and environments (Barney, 2008; Bradbury, 1988).

With the rise of 'green' development discourse and policy, the frontier has also become a space of conservation. Frontier landscapes are often framed as more 'natural' than densely settled regions, and thus more worthy of protection (Barney, 2008; Koninck, 2000). Many hold special status as 'biodiversity hotspots', nature reserves, or national parks. More and more, they are also described as stores of 'ecosystem services' that must be protected so that economic growth can continue (Engel et al., 2008; Ferraro, 2001; Jack et al., 2008). Yet, these environments are also under threat from deforestation and forest degradation caused by agriculture, ranching, and/or extraction (Hecht, 1993; Rodrigues et al., 2009). For some scholars, these environmental pressures are the result of structural poverty in the Global South that forces peasants to degrade resources (Dasgupta, 1995; World Bank, 2007, p. 9). Indeed, a common refrain is that ecological degradation is the result of underdevelopment, as disadvantaged groups struggle to overcome extreme conditions of poverty (Adams, 2009; Lélé, 1991, p. 612). To combat these problems, states and multilateral institutions have developed payment for ecosystem services projects that seek to combine poverty alleviation with conservation, known as 'conservation-based rural development'. Some of these programs – such as those serviced through the Clean Development Mechanism (CDM) of the Kyoto Protocol[2] – are funded by emissions trading schemes in the Global North.

In China, these concerns over environmental protection are often in conflict with other frontier development activities like mineral extraction and energy generation. The central state has set aside much of the rural west for 'ecological function zones' where economic activities are not allowed (China State Council, 2016). Areas with natural and scenic beauty are also being protected as nature reserves or national parks (Zinda, 2014). In other cases, however, environmental protection and development are seen as mutually reinforcing (Chen et al., 2017). In China, the state has used this discourse of green development to frame and combine anti-poverty and rural development programs with conservation. One of these, known as the Sloping Land Conversion Program (SLCP), is the world's largest payment for ecosystem services program that subsidizes poor farmers to plant trees on barren hillsides – a literal 'greening' of the frontier (Bennett, 2008; J. Liu et al., 2008).

Large-scale renewable energy offers a different kind of green development than that of ecological function zones or the SLCP. Indeed, it is based on an entirely different state logic. Programs like the SLCP seek to drive poverty alleviation and local economic development through conservation; they do not promote (or even allow) resource extraction activities that are

---

[2] CDM 'offsets' are designed to allow industrialized countries to reduce their CO_2 emissions under the Kyoto Protocol by investing in renewable energy and climate mitigation projects in low-income countries (Erlewein and Nüsser, 2011; Teng and Zhang, 2010; Hepburn, 2007).

ecologically destructive. From the perspective of the Chinese central state, such programs preserve parts of western China as an environmental buffer zone so that industrial economic activity can occur elsewhere. Renewable energy, in contrast, is itself an industrial economic activity, because it generates electricity for industrial consumption. It is 'green' because it has a much smaller ecological footprint than fossil fuels, measured in terms of localized landscape impacts and the reduction of greenhouse gas (GHG) emissions. Here, the state logic of renewable energy is that it produces low-carbon electricity for national green development. Such a logic effectively turns the frontier into a generator of low-carbon economic value for the state: it becomes what the title of this dissertation calls the *low-carbon frontier*.

I use this analytic of the low-carbon frontier because it captures how conservation-based rural development is accompanied (and sometimes supplanted) by carbon mitigation for national or global development. Because it can be detected and measured – though not easily – carbon is an ideal green commodity, which can be assigned a value, traded, and even securitized (Boyd et al., 2011; Knox-Hayes, 2013; Lövbrand and Stripple, 2011; Mol, 2012). As a 'fictitious' commodity (Huber, 2016; Lansing, 2012), it can also circulate through national and global markets, even though it is produced, mitigated, and sequestered in specific places. The low-carbon frontier highlights how certain landscapes are framed not just as stores of traditional resource wealth, but as stores of low-carbon value. Like other resources, low-carbon value must be located and extracted for its economic potential to be realized. Renewable energy is the primary vehicle through which such value is extracted and transferred to other places. As such, though renewable energy is certainly 'green', it shares similarities with traditional frontier extractive industries that primarily benefit investors and consumers elsewhere. Moreover, because carbon is a commodity, it is also subject to fluctuations in feed-in tariffs and carbon offset pricing due to state policy and broader dynamics in global markets. The low-carbon frontier, then, often experiences the unstable economic growth that characterizes traditional resource extraction and energy generation regions.

Recent work in geography abounds with studies of green and low-carbon development, primarily split into two strands. The first, situated in economic geography, examines the political economy of low-carbon industrial transition, emphasizing in particular the role of the state and of private institutions and markets (Gibbs, 1996; Liverman, 2004; While et al., 2010). This work focuses on cities, regions, and national economies in the Global North. It is concerned with issues of energy transition, industrial restructuring, and the making and functioning of markets. The second strand, situated in development studies and political ecology, investigates the power dynamics and impacts of green and low-carbon development programs on communities and environments (Dauvergne and Neville, 2010; Fletcher, 2010; Kull et al., 2015). This work is multi-scalar – linking local outcomes to national and international processes – but is often situated in the Global South. The best of this recent work aims to connect low-carbon transformation in the North with green development programs in the South. Studies by Bumpus and Liverman (2011, 2008), Simon (2010), and McAfee (1999) show how the ability of Northern firms to 'offset' GHG emissions through voluntary and compulsory schemes (such as the CDM) has turned rural areas in the South – often areas seen as 'frontiers' – into protectors of low-carbon value for others. Such regions may indeed be thought of as low-carbon frontiers, where communities and landscapes are buffeted by economic and environmental decisions made in other places and scales.

This dissertation builds on this work, but also differs from it, because I focus on the low-carbon frontier as a site of value production. Studies of offsets, though important, capture only a small (and dwindling) aspect of the geography of green development. They also primarily examine the relationship between the Global North and Global South, without peering into the sub-national processes that determine where offset programs are situated, or relations between countries in the Global South. By analyzing renewable energy – perhaps the largest 'green' economic sector in the world – I highlight the essential role of frontier regions in both reducing GHG emissions and driving regional and national economies. Moreover, by positioning renewable energy as an extractive industry – albeit a much greener one – I show how and why clean energy generation can further entrench existing spatial and class-based inequalities on resource frontiers. This dissertation is thus a challenge to the narrative of green development and low-carbon transition as inevitable processes with defined end points. Green development is, instead, an uneven geographical process, with environmental and economic benefits accruing to some places and groups and not to others. These insights, I believe, can shed light on the inequalities and impacts of green development policies more broadly, in China and elsewhere. I hope they can also be used to design more equitable green development programs, including those based on renewable energy.

1.3 Small hydropower in China

To make these arguments, I focus on one specific renewable energy technology: small hydropower (SHP). In China, SHP refers to plants of up to 50 MW installed capacity[3]; in most other countries, the upper limit is 10 MW[4]. SHP constitutes about one quarter of all hydropower in China, and with more than 47,000 stations, it is the oldest and most widespread renewable energy in the country (UNIDO and ICSHP, 2016). In Chinese, SHP is often referred to as 'rural hydropower' (农村水电), because it is traditionally approved and managed by local governments[5] in rural areas of the

---

[3] As a comparison, the Three Gorges Dam has 22,500 MW installed capacity.

[4] 'Installed capacity' refers to the amount of electricity that a plant can produce under ideal conditions. For example, a 1 MW plant operating for an hour generates 1 megawatt hour (MWH) of electricity.

[5] Throughout this dissertation, I use the term 'local government' to refer to the state apparatus at the prefecture (or prefecture-level city) and county levels.

country. Today, it is China's most mature renewable energy industry, with a total of 74.3 GW of installed capacity, making up 4.4% of the country's total energy portfolio (Fig. 1.2). China's installed SHP capacity is comparable to the *entire* installed hydropower capacity of Canada or the U.S., which rank third and fourth in the world in nations with the most installed hydropower capacity (Hennig and Harlan, 2017). Moreover, SHP is a more efficient technology than solar or wind, and it has the highest annual generation in terawatt-hours (TWh) of all renewable energy sources in China (excluding large hydropower) (Fig. 1.3).

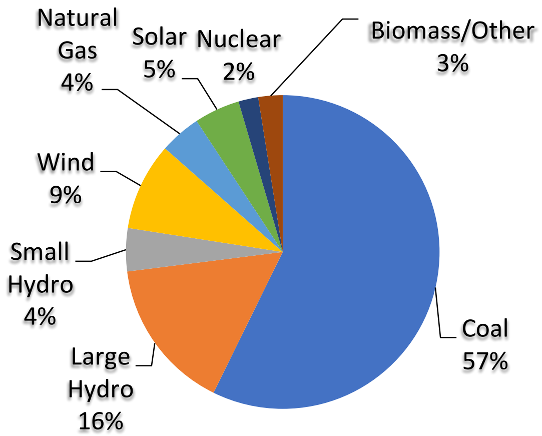


Fig. 1.2: *Percent* ***installed capacity*** *of different energy sources in China, December 2016 (China Electricity Council, 2017; EPS China Data, 2017)*

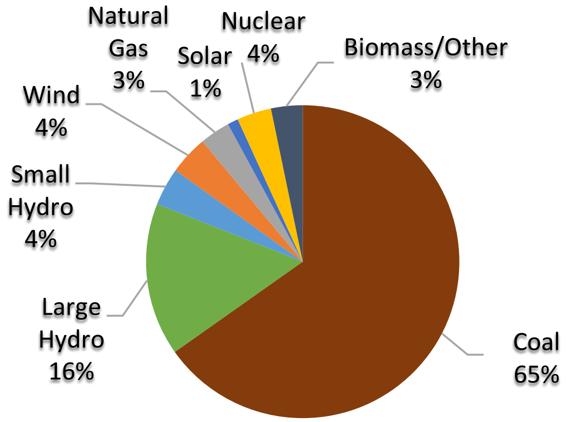


Fig. 1.3: *Percent* ***total annual generation*** *of different energy sources in China, December 2016 (China Electricity Council, 2017; EPS China Data, 2017)*

The technology of a typical SHP plant is different than that of a large hydroelectric project. Most SHP schemes, and 90% of SHP plants in China, are diversion-type run-of-river projects that do not have a dam. Instead, they divert water from a stream into a canal that directs water down an incline to the powerhouse, where the flow drives the turbines (Fig. 1.4). Since diversion-type run-of-river schemes do not have their own reservoir, they typically cannot store water for more than a few days, and can only generate electricity when the flow volume is sufficient to operate the turbines. However, some diversion-type schemes are situated along the same river in a cascade, with the first (and highest in elevation) plant sitting behind a dam and reservoir that can regulate streamflow for all downstream plants. In the case of SHP cascades, water that is diverted into the first plant may never re-enter the primary stream; instead, it flows through a canal directly from one plant to the next, and potentially into a larger trunk river.

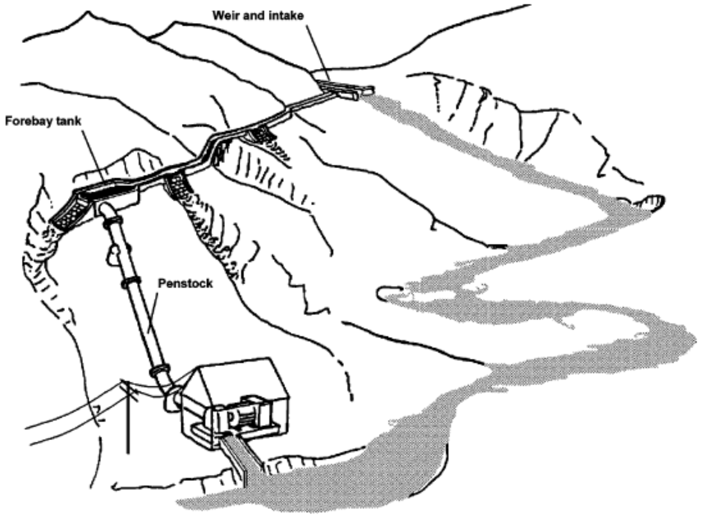


Fig. 1.4: *A typical diversion-type run-of-river hydropower scheme (copied from Paish 2002: 541)*

What sites are suitable for SHP plants? It goes without saying that SHP require a steady water supply, especially diversion-type run-of-river plants. But SHP also need a combination of swift flow and a high drop from the forebay tank into the powerhouse; the drop is called a 'head' (Fig. 1.5). The installed capacity (P) of an SHP plant in kilowatts (kW) is given by the equation

$$P = A * H * Q$$

Where H = head (in m), Q = discharge flowing through the turbine (in m^2/sec), and A = coefficient of between 7-8.7, which is the product of the efficiency of the turbine, efficiency of the generator, and the acceleration of gravity (µturbine x µgenerator x 9.81 m/sec). In general, SHP plants tend to be constructed near steep slopes to take advantage of a high head ranging between 100-1,000m. Plants may also be built on larger rivers with a head of only 1-10m, but these generate much less power per m^2/sec of flow. The type of turbine used depends on site specifications, and are divided into reaction turbines (such as Francis and Kaplan) and impulse turbines (Pelton and Turgo).

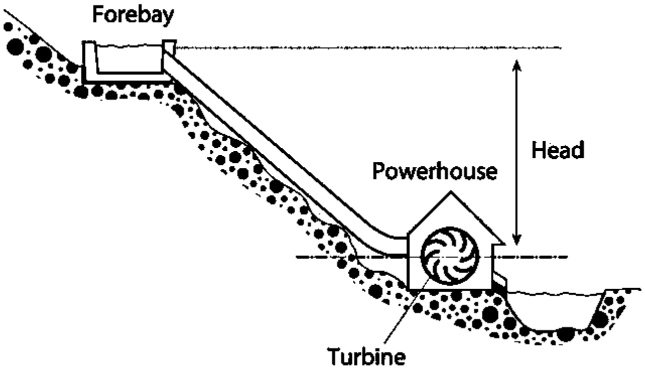


Fig. 1.5: *The 'head' of an SHP plant (copied from United States Department of Energy, 2017).*

Because most SHP plants require a high head and swift flow, they are mainly located in mountainous regions that are rich in water resources. In China, these regions are concentrated in the southeast and southwest of the country. The southeast includes the provinces of Guangdong, Fujian, Jiangxi, Hunan, and Zhejiang. The southwest includes the provinces of Guangxi, Guizhou, Sichuan, Yunnan, and Tibet Autonomous Region. Fig. 1.6 shows the total hydropower generation (large and small), theoretical SHP potential, and installed SHP capacity for all provinces in China. Note that Yunnan province has the highest installed SHP capacity in China (11.4 GW at end 2015), with Sichuan province a close second.

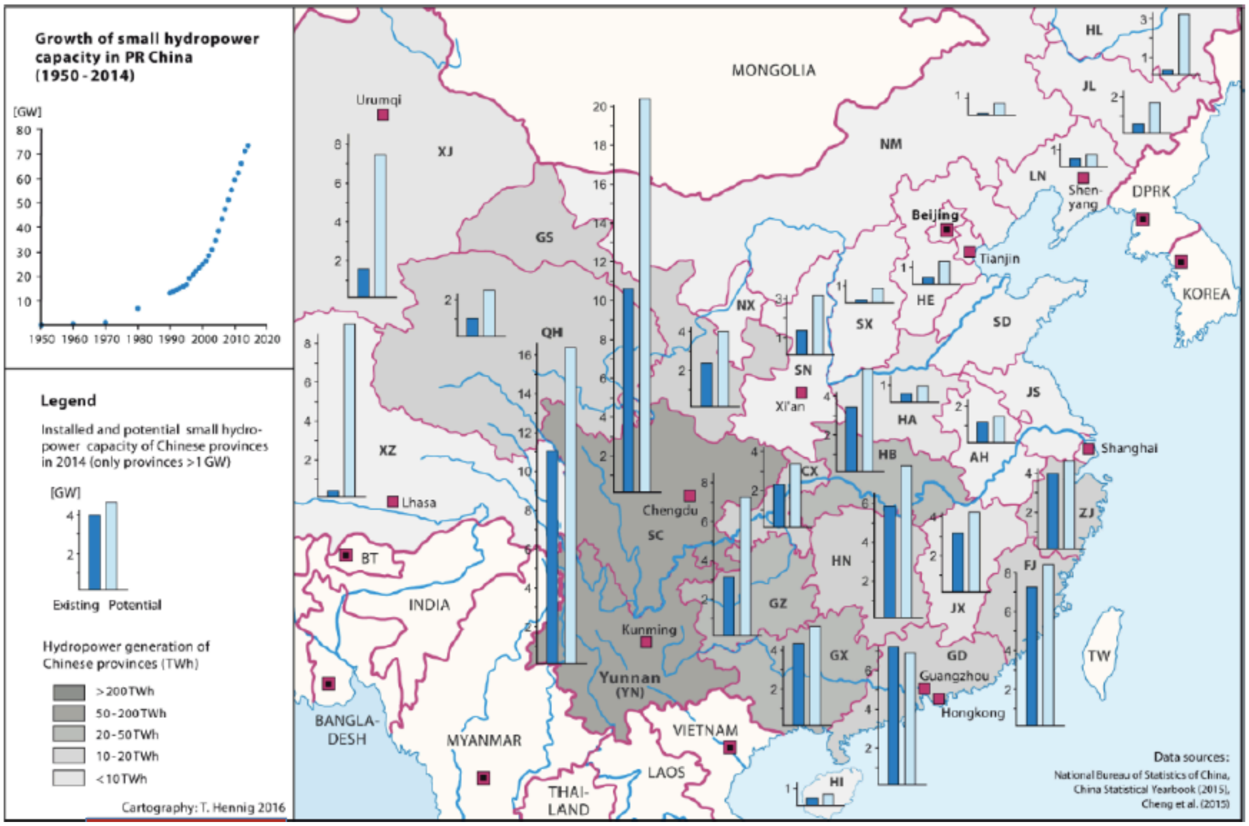


Fig. 1.6: Hydropower generation and potential / installed SHP capacity (>1 GW) of Chinese provinces at end 2015 (copied from Hennig and Harlan, 2017)

SHP is generally considered to be a 'green' energy source since it does not have the environmental footprint of large hydroelectric projects (Li et al., 2005; Okot, 2013). This is particularly the case for micro (<100 kW) projects, and for stand-alone SHP plants of a relatively low installed capacity (<10 MW). However, in China, where the definition of SHP includes plants of up to 50 MW, the effects of SHP cascades on stream flow can be much greater. Kibler and Tullos (2013), for example, find that extensive SHP development in the Nu River watershed has impacts on stream flow, water quality, and habitat protection (including adjacent conservation areas) that are greater than those of large dams. Other studies report that multiple diversions of flow from the primary stream can lead to dewatered river sections during the dry season (Baker et al., 2011; Hennig et al., 2013). In China, interbasin diversion is also widely used; this refers to diverting water from a neighboring basin to achieve a higher head (the vertical drop into the powerhouse) or to obtain additional water flow. These interbasin diversions can have significant effects on stream flow and aquatic species (Shao et al., 2003).

1.4 Small hydropower and the low-carbon frontier

Why focus on small hydropower in this dissertation, instead of solar, wind, or large hydropower? The main reason is that SHP has a much longer history than other renewable energy sources in China. It captures, in one technology, the different functions that renewable energy has served over time, and the places and communities designed to be its main beneficiaries. The first SHP plant in China was constructed in 1911 near Kunming, the capital of Yunnan, and was specifically designed to provide electrical power for rural households. Throughout the Maoist period, and into the 1980s, SHP was a primary means for rural electrification in southern China, and is rightfully considered a successful example of poverty alleviation and rural development (Hicks, 2004; Luo and Guo, 2013; Yang, 2003, 2011). The central government also constructed large hydropower plants during this period, but these only supplied industries and communities connected to the national grid. SHP, in contrast, could be supplied through local or regional grids[6]. By the early 2000s, SHP had been labeled as a tool of green development, because it is believed to replace peasant fuelwood collection with electricity, thus reducing deforestation (HRC, 2009). SHP plants were often constructed in the same areas targeted by the Sloping Land Conversion Program.

---

[6] These include (from smallest to largest): agricultural, township, county, and prefectural grids.

Since the mid-2000s, however, the main purpose of SHP has changed. It is no longer primarily used to generate electricity for rural households and protect forests. Instead, SHP has been framed as a renewable energy technology, tasked with generating low-carbon electricity to support China's green industrial transformation. Local governments took advantage of favorable policies to approve thousands of new grid-connected plants, many of which were much larger than those previously constructed. Private investors rushed to purchase SHP development rights and build stations exclusively for the sale of electricity to the grid. Together, local officials and investors also constructed new industrial facilities – such as mining, mineral processing, and manufacturing – to consume excess electricity generated by SHP (Hennig and Harlan, 2017). Especially during the late 2000s, SHP developers could generate and sell carbon offsets through the CDM. SHP has therefore become a green industry, scaled-up and privatized to compete with other energy technologies. It is caught between two green development goals: of conservation-based rural development, and of low-carbon electricity for national development.

The shift in the purpose of SHP provides insight into how the logics of state-led green development have changed over time in China. But it also reveals how green development schemes are tied to specific places and scales; they are innately geographical. Indeed, SHP has always targeted rural, frontier regions of China, first as a means of rural electrification and forest protection, and later as low-carbon energy source. During the Maoist era, and up through the 1990s, many SHP plants were constructed in southeast China, especially rural areas of Zhejiang, Fujian, and Guangdong. By the early 2000s, however, these provinces had become economic powerhouses, and SHP investment shifted to western China. Indeed, much of this new investment came *from* Zhejiang and Fujian as part of a national strategy to 'develop the west' (Shih, 2004; Zhao et al., 2012). SHP filled a real material need of generating electricity for rural electrification and development in western China, especially in places with few other industries. In doing so, SHP also bolstered the discourse of western China as backward and ecologically degraded – a place in need of green development. Thousands of SHP plants were constructed in Yunnan, Sichuan, and other western provinces, leading to a three-fold increase in national installed SHP capacity in just ten years (Fig. 1.7). Yet, while the original goals of SHP were rural electrification and fuelwood replacement, SHP is now used to generate renewable energy for sale to the grid, turning western China into a low-carbon frontier. This spatial relationship between China's east and west will likely become more entrenched through large-scale investment in wind and solar installations.

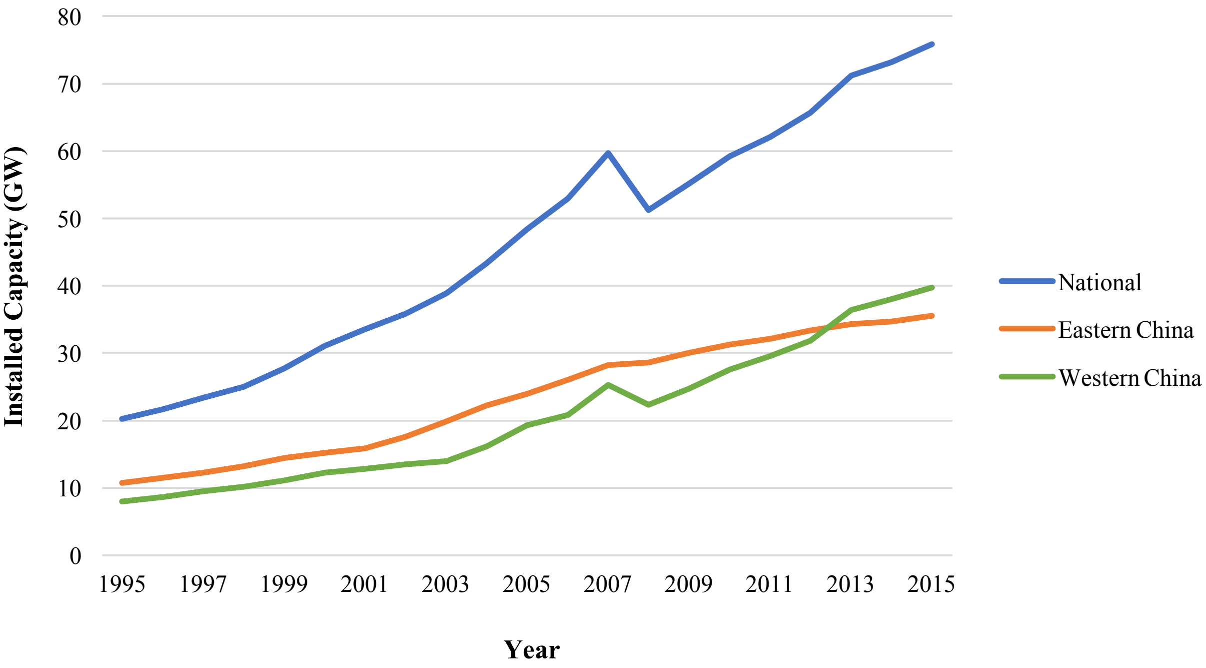


Fig. 1.7*: Installed SHP capacity of eastern and western China, 1995-2015*
(Data source: EPS China Data, 2017)

The result of the shift in the function of SHP – and the state logic that sits behind it – is that local officials and private investors in southwest China are incentivized to construct as many plants as possible. For local officials, SHP generates significant tax revenue that can be used for infrastructure, service provision, and industrial development. In Yunnan, the Nujiang and

Wenshan prefectural governments made SHP the foundation of their economic development strategy, while other prefectures (such as Yuxi) used SHP to supplement existing industries. Private operators, meanwhile, obtained an attractive return on investment from the sale of electricity, funds which were often funneled into new SHP construction. At the same time, local governments allocated too many SHP licenses and ceded river basin planning to private SHP operators. As a result, plants became larger, were situated in longer cascades, and often operated throughout the year, even during the dry season and periods of drought. Hennig and Harlan (2017) argue that SHP in southwest China is now over-developed, resulting in an oversupply of electricity that cannot be taken up by the grid. Such over-development is the outcome of national policy promoting renewable energy expansion and the political and profit motivations of local officials and investors.

The social and environmental impacts of SHP over-development are highly uneven. From a national perspective, SHP has generated thousands of TWh of renewable energy, which can reasonably be said to have replaced some coal-fired power. This is a laudable achievement. Yet the consequence of too many SHP plants is that additional power cannot be transmitted to the grid, causing stations in remote areas to heavily curtail generation during the wet season. Indeed, in 2016 the provincial governments of Yunnan and Sichuan announced new SHP restrictions that effectively prohibit any new construction. From a regional perspective, SHP has enabled an economic boom for rural areas formerly dependent on agriculture and extractive industries, which has improved the quality of life for many. Yet SHP has also been used to power new extractive industries that produce far more pollution and GHG emissions than SHP replaces. Moreover, new provincial SHP restrictions have cast the economic futures of SHP-dependent regions in doubt.

Here, SHP has operated as a low-carbon extractive industry, bringing windfall revenues during boom periods and uncertainty following a bust.

At the same time, the benefits and consequences of SHP do not affect all local actors, communities, or environments equally. The early years of SHP, up until the 1990s, saw significant improvements in rural livelihoods due to electricity access. Indeed, China is rightfully seen as a success story in promoting rural electrification through renewable energy. Even today, some plants in remote regions provide subsidized electricity through the central government's 'SHP Replace Fuelwood' program, which I found helps to reduce dependence on and use of fuelwood. However, since the function of SHP has changed to generating electricity for sale, rural households no longer receive any direct benefits. In many cases, the overdevelopment of SHP has reduced irrigation water access for farmers. Some SHP cascades also cause stream dewatering during the dry season, and the over-use of spillways during the wet season, which damages aquatic and riparian species and causes soil erosion (Baker et al., 2011; Fu et al., 2008; Shen and Diplas, 2010). Thus, the original goals of SHP to provide household electricity and protect forests have fallen by the wayside, and in some cases, have been made worse due to negative impacts from large-scale plants.

Yet, despite these serious problems with SHP on the frontier, Chinese leaders continue to promote it internationally as a green development model that other countries can learn from. They do this through two main multilateral organizations – the International Center for Small Hydropower (ICSHP) and the Hangzhou Regional Center for Small Hydropower (HRC) – which are under the auspices of the Chinese government. Chinese officials promote SHP as a 'green' technology because it helps to improve China's developmental reputation in other countries, especially in the context of the BRI. Small hydropower investors and manufacturers promote SHP because it situates the Chinese industry as an early pioneer of green development, helping it to sell goods and services overseas. Here, the ‘export’ of SHP is not just technology transfer: it is a process of green model-making, through which different ‘green’ and ‘development’ priorities are negotiated and reformulated through transnational encounters. Overseas aid and investment therefore presents a new kind of geopolitical and commercial frontier, both for traditional extractive industries and for renewable energy.

1.5 Dissertation field sites

This project uses SHP to investigate the geography of green development in China: specifically, how green development is conceptualized, implemented, and exported to other countries through aid and investment. I argue that SHP in China encapsulates the different state logics of what green development entails, and how it is to be achieved. In its early years, SHP was deployed as an off-grid, small-scale power source for villages without an electricity connection, which was later viewed as a way to replace fuelwood collection and prevent deforestation. Since the mid-2000s, however, SHP evolved into a grid-connected, low-carbon energy resource that fuels GDP growth while meeting renewable energy targets. These different roles create an uneven geography of energy production and ecological protection in China as they are negotiated, contested, and reworked to suit local conditions. As China continues to internationalize, these logics and practices may also influence how other countries conceive of and implement SHP-driven green development.

To investigate these issues, I conducted a case study of SHP development in China’s southwest Yunnan province. Yunnan is a mountainous region with a high degree of ecological diversity, from 6,000m peaks in the northwest, to heavily farmed river valleys in the southeast. Like much of southern China, Yunnan’s has a monsoonal rainfall pattern with a wet season between July-November; consequentially, the driest months are March-June. However, this rainfall is unevenly distributed throughout the province, with much of the southeast dependent upon irrigated agriculture during the dry season. Yunnan is very water rich, with more than 600 rivers in six large basins. Given Yunnan's relatively mild climate and ecological diversity, it is the source of many of China's subtropical and tropical agricultural products, such as bananas, sugarcane, and citrus fruits. The province is also heavily forested with a range of alpine, subtropical, and tropical species suitable as commercial timber. Moreover, Yunnan is one of China's most biodiverse regions, with more than 6% of its area under national or provincial protection, including 'hotspots' like the Nu River in the northwest of the province.

Yet, despite Yunnan's ecological wealth, it is still viewed as one of China's more peripheral and economically backward provinces. Yunnan's per capita disposable income in 2014 was ranked 27th of 31 provinces and autonomous regions in China, and its per capita gross regional product was ranked 29th of 31 (Yunnan Statistical Yearbook, 2015). Since the early 2000s, the Chinese central government has sought to help Yunnan 'catch up' with the eastern provinces through investments in infrastructure and regional connectivity along its Southeast Asian border. Part of this strategy has been hydropower development. As of the end of 2014, Yunnan had 51.3 GW of total installed hydropower capacity, and produced 217 TWh of hydroelectricity (EPS China Data, 2017). Of this, 11.6 GW (22.6% of total) is installed SHP capacity, which generated 38 TWh (17.5% of total) of electricity in 2014, the most of any province in China. Moreover, since Yunnan produces more energy that it can consume within the province, much is exported to other parts of China, particularly to load centers like the Pearl River Delta in Guangdong (driven by the policy of 'send western electricity east', or 西电送东) (see Magee, 2006). Large and small hydropower are now major industries in Yunnan.

Yunnan is also ethnically diverse and heavily rural. Ethnic minority groups comprise 33.4% (15.7 million) of the total population of approximately 47 million people, one of the highest proportions in China. Some 58% of the population reside in rural areas, compared to the national average of 45%. As Yunnan is a rural and mountainous region, many people continue to practice small-scale agriculture coupled with seasonal collection of non-timber forest products. Agricultural practices differ as one moves from heavily farmed valleys with irrigated paddy land, to steeper slopes terraced for dry copping. In the last fifteen years, many households have shifted from subsistence and wet rice cultivation to cash crops. Moreover, recent reforms to rural land rights have made it easier for households to transfer land to other households or agribusinesses, sometimes with fifteen- or thirty-year leases. Since small hydropower is located in rural areas, it is intimately tied to these changing agricultural practices.

Within the province, I focused specifically on Xinping, a county in central Yunnan situated in the upper Red River (红河) basin. There are at two reasons for selecting this site. First, Xinping is geographically diverse, with upland areas where the local economy is based on forest products, and lowland areas with productive irrigated agriculture. Since SHP plants are in both areas, this allows for a more comprehensive analysis of SHP implementation and impacts in different ecological and economic regions that could be obtained elsewhere. Second, the rapid development of SHP in Xinping mirrors that of other counties in Yunnan and southwest China. Xinping was named a ‘rural electrification’ county in the mid-1990s, and received funding for an ‘SHP Replace Fuelwood’ project in the early 2000s. Like many other counties in Yunnan, Xinping’s local county grid was also integrated into the China Southern Power Grid (CSPG, the national grid operator in southern China) in the early 2000s. This makes it a representative case study for SHP development in Yunnan, and a basis for comparison with other counties in southwest China.

However, to situate Xinping in a broader context, I conducted fieldwork in two other prefectures in Yunnan, as well as in Kunming, Beijing, and Hangzhou, where China’s international

SHP organizations are based. The two Yunnan prefectures – Wenshan and Nujiang – allow me to contextualize my Xinping case study findings and identify local factors that shape SHP implementation. Visiting Kunming and Beijing allowed me to analyze the policies and institutions that govern SHP in China and Yunnan province, and the logics of green development that these reflect. And finally, spending several weeks in Hangzhou at China's centers of global SHP exchange enabled me to ask how SHP is China is evaluated, packaged as a set of technologies and practices, and exported through training programs, aid projects, and investments. In this way, I gained a more comprehensive perspective of SHP in Yunnan as part of China's national green development and international investment activities. Fig. 1.8 provides an overview map of these field sites; detailed maps of the Yunnan prefectures and Xinping county are provided in Chapters 2 and 3.

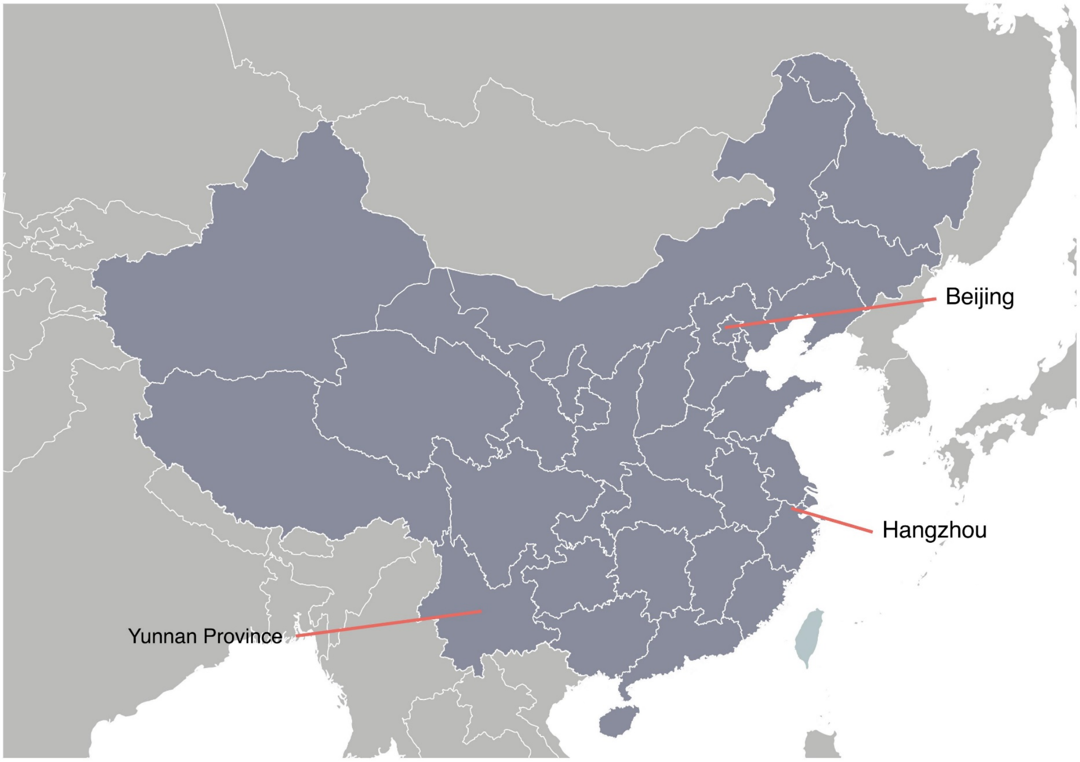


Fig. 1.8: *Field sites overview*

1.6 Research questions

This project asks four research questions, each of which correspond with a dissertation chapter.

1. *What policies and institutions govern SHP in China and Yunnan, and what logics of green development do they reflect?*

   This question aims to understand the institutional structure of SHP in China and Yunnan, as well as the current macro-economic and policy environment. It also asks what makes SHP 'green' in China, and the contribution it is supposed to make to green development at different scales. Additional questions include:

   - How is SHP promoted, developed, and managed in China and Yunnan?
   - What is the role of SHP in China and Yunnan's rural development strategy? What is its role in China and Yunnan's renewable energy strategy?
   - What is SHP's role in forest protection in China and Yunnan, and how has its performance been evaluated?
   - How many SHP stations in China and Yunnan have received CDM funding?
   - How do officials in China and Yunnan judge the success of SHP, and what challenges have they identified facing the sector?
   - What other renewable energy projects compete with SHP for attention and financing?
   - Why has central and provincial government support for SHP declined since 2016?

2. *How do local politics, economic considerations, financing channels, ecological conditions, and ideas about green development shape how SHP is implemented in Xinping?*

   This question aims to understand how SHP is implemented in Xinping county, and why it takes the form that it does. It also asks how specific SHP projects are developed, financed, constructed, and managed, and how CDM funds are used in this process. Additional questions include:

- Where are investors in Xinping projects from, and why do they choose to invest in such a remote area? Do they consider SHP to be a sound investment?
- How do the project investors, owners, and operators perceive the social and environmental benefits (and consequences) of SHP in Xinping?
- How was the level of CDM funding determined for Xinping projects, and who makes and influences this decision?
- To what extent do local farmers influence decision making in the Xinping projects, and do they contribute labor to the projects?
- What other benefits do SHP projects provide to local communities besides electricity (such as irrigation, water storage, etc.)?
- How much electricity is used in the local community, as opposed to being transferred? How much is provided to businesses as opposed to villages?
- What is the return on investment for typical SHP investments in Xinping? How do these compare with investments in western China and in other areas of Yunnan?

3. *What are the impacts of SHP on fuelwood use and irrigation water access in Xinping?*

This question aims to evaluate the social impacts of SHP in Xinping. It focuses on two aspects of SHP that have been identified in recent studies but not adequately evaluated. These are 1) its impact in reducing household fuelwood use (and replacing fuelwood with electricity), and 2) its effects on access to irrigation water for farmers. Additional questions include:

- Do SHP plants that began operating after rural grid upgrades have any bearing on household electricity use?
- What is the relationship between rural household electricity pricing and the presence of an SHP plant?

- Do villages in ‘SHP Replace Fuelwood’ project zones reduce fuelwood use and collection in favor of electricity?
- How has irrigation water access changed over the last ten years, and why?
- Do villages in Xinping experience more or less irrigation water access due to SHP? If water access is reduced, when does this typically occur?
- Does the geographical location of a village vis-à-vis an SHP plant affect household irrigation water access? Does the geographical location of individual household fields exert a similar effect?
- What influence, if any, does the presence of an SHP plant have on household decisions to shift crops and/or rent out their land to agribusinesses?

4. *What SHP technologies and ideas about green development are being transferred to other countries through training courses and investments?*

   This question aims to understand China’s influence over SHP development in other countries, both through training programs and investments. In doing so, it asks what kinds of SHP projects are interpreted as ‘green,’ and whether Chinese actors impart a vision of how SHP contributes to green development. Additional questions include:

   - How do Chinese trainers represent the social and environmental benefits (and consequences) of SHP, and what kinds of projects are advocated?
   - What size and type of projects are investors engaged in, and how do they seek to ensure a positive return on investment?
   - What kinds of Chinese aid / investment packages include SHP as opposed to other energy sources? How do Chinese actors explain the purpose of SHP in these packages?

1.7 Research design and methods

This study draws from recent work in geography in critical policy studies as a guide for research design. I seek to unearth what Peck and Theodore (2012, p. 23) call the 'social lives of globalizing policy models' – the processes and relations through which policies and practices are shaped and packaged in particular ideological and political contexts. Rather than asking if SHP in China is successful, I aim to understand how success is defined, implemented, and 'exported' internationally (Mosse, 2011). Thus, answering the research questions requires more than just policy documents or project evaluations; it necessitates a thorough understanding of the aims, roles, and practices of actors all along the policy and project continuum. I employed three interrelated methods: analysis of policies, government reports, and Chinese academic articles; interviews with government officials, SHP investors, resource managers, and farmers; and participant observation at international training workshops. Tab. 1.1 below summarizes these methods and the evidence they obtained. Methods are described in detail in each of the substantive dissertation chapters.

Tab. 1.1: *Research questions and methods*

Research question	Evidence needed	Methods
Q1: What policies and institutions govern small hydropower in China and Yunnan, and what vision(s) of green development do they reflect?	Central and provincial policies related to SHP, rural electrification, and hydro-electricity structure and pricing Institutional map of central, provincial, and local departments and bureaus that manage SHP Articles, speeches, and communiqués explaining the purpose, goals and context of SHP National policy and framework for obtaining CDM funds Number of CDM / non-CDM SHP in China and Yunnan since 2007 Official evaluation of SHP forest protection outcomes	**Policy analysis**: Obtain and analyze - official policies to piece together SHP official rationale and governance structure - CDM policy to understand financing channels and rationale for SHP 50 MW threshold - articles, speeches, and communiqués to understand ideas about green development embedded in policies - list of total SHP projects and CDM-funded projects in China and Yunnan since 2007. **Official interviews**: Interview officials in - central government MWR, SFA, ICSHP, and HRC - provincial government Water Bureau, Forest Bureau, and Environmental Protection Bureau to establish governance structure, specific policies in place, their rationale, evaluations so far, and ideas about green development.

Q2: How do local politics, economic considerations, environmental conditions, financing channels, and ideas about green development shape how small hydropower is implemented in Xinping?	Number, type, capacity, output, grid connection, year constructed, and location of SHP projects in Xinping Financing structure for Xinping SHP projects, including investor bios and level of CDM funding Planning process for Xinping projects including actors involved, local consultation, and oversight Ownership structure for projects i.e. individual owned, joint stock, private capital + SOE, or rent + run Environmental rationale for location and size of projects, and unforeseen operational barriers Process for obtaining CDM funding (if applicable), and influence over project design / implementation Methodology for determining CDM baseline and additionality	**Document analysis**: Obtain and analyze - county list of operational SHP projects. - project documents for projects in Xinping to understand ownership and financing structure, actors involved, ecological conditions, and expected outcomes - CDM documents for applicable projects. **Official interviews**: Interview officials in - prefecture Water, Forest, and Environmental Bureaus - county Water, Forest, and Environmental Bureaus to understand how SHP projects are initiated, their rationale, the planning process, and implementation issues. **Project interviews**: Conduct interviews with - project owners to understand their background, reason for ownership, and operational difficulties - project investors to understand rationale, dependence on CDM funds, expected ROI, and influence over decisions - carbon crediting agency to understand approval process, methodology, and rationale for supporting large SHP - local farmers to determine attitudes and influence, as well as benefits (if any) gained from projects.
Q3: What are the impacts of SHP on fuelwood use and irrigation water access in Xinping?	Basic demographic, land use, and crop data for eight villages in Xinping Rural electricity price in case study villages since 2005 Average household electricity use in case study villages since 2005 Average household fuelwood collection and use in case study villages since 2005 Household irrigation water use and access since operation of SHP plant Existence of conflicts with SHP plant, and how resolved Perceived impacts of SHP plant on livelihoods and local environment	**Household survey:** With five graduate students from Yunnan Normal University, conduct a survey of 120 households in eight villages in Xinping adjacent to SHP plants. Villages chosen using spatial methodology to maximize representativeness. The aim of this survey is twofold: first, to quantify the livelihood impacts (positive and negative) of SHP plants in Xinping, and second, to isolate the key explanatory variables that determine the degree or severity of impacts at the village level. **Farmer interviews:** Conduct in-depth interviews with three households in each village to better understand the drivers of electricity use, fuelwood use and collection, irrigation water use and access, and broader livelihood changes.
Q4: What small hydropower technologies and ideas about green development are being transferred to other countries through training courses and investments?	Principal technologies promoted by Chinese government, and whether they are tailored for each county Type and number of training courses offered, both China domestic and in-country, and reported outcomes Size, type, and rationale of projects advocated by the Chinese government Size, type, financing, and rationale of projects pursued by Chinese investors Influence of China SHP on global CDM and future carbon markets Comparison between reported ROI for Xinping and overseas projects	**Document analysis:** Obtain and analyze - list and summaries of training programs offered by ICSHP and HC-SHP - official / media releases for China overseas SHP projects - industry newsletters / reports and company literature on China overseas SHP investments **Official interviews:** Interview trainers in ICSHP and HC-SHP to determine technologies promoted, size and type of projects advocated, relationship to investors, and ideas about role of SHP in green development. **Investor interviews:** Interview Chinese SHP investors in overseas projects to determine technologies used, size and type of projects, use of CDM funds, rationale for investment and project design, and ideas about role of SHP in green development.

1.8 Outline of the dissertation

The rest of the dissertation is structured as follows.

Chapter 2*: Small Hydropower and Logics of Green Development in China.* This chapter analyzes how SHP came to be a driver of green development in China, and how different interpretations of green development in different places affect SHP implementation. I trace the *temporal* and *spatial* transition of SHP from its role in rural electrification and poverty alleviation to a generator of clean energy. I argue that this transition reflects two 'logics' of green development: a logic of conservation-based rural development, and a logic of industrial energy generation for national low-carbon development. To make this argument, I analyze Chinese national SHP policy, and compare SHP function and implementation in Nujiang (northwest Yunnan), Wenshan (southeast Yunnan), Yuxi (central Yunnan), and Lishui (southern Zhejiang) prefectures.

Chapter 3: *Rural Utility to Green Industry: Small Hydropower and the Industrialization of Renewable Energy in Xinping.* This chapter examines the emergence and growth of China's SHP industry, and how this has transformed SHP from small-scale plants to an industrial energy system. I analyze the governance and operation of SHP in Xinping county. Drawing on interviews with county officials, investors, SHP operators, and farmers, I show how local officials and investors are incentivized to produce as much electricity as possible, which creates larger SHP stations in multiple cascades that must be operated continuously. I also detail the financial, environmental, and technological structures and constraints that shape SHP design and implementation, and explain how and why some officials and local farmers contest SHP projects.

Chapter 4*: Is Small Beautiful? Social Impacts of Rapid Small Hydropower Development in Xinping.* In this chapter, I argue that the environmental and social costs of SHP in Xinping outweigh local benefits. I make two main points: first, that SHP only reduces fuel wood collection in areas with electricity subsidies, and second, that plants with large diversion structures can negatively impact irrigation water supply. Using data from the household survey, I show that villages situated below the intake for SHP plants are most affected, but receive no compensation.

Chapter* 5: A Green Development Model: Transnational Model-Making in China's Small Hydropower Training Programs.* This chapter details the practices and discourses that have made SHP in China an international model of green development. I show how officials and investors promote certain SHP projects and policies as successful, despite reservations about negative social and environmental impacts. Drawing on interviews and participant observation at training workshops in Hangzhou and Beijing, I then describe how SHP is framed for an international audience, even as the Chinese government places restrictions on SHP within the country. Thus, I suggest that this model serves two purposes: to draw attention to China's green credentials, and to drum up business for Chinese SHP overseas.

Chapter 6: *Conclusion.* This final chapter revisits the theoretical and empirical contributions of the dissertation. It places SHP in the broader context of continued renewable energy expansion in Yunnan and western China. It also reviews the limitations of this study and suggests areas for further research, in particular the rise of Chinese overseas renewable energy investment through the Belt and Road Initiative.

CHAPTER 2
Small Hydropower and Logics of Green Development in China

2.1 Introduction

Long seen by China’s leaders as developmentally backward and ecologically degraded, western China has undergone a dramatic economic and environmental transformation in the last two decades. Beginning with the Great Western Development Strategy in the early 2000s, to the current BRI, the central state has sought to bring the western provinces up to the standard of the urbanized east (Oakes, 2004; Su, 2014; Yeh et al., 2013). These strategies have been spearheaded by state-led investment in transportation and extractive industries, particularly mining and energy (Magee, 2006). They have also entailed state subsidies for large-scale ‘ecological construction’ and forest protection projects to combat land degradation (Bennett, 2008; Economy, 2002; J. Liu et al., 2008). A recent national policy to set aside ‘ecological function zones’ – many of them in western China – highlights the uneasy tension between state economic and environmental priorities (China State Council, 2016). Indeed, China’s leaders see issues of national political stability and future GDP growth as predicated upon an economically dynamic and ecologically sound west (Yeh, 2005).

Small hydropower, perhaps more than any other technology, is representative of the changes that have taken place in western China. In China, SHP is defined as <50 MW installed capacity, compared with the definition of <10 MW in many other countries (UNIDO and ICSHP, 2016). The first SHP plant in China was installed in 1911 in Yunnan, and since then, over 47,000 have been constructed (Kong et al., 2015). As of the end of 2015, the installed capacity of all SHP plants in China was 74.3 GW, making up nearly a quarter of China’s total hydropower installed capacity (EPS China Data, 2017). SHP was a prominent feature of ecological construction and poverty alleviation programs in western China because it replaces peasant firewood collection with electricity, which helps to protect forests and improve productivity (Cheng and Li, 2003; Cui and Qu, 2008). More recently, SHP has been promoted in China as a renewable energy source that reduces carbon and other GHG emissions. For these reasons, China's leaders uphold SHP internationally a model of green development (Harlan, 2017; HRC, 2017).

In the last two years, however, the state's SHP policy has undergone a complete reversal. In mid 2016, the provincial governments of Yunnan and Sichuan – which are ranked first and second in total SHP installed capacity in China – announced restrictions on SHP that have effectively halted approvals for new plant construction. These provincial restrictions were followed by the central government's 13th Five Year Renewable Energy Development Plan (2016-2020) that reduced national targets for new small and medium hydropower installed capacity to a mere 5 GW (NDRC, 2016b, p. 12). Paradoxically, the reason given for these new restrictions was to "protect the ecological environment" (保护生态环境) and to "promote regional sustainable development" (促进区城可持续发展) – which are precisely the outcomes that SHP is supposed to deliver (People's Government of Yunnan Province, 2016). Indeed, even before these decisions were announced, articles in state media had criticized local governments in western China for over-developing SHP and causing soil erosion and streamflow reductions (Guo, 2016; Yu, 2015; Zhao, 2016). New SHP restrictions are thus an explicit admission by the central and provincial governments that SHP has no place in China's future green development. This stance is curious given that state investment in large hydropower and resource extraction in western China is slated to continue, even though these projects have far larger negative environmental impacts than SHP.

This chapter has two aims. The first is to understand why the central and provincial governments reversed their prior support for SHP as a model of green development. I argue that, contrary to the narrative in state media, the primary reason that the state restricted SHP is not because it caused localized ecological damage due to over-development (though it has done so). Rather, it is because state authorities believe that SHP is a poor generator of renewable energy. That is, the main criteria that the state uses to evaluate SHP have changed from forest protection to low-carbon electricity generation. This shift was prompted by state policy in the mid-2000s that promoted SHP as a renewable energy, which forced plants to connect to the grid and mandated that utilities purchase SHP electricity. As a result, instead of developing SHP to meet household energy needs, some local governments built them to sell electricity to the grid and to power local industries. In parts of western China, local officials approved thousands of new SHP plants as an industrial development strategy. This strategy generated local tax revenue, but also caused an electricity glut. The central and provincial governments now want to halt SHP because they are unwilling to invest in the infrastructure needed to reduce over-capacity and smooth out seasonal fluctuations. New SHP restrictions, then, are based on the logic that it produces little green economic value for the central and provincial governments.

The second aim of this chapter is to analyze broader shifts in how green development is conceptualized by the Chinese state, and why certain schemes are implemented over others. To do this, I introduce the concept of 'logics of green development', which refers to the political-economic rationale for how the state manages the tension between environment and development in different times and places. I argue that state-led green development programs in the early 2000s were based on a national logic of *preserving* the green economic value of western China's forests, so as to protect greater wealth in eastern China and incorporate ethnic minorities into the national political fabric. This logic held that SHP was an environmental protection and poverty alleviation tool, which needed to be subsidized and bolstered by separate investments in large-scale resource extraction, even as SHP generated a small amount of revenue for local communities. Since the late

2000s, however, the state has broadened its interpretation of green development to include programs that *produce* green economic value, such as energy conservation, clean technologies, and renewable energy. This logic holds that SHP is also a green industry, which contributes to national climate change mitigation and local and regional economic development. Here, SHP generates its own revenue, replacing the need for subsidies from extractive industries by combining environmental protection and resource extraction in one technology. These logics are important to identify because they often contradict each other and are prioritized differently depending on prevailing political economic conditions, which can reduce or eliminate the local benefits that green development is supposed to provide. This is especially the case on China's low-carbon frontier where energy-based green development (such as SHP) exposes local communities to boom-and-bust cycles associated with traditional extractive industries.

In making these arguments, this chapter fills a scholarly gap on the geography of China's low-carbon transition and the changing role of resource frontiers in national development. A large body of existing work is concerned with spatial inequality and uneven development in China, including research on the distribution of environmental contamination and polluting industries (Lin and Chen, 2004; Zheng et al., 2014; Zhou et al., 2017; Zhu et al., 2014). However, there is much less work that brings a spatial perspective to bear on China's current green economic transformation, particularly as it relates to the energy sector. Here, studies of renewable energy in China tend to focus on national policy-making or urban mega-regions as the locus of agency, while resource-rich regions in China's west are rarely considered (Chang et al., 2003; Cherni and Kentish, 2007; Li et al., 2002; Liu and Liang, 2013). This chapter seeks to pivot the geographical focus of this research to western China, calling attention to resource frontiers as key sites where the contradictions of national green development are laid bare. I build on previous studies of ecological construction projects in western China, while highlighting the state's more recent desire to transform the region into a producer of green economic value. Analyzing how state logics are shaped, implemented, and re-made forces us to confront long-held questions about the problems that green development is meant to solve and the scale at which sustainability is determined (Adams, 2009, pp. 152–153).

Data for this chapter were collected through analysis of Chinese policy documents, interviews with SHP and hydropower experts, and interviews with local officials and SHP investors in three prefectures in Yunnan province and one prefecture in Zhejiang province. Section 2.2 reviews the theoretical literature on the environmentalization of the state and its application to the Chinese context. Sections 2.3 and 2.4 describe how a focus on logics of green development can help illuminate the role of role of resource frontiers in green economic production, particularly in western China. Section 2.5 describes the field sites and the actors and institutions with whom I conducted interviews. Sections 2.6, 2.7, and 2.8 then examine changes to SHP policy over time and connect them to implementation in Yunnan. Section 2.9 concludes by highlighting implications for studies of green development programs in China and elsewhere.

2.2 State environmentalization in China

China's leaders are now confronting the environmental consequences of three decades of growth-first development policy. Industrial activity has gone under-regulated ever since the reform period in the late 1970s, resulting in severe air pollution and contamination of water supplies in the populated east (Zhang and Wen, 2008; Zheng and Kahn, 2013). In western China, the economy's voracious appetite for raw materials – particularly fossil fuels, mineral resources, and timber – has degraded much of the country's forests and agricultural land. For years, such ecological damage was implicitly permitted by the state as long as economic growth was maintained (Economy, 2006).

Measures to curb pollution and degradation largely targeted singular problems, not structural reforms (Liu and Diamond, 2005; Liu et al., 2012). Yet as the economic costs of environmental have risen, the state has announced major industrial and energy policies that aim to bring about a national green development transformation. Under Xi Jinping, the party-state has adopted 'ecological civilization' as an ideological pillar of socialist development that is given equal weight to economic, political, and social construction (China Daily, 2007; Wen et al., 2012).

Scholarly analysis of China's green development tends to focus on the role of state and non-state actors who enact, interpret, and implement reforms (Blaikie and Muldavin, 2004; Geall, 2013; Jahiel, 1998; Yang, 2005). Much of this work is concerned with what Chen et al. (2017, p. 85), quoting Buttel (1992, p. 2), call the 'environmentalization' of the state, or the "concrete processes by which green concerns and environmental considerations are brought to bear in political and economic decisions…[and] in institutional practices." The empirical focus of these studies has shifted along with state environmental policy. In the 2000s, scholars such as Yeh (2005) and Tilt (2010) analyzed ecological construction programs and the closure of polluting township and village enterprises (TVEs) in rural China. As reforms accelerated in the past decade, scholars of China's environmental state have broadened their analysis from resource management and pollution control to include industrial restructuring (Lo and Tang, 2007; Yuan et al., 2006) and urban and regional planning (Chen, 2013; de Jong et al., 2013; Wilczak, 2017).

Two theoretical frameworks of Chinese state environmentalization stand out in the current literature. The first is ecological modernization, which analyzes "the restructuring of modern institutions to follow environmental interests, perspectives, and rationalities" (Mol, 2006, p. 30). Implementing these changes involves an 'ecological switchover', comprised of sectoral shifts in the economy, the development of clean technologies, efficient resource use, placing economic values on nature, and integrating environmental goals into other policy areas (Murphy, 2000, p. 3). Ecological modernization has been deployed both as theory and policy prescription, and has mainly been used to describe liberal market economies in Europe and North America (Christoff, 1996; Gibbs, 2000). Mol (2006), however, sees evidence of ecological modernization in China, pointing to the strengthening of state environmental authority and use of market tools to achieve environmental goals. Examples include the higher ranking given to the State Environmental Protection Agency in 1998 (later further upgraded to the Ministry of Environmental Protection in 2008), the growing independence of local environmental protection bureaus, and higher taxes and fees on polluters (*ibid*). In contrast, Huan (2007) and Hong et al. (2014) argue that ecological modernization over-simplifies structural limitations to environmental reforms in China and the lack of political and social change.

A second theoretical framework for state environmentalization is eco-state restructuring, defined as "the reorganization of state powers, capacities, regulations, and territorial structures around institutional pathways and strategic projects, which are…viewed as less environmentally damaging than previous trajectories" (While et al., 2010, p. 80). Eco-state restructuring is rooted in neo-Marxism and regulation theory, which see environmental regulation as a key strategy through which the state maintains capital accumulation and political stability (Jessop, 1995; Peck and Tickell, 1992). In contrast to ecological modernization, which tends to be optimistic about the potential for change, eco-state restructuring foregrounds the power struggles and conflicts that shape modes of environmental governance in different times and places (While et al., 2010, p. 77). Chang et al. (2016) argue that eco-state restructuring helps describe the relationship between China's broader political economy and environmental initiatives, particularly at the local scale. Using the example of the Tianjin-Binhai Eco-City, they show how the central state's concern with promoting domestic consumption, reducing carbon emissions, and promoting inter-Asian collaboration elevated Tianjin-Binhai as a best practice model for green urbanism in China. Here, Chang, Leitner and Sheppard view eco-city models as outcomes of struggle between national and local political, economic, and environmental priorities.

The benefit of an eco-state restructuring framework is that it alerts us to why modes of environmental governance arise in certain times and places, in China and elsewhere. It complicates the notion engrained in ecological modernization that the 'greening' of the state follows a specific pattern of political reform, technological innovation, and a greater role for markets and market tools. Indeed, eco-state restructuring considers ecological modernization "as only one of a number of possible transition pathways" (While et al., 2010, p. 80). Yet while eco-state restructuring emphasizes how modes of governance are shaped by competing interests, it situates these interests within the same political-economic rationale: that the state must intervene to prevent capitalism from destroying the environmental conditions of production and social reproduction. But there is a difference, I suggest, between a logic that environmental protection *preserves* nature for its economic value, and the logic that environmental protection itself *produces* economic value. That is, there is a difference in logic between green development programs that separate environmental protection from production, and those that combine them. This distinction is somewhat hidden in the eco-state restructuring literature, but it is of fundamental importance.

2.3 Logics of green development

Building on eco-state restructuring, I put forward the concept of logics of green development, which refers to the political-economic rationale for how the state manages the tension between environment and development in different times and places. I suggest that the Chinese state has shifted from viewing green development as only a political and economic necessity, to also viewing it as a political and economic opportunity. At risk of over-simplification, these two logics can be separated into a logic of *preserving* green economic value and a logic of *producing* green economic value. Both logics are grounded in the economic valuation of natural capital, but the difference is that one treats the environment as a barrier to capital accumulation, and the other as a 'green' vehicle for further accumulation. These logics are also inherently relational, in that the logic for green development interventions in one location – such as western China – is intimately tied to state goals at other locations and scales. Moreover, both can and are applied to a range of ecological issues – from conservation, to pollution control, to carbon mitigation – and can overlap and come into conflict with each other and with state logics that are not environmental in nature.

This concept of logics of green development builds on Castree's (2008a, 2008b) work on 'environmental fixes' in the neoliberalization of nature. Castree, drawing on geographical political economy and regulation theory, argues that the capitalist state and firms employ environmental fixes to resolve ecological crisis tendencies endemic to capitalism. The range of fixes that are used shift with different 'regimes of accumulation', which refer to the dominant mode of economic growth coupled with habits and customs, social norms, laws, and state forms of a given society (Jessop, 2002, p. 345; Peck and Tickell, 1992, p. 349). Castree argues that under neoliberalism – the current global governance regime – markets have been deployed as the solution to nearly all environmental problems, a so-called liberal or 'market' environmentalism (Bakker, 2005, p. 543; Bernstein, 2002). In this context, Castree describes how the state at times chooses to 'fix' the economy-environment contradiction by off-loading environmental governance responsibilities to the private sector, by allowing nature to be commodified and traded, and/or by adopting a minimal stance towards environmental governance in general (2008a, pp. 146–149). These different fixes, he argues, have different political-economic logics. Here, while Castree does not explicitly engage with an eco-state restructuring framework, his work is intent on explaining the logics behind *why* neoliberalism has become the dominant mode of environmental governance.

Logics of green development differs from Castree's formulation in two respects. First, I focus explicitly on the environmentalization of the state – the inclusion of 'green' concerns in state political and economic decision making – rather than the neoliberalization of nature. This analytical perspective casts light on the broader economic and environmental policies that are not explicitly tied to natural resource governance, such as industrial restructuring and the promotion of clean technologies. Second, and relatedly, Castree's focus on neoliberal natures writ large obscures the different state logics of protecting nature through the commodification and/or privatization of resources, and producing economic value through the construction of green industries. For example, the state may subsidize certain green industries or technologies (such as renewable energy) based on anticipated economic benefits, and/or promote green economic activities (such as eco-tourism) alongside new environmental regulations. In short, I make a distinction between the logic of "selling nature to save it" (McAfee, 1999) that manifests primarily in environmental management strategies, and the logic of producing green economic value that manifests primarily in economic and industrial policy.

Whether these logics are aligned or in conflict is shaped by the environmental issue (or issues) in question, the scale of intervention, and the competing priorities of state actors and institutions – all of which shift over time and space. Carbon sequestration initiatives provide a useful example. Here, one of the main ways to reduce emissions is to preserve landscapes that absorb and store carbon, such as forests and peatlands. At the national or global scale, the state must set aside tax revenue generated through economic activity for landscape protection. This kind of initiative is based on a logic of preserving green economic value. At the same time, provincial or local state actors may be incentivized to protect landscapes based on the economic benefits of doing so. The CDM, for instance, funds local governments and project developers to sustainably manage forest landscapes that they might otherwise use for resource extraction. These funds are subsidized at the national and global scales, but offer a revenue stream for state actors at the provincial and local scales. Thus, the local implementation of this initiative is primarily based on a logic of producing green economic value. At the same time, the benefits of such an initiative can accrue unevenly, to the extent that some local state actors and institutions support landscape protection while others do not.

Why do these logics matter to studies of state-led green development, in China and elsewhere? They matter, I argue, because the decision to preserve and/or produce green economic value is central to the kinds of green development initiatives that are proposed and implemented in specific times and places. That is, logics matter because state-led green development has a distinct historical geography that is absent from much of the work on state environmentalization. The concept of logics enables us to analyze this historical geography by focusing on the broader state rationale for green development in different locations, and on the local state rationale for green development in those locations. In doing so, it draws out the engrained links between the preservation of green economic value at one location and scale to its production in another location and scale. Logics, then, help us make sense of the why the economic benefits of green development are so often unevenly distributed, and indeed, why the state implements green development at all. In the case of China, this spatial unevenness is most obvious in the vast economic disparities between the urbanized east and the rural west and their shifting roles in national green development.

2.4 Green development in western China

What kinds of green development initiatives are implemented in China, and where? The answer to this question has changed significantly over time and space. The first environmental protection laws were established in the late 1970s, at the beginning of the reform period, but were rarely comprehensively enforced (Economy, 2010). In the early 1990s, however, China's leaders began to adopt the language of 'sustainable development' – popularized in the 1987 *Our Common Future* report – and to talk openly about the need to reconcile economic growth and the environment (Morton, 2005; Nielsen, 2003). China's Agenda 21 blueprint (1994), known as the *White Paper on China's Population, Environment and Development in the 21st Century*, outlined new policies and regulations for controlling pollution, increasing production efficiency, and protecting natural resources. Nonetheless, the report still regarded environmental protection as subordinate to economic growth, stating that "Only when the economic growth rate reaches and is sustained at a certain level, can poverty be eradicated, people's livelihoods improved and the necessary forces and conditions for supporting sustainable development provided" (1994: Article 2.1). Moreover, the language of poverty and livelihoods in the report, reiterated in the 9th (1996-2000) and 10th (2001-2005) Five-Year Plans, indicated that state-led green development would primarily focus on rural development and natural resource management, not economic restructuring (NDRC, 2001, 1996).

Indeed, what was striking about the projects that followed was that they explicitly targeted rural western China as the place most in need of green development. Yeh (2005, p. 12) notes that the late 1990s and 2000s saw an "emergent definition of the west as a coherent territory characterized by degraded landscapes and impoverished peoples," which blamed ecological destruction on poverty and mismanagement of resources. The state's proposed solution to these problems was two-fold: first, to invest in major infrastructure in western China so that it could ‘catch up’ to the east, and second, to subsidize large-scale ‘ecological construction’ projects to stabilize western forests and grasslands (Shih, 2004; Tian, 2004). Under the banner of the ‘Great Western Development Strategy’, state and private investment in transportation and extractive industries increased rapidly, while more than 126 million hectares of land area were placed under state protection and/or afforested by paying farmers to plant trees (Wang et al., 2007, p. 1556). Critical studies of these green development initiatives (Oakes, 2004; Robbins and Harrell, 2014; Yeh, 2013), argue that their main rationale was to incorporate western territories and ethnic minorities into the national fold while protecting the much greater wealth generated in the eastern regions. We can thus think of these programs as based on a logic of preserving green economic value, subsidized through fiscal transfers from the central government to provincial and local governments in the west.

In the mid-late 2000s, however, the focus of state-led green development began to broaden. China’s 2001 entry into the World Trade Organization, selection to host the Beijing Olympics in 2008, and ascendance to the world’s second-largest economy in 2010 trained an international spotlight on the country’s rapid growth and resultant ecological crises. Growing numbers of civic protests against environmental pollution, some led by the urban middle class, convinced many in the government of the necessity of nationwide green reforms. China’s participation in international climate change negotiations, moreover, required the state to draw up plans for reducing GHG emissions. As a result, the state announced new targets in the 11th (2006-2010) Five Year Plan aimed at national green economic reforms, including energy efficiency, pollution reductions, and development of clean technologies and industries (NDRC, 2006). The urbanized east saw rapid increases in state and private investment in wind and solar equipment manufacturing (Ru et al., 2012; Sun et al., 2014). Yet rather than deploy clean energy domestically – which would have required restructuring the energy sector – the state instead focused on exporting turbines and solar photovoltaic (PV) panels to overseas markets (Zhang et al., 2014). These early clean energy investments represented an emerging logic of producing green economic value, with the primarily goal of boosting China's competitiveness in the global economy. What counts as 'green development' in China was thus expanded to include both ongoing ecological construction projects in the rural west, and green urban and industrial transformation in the populated east.

The period since 2010 has seen attempts to both preserve and produce green economic value in China. The global financial crisis of 2007-08 reduced demand for Chinese exports and precipitated a crisis of industrial overcapacity. State banks continued to lend to failing industrial firms and local governments were mired in unviable construction projects. All the while, environmental conditions kept deteriorating: China now has 16 of the 20 most polluted cities in the world; 75% of rivers and lakes are severely toxic; 10% of soil is polluted; and food scares dominate the headlines (Geall, 2013). In response, the 12th (2011-2015) and 13th (2016-2020) Five Year Plans called for a transformation of China's economic growth model, from export-oriented industrialization to higher-value industries aimed at domestic consumption (NDRC, 2016a, 2011). This ongoing economic transformation entails hard targets for reducing GHG and pollutant emissions through new taxes, regulations, and enforceable fines (NDRC, 2012). It also involves continued investment in green industries, which have expanded from clean energy manufacturing to include energy facility design and construction, eco-city projects, and organic agriculture. These strategies seek to simultaneously preserve and produce green economic value by replacing dirty, polluting industries with globally competitive green industries. China's eastern provinces and cities have responded to this national policy by seeking to attain ‘model’ ecological status and building up favored green industries (de Jong et al., 2013; Y. Wang et al., 2015).

What do these shifting logics of green development mean for rural western China? Contemporary state discourse and policy promotes urban environmental projects like eco-cities as keys to national green development, because they enable more efficient resource use and act as incubators of new green industries. In contrast, rural areas – especially resource-rich regions in western China – are discursively and materially set aside as spaces to be protected. Indeed, in 2015, the state announced new ‘ecological function zones’ that limit industrial development in fragile and/or biodiverse regions in western China (Fan and Li, 2009; Wang et al., 2014). At the same time, environmental protection programs are in tension with longstanding resource extraction and agricultural activities, which have been forced to continually ramp up production. We might expect this tension to nearly always result in a zero-sum game, in which local governments can either choose to preserve the environment – and lose potential revenue – or promote economic growth without regard for the environment. However, building on Zinda et al.’s (2017) insights into the growth of timber production in western China’s ecological construction forests, I argue that state policy has provided new opportunities for local governments to produce green economic value, particularly through clean energy generation. The concept of logics of green development helps us to identify and analyze this shift, one that has received little attention in the literature on rural China or on green development transformation more broadly.

Small hydropower is the ideal technology from which to examine these shifting green development logics and their consequences. When SHP was first deployed in western China in the 1960s, its role was to provide household electricity and power local industries; it had no ‘green’ function. In the 1990s, the state reframed SHP as a forest protection tool alongside ecological construction programs, and provided subsidies to local governments for new plant construction. In the mid-2000s, however, SHP took on its current role to produce clean energy, resulting in a near-tripling of installed capacity in less than a decade. Here, however, the logic of producing green economic value through energy generation often conflicts with the logic of preservation, because SHP cascades can reduce streamflow during dry periods and cause soil erosion during wet periods. Moreover, given that the investment in SHP mainly originates in eastern China, much of the green economic value produced through energy generation accrues to investors in the east, leading to local economic dependence. Local governments in western China that developed SHP as an industrial strategy – and increased their revenues in the process – are now reeling from central state policy restricting further SHP plant construction.

2.5 Field sites

Investigating shifts in SHP policy in China, and the green development logics that sit behind them, requires data from multiple geographic scales. My methods and field sites in this chapter reflect this multi-scalar approach. I collected data in six sites in China associated with three scales of analysis: Beijing (national scale); Kunming, the capital of Yunnan province (provincial scale); and three prefectures in Yunnan province and one prefecture in Zhejiang province (local scale). I chose the prefecture as the local unit of analysis since the prefecture government approves SHP stations and conducts river basin planning. However, to provide further geographic detail, I also chose one county in each of the three Yunnan prefectures for additional analysis. I employed two related methods in each of these locations: interviews with government officials, SHP investors, and academic experts; and analysis of government policies, reports, and communiques.

Details of the prefectures selected in Yunnan and Zhejiang are provided in Tab. 2.1. In Yunnan, I aimed to choose prefectures with a wide range of geographical diversity and degree of connectivity to the Yunnan Power Grid (hereafter YPG), as well as different levels of gross domestic product (GDP), average income per household, and degree of economic diversification. All the selected Yunnan prefectures have high levels of SHP exploitable potential, but differ in the exact amount. In Zhejiang, I selected Lishui prefecture as a representative sub-district for SHP development in eastern China. Lishui is the 'control' prefecture in this chapter, because SHP developed much earlier in Lishui (and Zhejiang) than in Yunnan, so that plants in Lishui have a different function and role in power generation than those in the west. In addition, most of the SHP investors active in Yunnan are themselves from Zhejiang and Fujiang provinces (and some are from Lishui prefecture). These four prefectures, then, provide a comprehensive snapshot of how SHP policy has changed over time and space at the local scale in China.

Tab. 2.1: *Characteristics of case study prefectures and counties*

		Yunnan Province		**Zhejiang Province**
	Nujiang	**Wenshan**	**Yuxi**	**Lishui**
Size **(km^2)**	14,703	32,239	15,285	17,298
Population **(m)**	0.54	3.59	2.35	2.66
Prefecture GDP **(100m RMB)**	100.12	615.87	1,184.73	1,051.75
Per capita income **(RMB)**	4,297	6,998	9,969	13,365
Main industries	Mining, hydropower, tourism	Mining, agriculture, hydropower	Mining, agriculture, manufacturing	Mining, hydropower, tourism
Total installed power capacity **(MW)**	1,282	no data	735	
Total HP capacity **(MW)**	1,282	no data	542	
Total SHP capacity **(MW)**	1,003	1,201	386	
Representative county	**Gongshan**	**Maguan**	**Xinping**	-
County population **(m)**	0.04	0.38	0.28	-
County GDP **(100m RMB)**	9.68	71.30	113.05	-
Per capita income **(RMB)**	2,209	4,716	6,666	-

In each Yunnan prefecture, I visited relevant bureaus associated with SHP policy and management, including the Bureau of Water Resources, Development and Reform Commission, Environmental Protection Bureau, and office of the China Southern Power Grid. I then chose one county in each prefecture and interviewed officials in these same bureaus at the county level. These counties are Gongshan County in Nujiang Prefecture, Maguan County in Wenshan Prefecture, and Xinping County in Yuxi Prefecture. Following these initial interviews, I visited approximately 30 SHP plants and interviewed the on-site manager. In this way, I sought to triangulate the data and provide a comprehensive view of the different factors that shape SHP policy and management. The locations of the case study prefectures in Yunnan and Zhejiang are shown in Fig. 2.1.

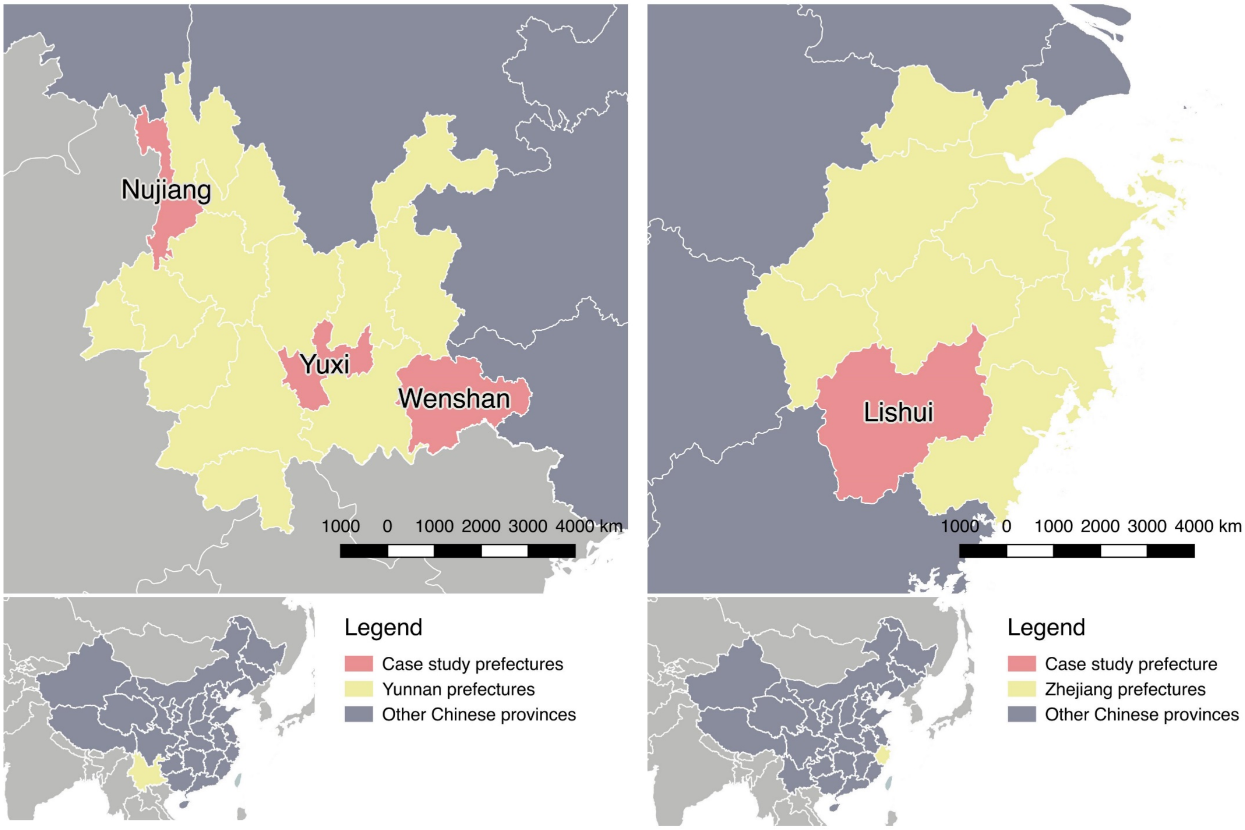


Fig. 2.1: *Map of case study prefectures*

2.6 SHP for poverty alleviation and forest protection

The next three sections analyze changes to China’s small hydropower policy since the late 1970s and their implementation in rural western China. I identify the broader state logics of green development that shape the primary function of SHP different times and places. I also examine how these logics are interpreted by the local governments in western China who approve and manage SHP plants. As will become clear, the state’s framing of SHP as a driver of green development – first as a tool of forest protection, then as a renewable energy – is grounded in the national-scale logics of preserving and producing the green economic value embodied in natural resources. Since hydropower and other natural resources are concentrated in western China, the framing of SHP as a green development tool originated in the western Chinese context. Throughout these three sections, I draw on evidence from Lishui and Zhejiang province in eastern China to show how and why SHP developed differently there than in western China, and why it has not experienced the same SHP ‘bust’ that Yunnan is currently facing.

When the P.R.C. was established in 1949, only 3.6 MW of SHP was installed in the entire country. Plants were mainly comprised of very small (typically <50 kW) wood or wood-iron turbines built out of spare agricultural parts and placed in a stream. During this period, and until the 1970s, the main purpose of SHP plants was to generate low-voltage electricity for household lighting and agricultural goods processing. In some areas, plants were coupled with water management infrastructure to provide drainage and irrigation functions. Under the policy of ‘self-construction, self-management, and self-consumption’, townships and villages were encouraged to exploit local rivers and streams based on their own electricity needs, using local materials (Zhao et al., 2012). Thus, most SHP plants were managed outside of central or provincial government oversight, which enabled plants to produce electricity directly for local households and incentivized local governments to re-invest earnings in new projects (Peng and Pan, 2006, p. 76). By the end of the 1970s, installed capacity reached over 6,000 MW, providing electricity for more than 150 million people (Cheng et al., 2015, p. 45; Hicks, 2004, p. 38). Much of this new installed capacity was in eastern China, primarily the water-rich provinces of Zhejiang, Fujian, and Guangdong (see Chapter 1, Figure 1.7).

Beginning in the late 1970s, the beginning of China's reform period, state policy began to promote SHP construction for rural electrification in poor, mountainous regions that were not yet connected to the grid. While investment in eastern China continued, more plants were also constructed in the western provinces, including Yunnan. In 1982, the State Council allocated ¥100 million in yearly subsidies for 109 rural electrification counties, mainly in areas suitable for SHP. These subsidies were later extended to additional counties in 1990 and 1995 and matched with provincial rural electrification funds (HRC, 2009, pp. 4–5). Our Yunnan case study prefectures of Nujiang, Wenshan, and Yuxi included counties that were part of this program. According to yearly reports from the Yunnan Bureau of Water Resources and Development and Reform Commission, these funds were used primarily for rural grid and SHP plant construction. Some local governments in China also experimented during this period with a shareholding structure for SHP plants, which allowed local people to purchase shares and earn revenue (though shares were mainly held by cadres and/or local leaders). At this point, SHP was not yet considered an environmental protection technology, as the need for green development had only recently entered the national discourse.

By the late 1990s, however, SHP was fully enrolled in ecological construction programs in western China. SHP was identified as an environmental protection tool in the 10th Five Year Plan (2001-2005) alongside the Sloping Land Conversion Program, National Forest Protection Program, and other subsidized projects targeting poor mountainous areas. SHP was considered a supplement to these larger programs because it could help replace peasant firewood collection with stable electricity, thus protecting forests. This approach was solidified in a 2002 central government program called ‘SHP Replace Fuelwood’ that subsidized electricity prices for select SHP stations by one-half, a commitment of ¥127 billion (~US$19 billion) over five years (Cheng and Li, 2003, p. 40). Each of the representative counties in this analysis hosted (and still hosts) at least one of these projects. SHP construction grew rapidly in the lead up to and after this program was announced, totaling 23.5 GW at the end of 2000. Through this program, we can see a shift in the state logic for promoting and subsidizing SHP: from a concern primary with poverty alleviation, to one of environmental protection through poverty alleviation. That is, the logic of the ‘SHP Replace Fuelwood’ program is one of preserving green economic value by subsidizing rural energy infrastructure.

But what did local governments in western China do with these plants, and the subsidies provided for them? The situation in eastern China, and specifically of Lishui prefecture in Zhejiang, provides a preview of what was to come in Yunnan. In the early 1990s, while western Chinese SHP was being subsidized through rural electrification programs, Zhejiang province was experiencing rapid rural industrialization through the proliferation of TVEs (Oi, 1999). As a result, there was an imbalance between electricity supply and demand, which provincial leaders sought to rectify through SHP. The provincial government enacted market-based reforms to feed-in tariff pricing that raised the price for selling SHP electricity to the grid, and further encouraged shareholding corporations to invest in SHP. In Lishui, local entrepreneurs and investors from Taiwan constructed new SHP stations using 60-70% of their own funds, supplemented by commercial bank loans. This was a significant departure from the state-owned model still in place in Yunnan and western China. Moreover, new stations also often were situated in cascades with a reservoir that regulated downstream flow. Between 1995 and 2000, the installed capacity of SHP in Zhejiang rose from 964 MW to 1,692 MW (EPS China Data, 2017). Even before SHP was identified as 'green', then, local governments in the populated east were using them to power local industry and earn revenue from sales to the grid.

In western China, meanwhile, provincial and regional economies were (and still are) based on agriculture and large-scale resource extraction, the latter of which required more stable electricity than could be provided by SHP at the time. As such, most SHP plants built in the late 1990s and early 2000s were subsidized by central and provincial government funds and oriented towards rural electrification; only a few were constructed to power local industries, such as small-scale mining and mineral processing. Further SHP and industrial development was impeded by poor transportation infrastructure and a lack of grid connectivity. The central government's rural grid refurbishment program, announced in 1998 with ¥298 billion in subsidies over five years (Peng and Pan, 2006, p. 82), had only begun implementation in Yunnan and would not be completed until the mid-2000s. Nujiang prefecture, for example, was completely disconnected from the national grid until 2004 and is still only accessible via one long, narrow highway through the mountains. This lack of economic diversification and poor connectivity made local governments in Yunnan dependent upon fiscal transfers and extractive industry investments from eastern China for nearly all their revenue.

2.7 SHP for economic growth and renewable energy

In the early-mid 2000s, however, China's SHP policies began to change. The electricity shortages that plagued Zhejiang in the 1990s had become a national phenomenon, which the central government sought to rectify by exploiting new energy resources, particularly hydropower. Some of this need was fulfilled through state investment in large dam cascades with dedicated transmission lines to the Pearl River Delta in Guangdong (Magee, 2006). In 2002, however, the central government announced a complete restructuring of the electricity sector along market principles. This restructuring had three main elements (J.-H. Wang et al. 2015). First, power generation was separated from transmission, with state-owned generation enterprises encouraged to adopt commercial behavior and compete against each other. Second, independent grids were centralized under two grid state-owned enterprises: The State Grid Corporation of China, which manages the power grid in most of the country, and the China Southern Power Grid, which manages the grid in Guangdong, Hainan, Guangxi, Guizhou, and Yunnan provinces. Existing power supply bureaus at the provincial, prefecture, and county levels were absorbed into their respective grid enterprises and managed as quasi-commercial entities. Third, all existing rural, county, and prefectural grids were forced to connect to provincial and national grids, so that electricity could be more freely transferred between different administrative territories. This latter reform includes a policy of ‘forced connection’ of power plants to the grid, implying that SHP plants would no longer operate independently for a single power supply area.

The release of the 11th Five Year Plan (2006-2010) at the end of 2005 introduced what was perhaps the defining change to SHP policy: the new nationwide push to develop renewable energy. The Plan was followed a year later with China’s 2006 Renewable Energy Law, which stipulated that grid operators must purchase electricity from renewable energy plant operators. A 2007 amendment titled “Administrative Provisions on Renewable Energy Power Generation” further mandated that grid operators construct ancillary grid access systems for renewable projects, including SHP (Zhang et al., 2014). From this period onwards, SHP developers could apply for discounted bank loans earmarked for renewable energy and expect the local grid to construct substations and transmission lines to areas with high hydropower potential. Together with energy sector reform, these new renewable energy policies capped a gradual shift in the function of SHP that had begun in the early 2000s. SHP was no longer solely used for poverty alleviation and forest protection, dependent upon central and provincial government subsidies. It had become its own green industry, and one that made up 93% of all renewable energy installed capacity nationwide by the end of 2006 (excluding large hydropower)[7]. Indeed, from the mid-2000s onwards, even SHP plants that were not part of the 'SHP Replace Fuelwood' program were considered to be 'green' because of their role in national carbon mitigation.

In Yunnan, the provincial government was quick to react to energy sector reforms, calling for rapid growth of SHP in the 2003 document "Decision to Accelerate the Development of Medium and Small Hydropower" (People's Government of Yunnan Province, 2003). The Yunnan government also sought to attract domestic and foreign investors to develop SHP in Yunnan, clearly with an eye on the earlier success of SHP in Zhejiang province. Investors in the eastern provinces of Fujian and Zhejiang – including from Lishui prefecture – traveled to Yunnan province at the behest of local governments to construct new SHP plants. From 2003 onwards, Yuxi prefecture and its county-level governments offered a tax incentives to SHP investors and quickly moved projects through the approval phase. Wenshan and Nujiang prefectures quickly followed suit. Due to the autonomous nature of grid management in Yunnan, local governments could adjust feed-in tariff rates to attract investors to remote areas. Investors themselves saw tremendous profit potential in Yunnan's undeveloped SHP resources – one Lishui investor stated that he would partner with others (抱团投资) to construct plants over an entire cascade. Because of this new investment, Yunnan's installed SHP capacity boomed, growing from 2.5 GW to 8.5 GW between 2000-2010 – a more than three-fold increase in ten years (EPS China Data, 2017).

---

[7] SHP comprised 53 GW of China's total renewable energy installed capacity of 57 GW (not including large hydropower) at the end of 2006 (EPS China Data, 2017; REN21, 2006, p. 21).

Local governments in Yunnan had two main economic reasons for attracting SHP investment and approving new plant construction. First, all electricity generated by SHP is taxable, and the majority (>50%) of tax revenues accrue to the county or prefecture governments. Because SHP plants during this period were financed by private investors, local governments did not need to use their own funds – they only needed to facilitate the approvals and loan process (if investors applied for loans at a local bank branch). Moreover, energy sector reforms and the gradual refurbishment of rural grids provided the necessary infrastructure for transmitting electricity from remote counties and prefectures to the national grid, which was forced to purchase SHP electricity. SHP thus presented a potential long-term tax revenue stream for local officials. Second, SHP provided a source of cheap electricity for local industrial development. In Yunnan, industrial development took the form of mining and mineral processing facilities. Extractive industries are highly energy-intensive and are often located near exploitable SHP resources, which reduces transmission losses. The central government had promoted SHP as an energy source for mining in the 1980s, and the Yunnan government revived this policy in 2002, calling for "integrated SHP and mining operations" (水电矿产结合) (Qi, 2003). SHP, then, promised a path towards an industrial economy for Yunnan's rural regions.

The degree to which local governments developed SHP in Yunnan was shaped by four main factors, outlined in a typology developed by Hennig and Harlan (2017). These were the local grid management structure, grid connectivity, local industrial development strategy, and the existing local energy portfolio. *Grid management structure* affects SHP because one of the major costs of new plant construction is the transmission line from the powerhouse to a nearby transformer. Since local grid companies manage their own infrastructure, they can choose to build a new transformer near potential SHP sites to attract investors. Alternatively, if local grid companies do not provide such infrastructure, then there will be less investment in SHP. *Grid connectivity* is a factor because several prefectural grids in Yunnan (including Nujiang and Wenshan) are still semi-autonomous, meaning that they only have one high-kilovolt transmission line connection to the national grid. This lack of connectivity causes major network congestion during the wet season, and thus limits the electricity that they can 'export' outside the prefecture. The *local industrial development strategy* is generally comprised of a mix of SHP electricity exports and mining and mineral processing. The feasibility of different strategies is shaped by the availability of mineral deposits, transportation infrastructure, commodity prices, and local government actors themselves. Finally, the *existing energy portfolio* affects SHP because local governments with significant large hydropower resources are less enthusiastic about developing SHP, especially in parallel with local energy-intensive mining and mineral processing.

The trajectories of SHP development in the three Yunnan case study prefectures reflect the influence of these local factors. Local officials in Yuxi prefecture, and their county-level counterparts in Xinping county, began to rapidly approve SHP plants following the 2003 Yunnan government announcement. The same year, the large provincial state-owned mining enterprise Kunming Steel (昆明钢铁) began operations in the new Dahongshan (大红山) mine in Xinping, located adjacent to several streams suitable for hydropower generation. This mine is almost exclusively supplied by electricity from SHP. However, while installed SHP capacity grew rapidly across the prefecture in the mid-late 2000s, the Yuxi government was not completely dependent upon SHP-led industrialization, because the prefecture already boasted well-developed tobacco processing and manufacturing operations. Wenshan and Nujiang prefectures, by contrast, had few industries and no large hydropower plants in the mid-2000s, and saw in SHP the opportunity to build a rural industrial economy. Between 2005-10 both prefecture governments rapidly approved new SHP plants and small-scale mining and mineral processing facilities, primarily for silicon, zinc, copper, and tin. While I was unable to obtain specific tax revenue figures, local officials mentioned that the contribution of SHP to the local economy was extremely high. Coupled with extractive industries using SHP electricity, the prefectures of Wenshan and Nujiang – and many other regions of western China – transformed their economies from small-scale agriculture to net energy and mineral exporters. By 2010, installed SHP capacity in all case study prefectures had more than tripled.

Fig. 2.2 provides an overview of the installed SHP capacity and transmission infrastructure of Yunnan's prefectures, including the three case study prefectures. Note that while Yuxi and Wenshan are connected to the CPSG via high-voltage transmission lines, Nujiang prefecture has no such infrastructure, making it difficult for Nujiang export electricity during the wet season.

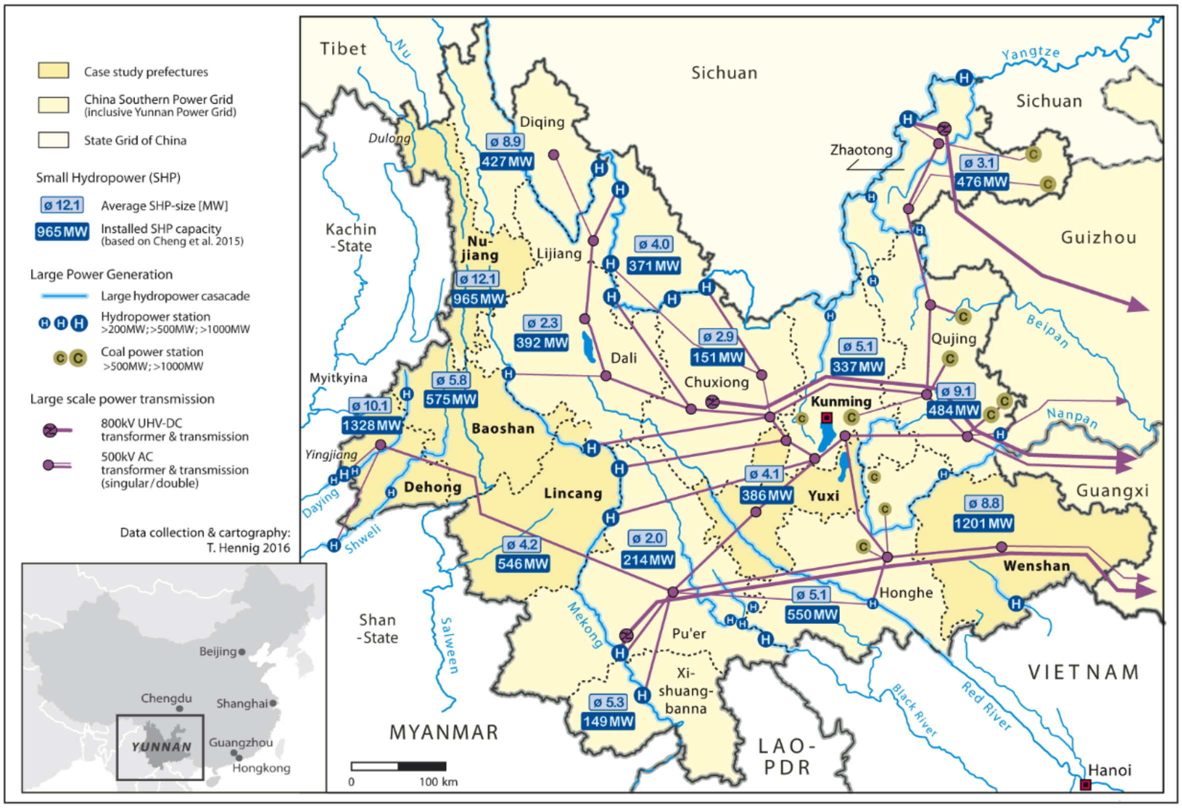


Fig. 2.2: *SHP capacity of Yunnan's prefectures and major transmission lines (copied from Hennig and Harlan, 2017)*

2.8 The SHP bust

While the central government continued to promote SHP in the 12th Five Year Plan (2011-2015), other policy changes were beginning to limit further SHP expansion in western China. Chief among these were new state subsidies for solar PV and wind technologies, which had been considered too expensive for domestic use in the 2000s. In 2010, the central government unveiled the "Decision of the State Council on Accelerating the Fostering and Development of Strategic Emerging Industries" that identified 'new energy' as an emerging economic sector (Zhang et al., 2014). However, the list of 'new energy' technologies in the document did not include SHP. Similarly, in 2012, the government released the 12th Five Year Plan for Renewable Energy Development that specified favorable policies and subsidies for solar PV and wind, but not SHP. Contradictory reports emerged about the state of national SHP resources: whereas the Ministry of Water Resources released findings in 2012 that only 33% of SHP potential had been exploited, hydropower experts in Beijing suggested privately that few economically feasible sites remained, due to their remoteness and declining profitability. SHP was slowly losing its appeal as China's de facto renewable energy of choice.

In Yunnan, the central state's gradual reversal of support for SHP was being felt in other ways. In 2010, the government announced that all 'illegal' plants that had not passed a proper environmental impact assessment (EIA) were to be shut down, resulting in a loss of revenue for some local governments (including Nujiang and Wenshan prefectures). Local environmental protection bureaus were given more power to hold up projects that did not pass their EIAs. A 2014 regulation from the Yunnan branch of the CSPG also mandated that new SHP applications must show the ability to operate more than 4,500 hours per year, or they would not be approved. Most significantly, however, was the Yunnan government's decision to set feed-in tariff prices at the provincial level, giving prefecture governments little wiggle room to entice new SHP investors with high electricity rates. By 2014, the provincial SHP feed-in tariff was set at ¥0.175/kilowatt hour (kWh) during the wet season and ¥0.25/kWh during the dry season – the lowest price of any province in China. As a result, plants that may have earned back their initial investment in 3-5 years in the mid 2000s were suddenly faced with a 10-15 year timeframe. While suitable SHP sites still existed, they were no longer profitable to exploit without strong local government support and the promise of a high rate of return. Investment thus began to dry up.

In 2016, the central state's gradual reversal of support for SHP was finally written into provincial and national policy. The first step occurred in March, when the Yunnan government announced that no further SHP plants would be approved in the upper Nu River basin, most of which is in Nujiang prefecture (Li, 2016). The reason given in the announcement was that SHP had been 'over-developed', a common phrase used in several media articles that led up to the decision. The consequence of over-development, the government said, was the loss of soil and vegetation on steep hillsides – the same problem that the 'SHP Replace Fuelwood' program was meant to solve. Then, in July, the Yunnan and Sichuan governments simultaneously announced that all future SHP plants would need to be approved at the provincial level. This document, called "Some Suggestions for Strengthening the Use and Management of Small and Medium Hydropower", also set new standards for minimum plant size, operating time, generation efficiency, and post-construction revegetation that were widely seen by investors and local governments as precluding any new SHP development (People's Government of Yunnan Province, 2016). Finally, in the 13th Five Year Plan for Energy released at the beginning of 2017, SHP was given only slightly higher targets for new installations, all to be met by plants already funded and in the planning or construction stage (NDRC, 2016b). The SHP boom in western China was over.

What caused this reversal in central and provincial government SHP policy? The claim that all the ‘good’ SHP resources had been exploited, repeated constantly in reports and conversations, had relatively little influence over this decision, since the SHP industry was and is still willing to invest in new plants. Indeed, the existence of ‘good’ resources is not just a function of physical geography, but also of existing infrastructure (especially transformers), the feed-in tariff price, and political will. Similarly, the Yunnan government’s assertion that SHP had caused significant ecological impacts – though true in many cases – was an odd position to take, given that it continued to invest in large hydropower, mineral extraction, and processing. At the national scale, the 13th Five Year Plan announced 60 GW in new large hydropower construction, and still listed the Nu River basin as a potential ‘hydropower base’ for a thirteen-dam cascade, even as it cut support for new SHP expansion (NDRC, 2016a, p. 11). Finally, though my own research in Xinping county found that SHP often reduces farmers’ irrigation water access, this issue only concerned local water and agricultural officials, not provincial leaders. Even up to this period, SHP was still officially considered a pro-poor, green technology that improved farmers’ livelihoods, and no mention was made of its negative social impacts in the decisions to restrict further construction.

Rather, the main reason for restricting SHP was that the state considered it a flawed renewable energy technology. This assessment was made for two main reasons, according to my interviews with local, provincial, and national officials. First, due to Yunnan’s mountainous terrain and limited transmission connectivity, much of the electricity generated by SHP during the wet season could not be ‘exported’ outside of the county or prefectural grid. This was especially the case in Wenshan, Nujiang, and other prefectures with semi-autonomous grids and a single high-kilovolt transmission line. Moreover, 90% of SHP plants in China are diversion-type run-of-river, without a reservoir at the head of the cascade. This makes SHP power generation unstable over daily and seasonal timeframes, leading one former CSPG employee to call it “garbage electricity”. Second, solar PV and wind are highly subsidized by the central government and their technology has improved over the past decade. The Chinese central government sees these ‘new energy’ technologies as a key to China’s competitiveness in the global green economy. SHP, in contrast, is viewed as an old and ‘backward’ technology that is not based in scientific research and management. Moreover, the industries that SHP supports – mainly small-scale mining and mineral processing – are now being closed or consolidated into larger facilities that the state believes are more efficient (Woodworth, 2017). SHP thus has no place in the ‘modern’ western China of mechanized agriculture, large-scale energy generation, and eco-tourism – even if these latter activities develop slowly or fail to materialize.

2.9 Conclusion

Green development in China cannot be understood as a singular logic, or as a transition to some pre-defined ‘green’ outcome. It is, instead, a term that captures the prevailing political, economic, and environmental priorities in specific times and places, which are operationalized through technologies like SHP. In this chapter, I identified two ‘logics’ of green development through which the central state views western China: as a place to be *preserved* for its green economic value, and as a place that itself *produces* green economic value. SHP is meant to preserve this value by generating electricity for poor rural households, reducing their need to collect firewood. From the mid-2000s, SHP was also deployed to produce value as a renewable energy. However, though it generated significant tax and industrial revenue for local governments in Yunnan – many of which built their economies on SHP – it has since been demoted as a model of green development by the central and provincial governments. SHP is now represented as doubly problematic: it causes soil erosion and stream dewatering instead of preserving forests, and produces unstable electricity prone to grid congestion instead of a steady low-carbon energy supply.

These findings present empirical and theoretical implications for studies of green and low-carbon economic transformation, in China and elsewhere. First, I show that natural resources management is more than a trade-off between economic, environmental, and/or social uses; there are also tensions within these categories. In the case of SHP in China, water resources were exploited to preserve surrounding forests. However, once SHP was considered a renewable energy, its water resources were used to produce low-carbon electricity, leading to an over-development of plants and subsequent loss of ecosystem health. In addition, as Hennig and Harlan (2017) have shown, much of the electricity generated by SHP in western and southeastern Yunnan (including Nujiang and Wenshan) supplied energy-intensive mining and mineral processing industries that would otherwise not have been developed. These industries provided tax revenues to local governments, while emitting high levels of airborne pollutants and GHGs. Thus, in some cases, SHP provided no net carbon mitigation.

Second, the case of SHP highlights how resource-rich regions are constantly subjected to boom and bust economic cycles, even when the main industry is a renewable energy technology. Renewable energy can bring enormous benefits to rural and remote communities: including jobs, skills training, tax revenues, low-impact industry, and in some cases, rural electrification. Indeed, SHP was the first electricity source for many rural households in China, and generated local government revenues used for infrastructure, education, and social services. Yet SHP and other energy systems do not operate outside of existing political-economic relationships that cast rural regions as resource providers for the national economy. Water, solar energy, and wind energy are themselves resources that need to be extracted, often in ways that privilege outside capital and urban populations. Moreover, ongoing policy changes and technological innovation can induce severe commodity price swings and asset devaluation associated with traditional extractive industries. These considerations must be present in any policy that seeks to ramp up renewable energy generation in resource-rich regions.

Third, and finally, this chapter suggests that current political-economic readings of green development focus on state goals and strategies (the what) at the expense of logics (the why). Taking a cue from studies of neoliberalization (Brenner et al., 2010; Castree, 2008a; Peck, 2010), I argue for greater attention to how logics of green development are shaped by geography – the material characteristics of places, their ideological constructions, and the local actors and institutions remake and contest central state programs and policies. Green development has multiple interpretations, even within an authoritarian party-state: it encapsulates the preservationist logic of conservation and poverty alleviation, and the productivist logic of renewable energy and industrial transformation. The ways that these logics align, contradict, and are reshaped locally raise new questions about how sustainable development should be defined, the scale at which it should be determined, and who wins and loses in the process of green economic transformation.

CHAPTER 3

Rural Utility to Green Industry: Small Hydropower and the Industrialization of Renewable Energy in Xinping

3.1 Introduction

The preceding chapter documents the 'boom and bust' of small hydropower in China, driven by central state policy and local officials eager to boost tax revenues and industry in their districts. By the early 2010s, new SHP plants had been constructed on thousands of tributaries in Yunnan and western China. Yet, while the approval, monitoring, and evaluation of SHP is the responsibility of local government bureaus, the plants themselves are operated by private enterprises. During the SHP boom, these enterprises were allied with local officials who could offer guaranteed feed-in-tariffs for the sale of electricity to the grid. This chapter investigates this 'green industry' and its role in the implementation and operation of SHP plants in Xinping.

I focus on this 'green industry' because it has played a major role in the transformation of SHP from a small-scale renewable energy to an industrial electricity source, an evolution mirrored in the histories of China's solar and wind industries. Indeed, when the term 'renewable energy' first entered official Chinese discourse in the 1990s, it referred to small-scale technologies like SHP that were deployed in remote areas for off-grid rural electrification. Early government documents described these technologies as 'clean' because they were seen as replacements for 'dirty' biomass and fuelwood use in poor rural households. Government programs in the 1990s and early 2000s promoted the use of small-scale wind, solar PV, biogas, and hydropower installations in areas with poor or nonexistent grid connectivity, and many gained financing through the CDM. I refer to these systems in this chapter as 'rural renewable energy' because they primarily feed into local grids and serve a local, rural consumer base (see also Zhu, 2005, pp. 158–159). SHP, as described in Chapter 2, was the first and most widespread of these sources.

It is only in the last decade, however, that SHP came to be seen in a broader light: as a technology that could help China meet national electricity production and emissions reduction goals. This realization followed three major changes in the electricity sector in the early 2000s: the central state's extension of grid electricity access to over 99% of households, the partial privatization of electricity generation, and the availability of CDM credits. Local governments were empowered by these changes to approve privately-operated SHP plants of up to 50 MW installed capacity, and grid companies were required to purchase SHP electricity (J.-H. Wang et al., 2015). The result is that China's SHP installed capacity nearly tripled between 2004 and 2015, spawning a vast SHP industry made up of private investors, operating companies, turbine manufacturers, and engineering, procurement, and construction management firms. SHP thus has a dual role in China: as an energy source and fuel wood substitute for rural areas, and as a green industry generating electricity alongside large-scale renewable energy systems.

This chapter argues that the transformation of SHP from a rural utility to a green industry – prompted by state policy and by private investors – has put electricity revenues and emissions reductions ahead of rural development and conservation. I specifically analyze the economic and political incentives for investors and local officials in Xinping to construct large-scale SHP systems – that is, cascaded systems with multiple plants of a high installed capacity – and then to operate these systems throughout the year. Investors favor large-scale systems because they produce greater amounts of electricity for sale to the grid, and tend to operate them continuously due to rising costs, low feed-in tariff pricing, and competition from other renewable sources. Officials approve larger systems because they generate greater amounts of energy, a goal incentivized through cadre promotion criteria, potential taxation revenues, and CDM funding opportunities. This resulted in a boom in SHP construction that, while generating energy and private profits, has limited local water availability and reduced stream flow. This case thus exposes the trade-offs of privatizing and integrating rural renewable energy into national production networks without strong local environmental and social safeguards, suggesting that these systems must be designed and managed to prioritize local needs.

The remainder of this chapter is structured as follows. First, I review scholarship on rural renewable energy in the Global South, focusing both on its role in rural development and efforts to increase electricity access through carbon offsets and private finance. I then highlight the lack of scholarship on the scaling up and privatization of rural renewable energy systems, both in China and more broadly. This sets the stage for the next section, which examines the industrialization and privatization of SHP in China and Yunnan, placing it in the context of rural electrification, forest protection, and renewable energy policies described in Chapter 2. Third, I describe my research methodology and case study of Xinping county. Fourth, using evidence from Xinping, I detail the profit motivations and political incentives that influence local actors to construct large-scale SHP systems and operate them throughout the year. Finally, I conclude with implications for studies of rural renewable energy as a green industry and make specific suggestions for improving SHP governance in China and re-focusing attention on providing local benefits.

3.2 From rural utility to green industry

Existing scholarship on rural renewable energy focuses on two related areas of research. The first is a (now longstanding) inquiry into the relationship between rural energy and rural development – specifically, issues of energy access and affordability, forest degradation, and outcomes of rural electrification for incomes, education, and health (Ashworth and Neuendorffer, 1982; Gamser, 1980, Haines et al.; 2007, Winkler et al.; 2011). One of the goals of these studies is to determine appropriate models of small-scale renewable energy that are low-cost, equitable, and affordable for poor consumers (Kaygusuz, 2012; Palit, 2013). A second, more recent set of work examines rural renewable energy in the context of efforts to reduce global carbon emissions, both locally and globally (Schroeder, 2009; Yan and Zhu, 2011). Research in this vein primarily investigates the incorporation of rural renewable energy into global carbon markets, with some scholars highlighting that carbon offsets prioritize carbon mitigation over rural development (Olsen, 2007; Bumpus and Liverman, 2011). In response, other scholars point out the need for private finance to limit reliance on carbon markets and enable the industry to become self-sustainable (Deichmann et al., 2011; Mainali and Silveira, 2011). In this section, I review this literature and situate small hydropower in China as an example of rural renewable energy turned green industry – a case that offers insights into the growth and scaling up of these technologies in other parts of the world.

Scholarship on the relationship between rural renewable energy and rural development mainly focuses on its role in rural electrification for communities without national grid access. Often implicit to these studies is the concept of the ‘energy ladder’, or a hierarchy of fuel sources corresponding with socioeconomic status in which ‘traditional’ biomass is at the bottom, and modern electricity is at the top (van der Kroon et al., 2013). Studies building on this concept highlight that burning traditional biomass causes exposure to indoor air pollution (Mishra, 2003), is inefficient and time-consuming to collect (Liu et al., 2008), and can exacerbate deforestation and land degradation (Heltberg et al., 2000). Moreover, research suggests that without modern electricity, poor households have difficulty raising their incomes because they cannot access modern services or devote time to employment and education (Cabraal et al., 2005).

Rural renewable energy offers a potential way out of this spiral without the high costs associated with grid extension or reliance on diesel generators. Case studies show that solar, wind, and SHP systems can provide electricity for lighting and agricultural processing for a relatively low cost (Byrne et al., 2007; Urmee et al., 2009). In some cases, poor villagers can also form rural cooperatives and purchase a small-scale system, which they then use to generate electricity for sale to wealthier villagers and pay off the initial loan (Biswas et al., 2001). Scholars recognize that rural renewable energy access is not a 'silver bullet' solution to poverty – it must also be affordable and situated within a broader rural development framework – but that it does provide a means to replace traditional fuels, improve productivity, and enable rural people to access modern services. For these reasons, and despite reservations about cost and intermittency, rural renewable energy systems have gained mainstream recognition as a poverty alleviation and forest protection tool (Haines et al., 2007; Ottinger and Williams, 2002).

Beyond rural development, several studies also analyze the role and contribution of rural renewable energy to carbon emissions reductions. This is particularly important in the context of global sustainable development and 'green economy' (UNEP, 2011) discourse and policy. International institutions such as the World Bank (2012) and the Inter-Governmental Panel on Climate Change (IPCC) (2014) have identified rural renewable energy as a solution to the two-fold challenges of rural development and low-carbon growth. Moreover, since 2000, rural renewable energy project developers have been able to apply for CDM funding initiated through the Kyoto Protocol. Scholarly work on CDM-financed rural renewable energy has identified benefits to rural communities in accelerating energy access and promoting entrepreneurship (Lloyd and Subbarao, 2008), while also highlighting that the high transaction costs of applying for CDM funds favor large-scale projects (Olsen, 2007), that funded projects would have been constructed even without CDM funds (Ghazoul et al., 2010), and that projects in many cases have exacerbated social and economic inequality in rural communities (Sutter and Parreño, 2007).

Given these issues with carbon offsets, and uncertainty over the future of the CDM and carbon pricing, some rural renewable energy promoters and experts have called for increased private finance in small-scale systems (Huang, 2009; Mainali and Silveira, 2011; World Bank, 2012, The Climate Group, 2015). At the national scale, rural renewable energy is still highly reliant on government funding, such as equipment and power generation subsidies, tax exemptions/ reductions, and financial support for household electricity connections (Mainali and Silveira, 2011). Households or rural cooperatives generally purchase solar, wind, or small hydropower systems through local dealers, or pay a fee-for-service to an operating company that collects payments and provides long-term maintenance. Yet case studies have shown that private renewable energy companies are unable to access sufficient credit to expand their operations (Huang, 2009; Urmee et al., 2009). Private investors view off-grid small-scale systems as high risk due to the difficulty of collecting fees, low profit margins, and uncertainty about government policies to extend the grid to rural areas (World Bank, 2012; The Climate Group, 2015). Instead, investors prefer industrial systems that are grid-connected. Rural renewable energy promoters recognize these risks, but hope the high growth potential and favorable policies will enable small-scale energy companies to mature into profitable green enterprises, capable of meeting rural electricity needs and contributing to national and international low-carbon growth in a way that offsets cannot.

Yet, while scholars have analyzed different models of investment and ownership of rural renewable energy (Biswas et al., 2001; Byrne et al, 2007; Martinot et al., 2002), few studies investigate actual cases of scaling up into a green industry. This is primarily because rural renewable energy remains small-scale and reliant on subsidies and offsets in most areas of the Global South. But small hydropower in China is different: investment in SHP has grown rapidly over the last decade, transforming what was once a small-scale and off-grid source of rural electricity into a private for-profit industry. Private investment poured into the sector following electricity sector reforms and grid extension in the mid-2000s, with many investors taking advantage of CDM and carbon offset funding (Cheng et al., 2015). SHP is now one of China's largest renewable energy industries measured by total installed capacity. Government officials still state that a main purpose of SHP is to drive rural development, but no research has examined whether or not this is the case. Indeed, the implications of such a rapid industrialization of rural renewable energy – particularly an increase in the size, number, and operating time of installations – remains unexplored in the literature, both in China and more broadly. This chapter addresses this gap by investigating what rural renewable energy turned 'green industry' looks like on the ground, and the consequences of these developments for local communities.

3.3 The industrialization of SHP in China

3.3.1 China's SHP industry

What is the SHP 'green industry' in China, and how has it driven SHP industrialization? This section answers these questions by describing the actors and institutions involved in SHP in China, and their role in the expansion and scaling up of SHP plants. By 'green industry', I refer to commercially-oriented firms that generate economic value through environmental activities (such as through renewable electricity generation). While the SHP policies described in Chapter 2 aimed to encourage SHP expansion in China, it is the SHP industry that constructs, operates, and manages the plants themselves.

The most prominent members of the SHP industry are private investors, the most whom are based in the eastern provinces of Zhejiang, Fujian, and Guangdong. The private firms range dramatically in size: some are one-person operations, while others are subsidiaries of large energy conglomerates involved in many kinds of renewable and fossil-fuel based projects (including, often, large hydropower projects). Small firms are generally established for the exclusive purpose of investing in and operating an SHP plant or cascade. To do this, firms must obtain a business license from the local government authority, purchase river development and land use rights along the tributary of interest, obtain a commercial bank loan, and consult with township- and village-level cadres about compensation for affected households. Often, small firms will pool investment capital from several private individuals, rather than pay higher interest on a commercial loan. In contrast, large enterprises or conglomerates tend to be involved in all aspects of the SHP industry, from turbine and powerhouse equipment manufacturing, to design, investment, and operation.

In addition to private firms, however, the SHP industry also includes local government officials who conduct river basin planning, approve SHP design and construction, and conduct monitoring and evaluation of SHP operation. SHP oversight is the responsibility of the local Bureau of Water Resources, while river basin planning and SHP plant approvals are conducted by the local Development and Reform Commission.[1] As Chapter 2 documented, officials approved thousands of new SHP plants during the 2000s in order to increase local tax revenues and reduce the need for electricity imports from elsewhere in the CSPG network. At times, the line between state and private sector SHP interests could become blurry: one SHP expert in Kunming described

---

[1] Whether SHP falls under the responsibility of the prefecture or county is determined by its installed capacity. In Yunnan prior to 2016, SHP plants ≤10 MW of installed capacity were approved at the county level, plants between 10-25 MW were approved at the prefecture level, and plants between 25-50 MW were approved at the provincial level. After 2016, all plants must be approved at the provincial level. These regulations are set by the provincial government and differ between provinces.

cases where local cadres would spin off their own SHP investment enterprise and use their *guanxi* (关系, literally, ‘connections’) to obtain financing and development rights (I interviewed one company with this background in Xinping). The point here is that there is not an antagonistic relationship between private investors and local officials. Rather, local officials (at least during the 2000s boom) actively seek out and facilitate SHP investment while turning a blind eye to problems like dry season operation and stream dewatering.

Finally, in addition to private firms and local officials, the SHP industry also includes the provincial power grid company and its local subsidiaries. Since electricity reforms in 2002, the national electricity grid has been overseen by two different state-owned grid companies: the State Grid Corporation of China and the CSPG. The CSPG is comprised of provincial subsidiary companies that operate the grid in each province, including the Yunnan Power Grid (YPG). These provincial grid companies are further subdivided into prefecture- and county-level branches. Under this nested structure, the local grid subsidiary is responsible for most of the grid infrastructure and electricity dispatch for its administrative area. When required, the local grid company will liaise with the grid company at the next highest administrative level to either ‘import’ electricity to meet higher demand, or ‘export’ excess electricity to another region. Moreover, local grid companies are responsible for investing and constructing electricity lines and transformers in their districts (high-voltage transmission is the responsibility of the provincial grid company or the CSPG). Local grid companies are thus major players in the SHP industry because they determine where in the county or prefecture that private firms can invest in SHP plants that do not require their own extensive transmission infrastructure.

3.3.2 Privatizing and scaling up SHP in Yunnan

The emergence of the SHP industry coincided with a rapid increase in the number, size, and annual generation of SHP plants in Yunnan and western China. This increase was, in part, a response to the changing policy landscape described in Chapter 2, particularly subsidies for rural electrification counties in the 1980s and 1990s, and later support for SHP as a renewable energy technology in the mid-2000s. By the late 1990s, the central state had also raised the definition of SHP to 50 MW, allowing local governments the ability to approve larger plants. The late 1990s also saw major central and provincial investment outlays in state grid extension to townships and villages in western China that previously operated prefectural or local grids (Peng and Pan, 2006). Local governments in Yunnan augmented state investment with construction of new local transformers and electricity distribution infrastructure. The conditions were thus ripe in the early 2000s for the SHP industry to build new, larger plants in longer cascades. Fig. 3.1 provides a timeline of growth in installed capacity and annual generation for SHP of all sizes in Yunnan since 1995.

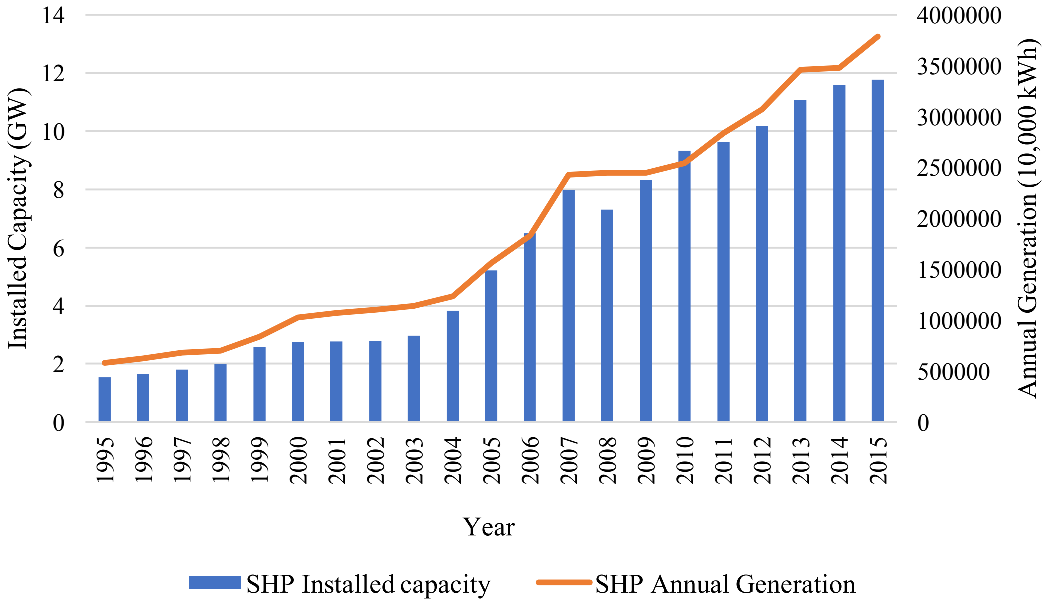


Fig. 3.1: *Installed capacity and annual generation of SHP in Yunnan, 1995-2015 (Data source: EPS China Data, 2017)*

As shown in Fig. 3.1, Yunnan's SHP installed capacity increased five-fold between 2000 and 2015, from 2.2 to 11.6 GW. Two main factors account for this growth, in addition to the policy and investment landscape described above. The first, and arguably the most important, was the privatization of electricity generation as a consequence of power sector reforms in 2002. Chinese leaders had already allowed some foreign and privately-owned companies to invest in the large power sector in the late 1990s to meet rapidly rising electricity demand (J.-H. Wang et al., 2015, p. 5), and in 2002, this was extended to all generation activities, including SHP. Yunnan, which still had a great deal of unexploited SHP potential, was well placed to channel this increased private investment into new stations and cascade systems, and SHP construction grew rapidly across all prefectures. New stations were nearly all privately-owned, and local governments had to sell off (privatize) much of their older SHP assets. As of 2015, 80.8% of SHP stations in China are operated by private companies (Cheng, 2015).

Second, the availability of CDM funding since the early 2000s has been a major driver of SHP construction in Yunnan. CDM 'offsets' are designed to allow industrialized countries to reduce their CO_2 emissions under the Kyoto Protocol by investing in renewable energy and climate mitigation projects in low-income countries (Erlewein and Nüsser, 2011; Teng and Zhang, 2010; Hepburn, 2007). Based on my analysis of publicly available CDM data (UNEP and DTU, 2016), I found that China has received more CDM funding than any other country, and boasts approximately two-thirds of global registered SHP CDM projects (62.6% of projects and 68.5% of global installed capacity using the <50 MW definition). Of these, Yunnan itself contains 164 of all worldwide registered 1,047 SHP CDM projects and 15.9% of global SHP CDM installed capacity (18,036 MW). For SHP investors in Yunnan, the CDM provided additional funds that made SHP an even more financially attractive investment because investors could earn back their initial outlay more quickly. The CDM thus primarily benefitted private investors and contributed to the boom in SHP construction in Yunnan.

Fig. 3.2 displays the growth in SHP of different size classes in Yunnan in the period 2008-2011 (unfortunately a longer data time series is not available). Fig. 3.3 displays growth in annual generation for different size classes for the same period. Note that despite the short time frame of Figs. 3.2 and 3.3, the growth in SHP plants 10-50 MW is still very evident.

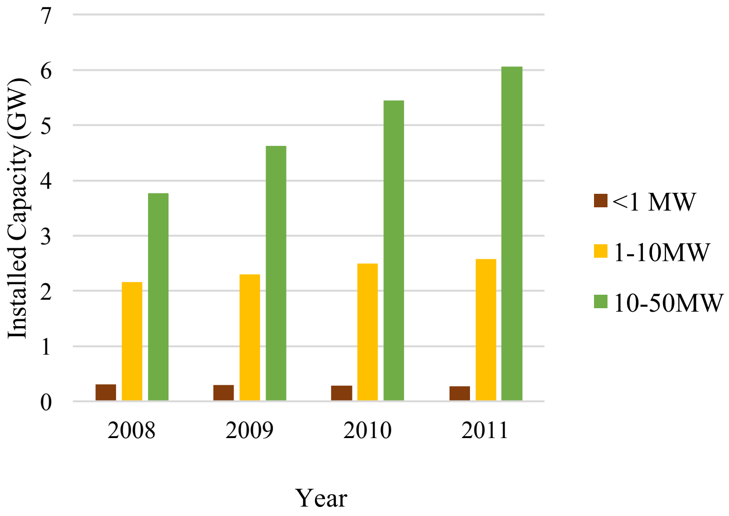


***Fig. 3.2:** Installed capacity of SHP in Yunnan of different size classes, 2008-2011 (Data source: EPS China Data, 2017)*

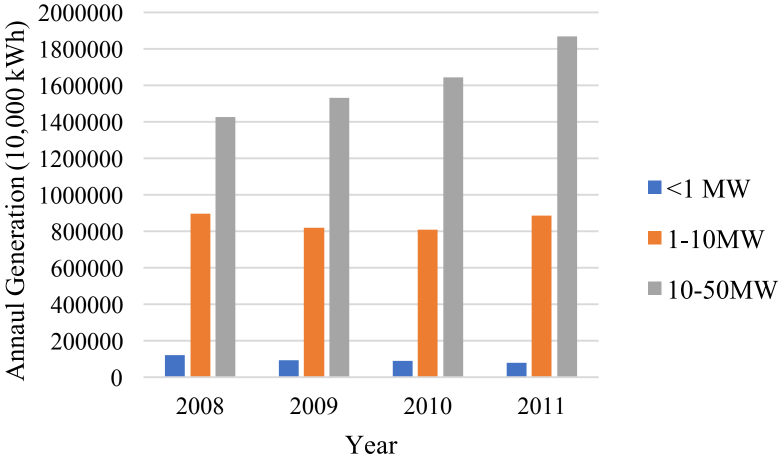


***Fig. 3.3:** Annual generation of SHP in Yunnan of different size classes, 2008-2011 (Data source: EPS China Data, 2017)*

Amid this growth, however, SHP remains an anomaly in Yunnan's and China's overall energy landscape, because it is the only rural renewable energy that makes a measurable contribution to national electricity production. Indeed, it is 'rural renewable energy'[5] even though nearly all plants are now grid-connected and account for 6.5% of China's total electricity production in 2014. Other grid-connected renewable energy technologies, such as large hydropower, wind, and solar PV, are large-scale installations that are not considered to be 'rural', since they do not have a history of providing off-grid electricity for rural development like SHP. Moreover, while the Chinese government does indeed claim that large hydropower provides rural development benefits (Tilt and Gerkey, 2016; Wilmsen, 2016), these facilities are entirely state-owned and require major infrastructure investments that must be approved at the central government level. From this perspective, SHP is unique because it shares the rural development and local conservation objectives of other green development programs in China, such as forest and grassland protection (J. Liu et al., 2008; Yeh, 2005), but also leads to the intensification of water and land use common to large hydropower projects built to supply electricity for urban consumers (Magee, 2006). This intensification is the result of the transformation of SHP into a 'green industry' that seeks out profit. These issues are described in the following sections.

3.4 Field site

To analyze this transformation of SHP in China, I conducted interviews between July-December 2015 in Xinping county in Yuxi prefecture (Fig. 3.4). I interviewed officials in all county-level government bureaus in Xinping that are involved in SHP approval or implementation, as well as the county office of the CSPG. These interviews asked about central and provincial government subsidies, the approval process for SHP, SHP governance and operation, and impacts of plants on farmers, stream flow, and forest cover. I also interviewed the directors of five SHP operating companies and the operators of 18 SHP plants (out of 25 in the county) to investigate investor behavior, sources of finance, and management strategies. In addition, I also conducted interviews with township water management and agricultural extension officials in Xinping, and interviewed over 50 farming households living adjacent to SHP plants. These households came from different ethnic groups, but were primarily Han (the majority ethnicity in China) and Dai, an ethnic minority group in Yunnan with a population of approx. 1.1 million. These interviews provided insight into the on-the-ground implementation and impacts of SHP. All interviews were conducted in either Mandarin Chinese or the local Yunnanese dialect; if the interview was in the dialect, a research assistant from Yunnan Normal University translated into Mandarin.

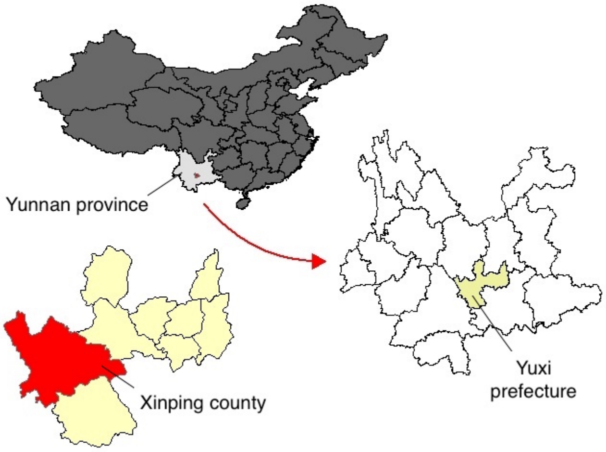


***Fig. 3.4:** Location of Xinping county in China*

Other foreign scholars who have examined large-scale hydropower and water resources projects in China have highlighted the sensitive political environment that makes it difficult to obtain information from officials, much less visit plants and interview nearby residents (Dore et al., 2007; Magee, 2006). Magee and McDonald (2006, p. 52) suggest that this is because of government concerns about international activists fanning local opposition to dams, but it is also due to potential trans-boundary impacts of large dams located near China's international borders

(Hennig, 2016). I took a different approach: instead of framing this project as ‘hydropower’, I introduced my research as ‘rural renewable energy’, which has a much more positive connotation associated with conservation and rural electrification. Somewhat surprisingly, officials in Xinping (and in Kunming, the provincial capital) were also willing to talk about problems with SHP, without being prompted. This is mainly because officials believe that negative impacts on water access and stream flow can be blamed on private investors or mistaken local managers, rather than a concerted effort by the provincial or central government. In contrast, actual electricity generation and consumption data from SHP plants proved impossible to obtain, as these data are considered state secrets. Nevertheless, while interview respondents were no doubt selective in the information they disclosed, they provided a comprehensive picture of SHP in Xinping and its impacts.

3.5 The small hydropower ‘green industry’ in Xinping

This section analyzes how SHP in Xinping is constructed, operated, and managed. I highlight the profit motivations and political incentives for investors, plant operators, and local government officials to construct large-scale SHP plants, and then to operate them continuously throughout the year. First, *profit motivations* drive SHP investors and plant operators to sell as much electricity to the grid as possible. This was due initially (in the mid-late 2000s) to the financial attractiveness of large plants, and more recently to a profit squeeze from the high costs of SHP construction, the feed-in tariff price for SHP, and competition from other renewable energy industries. Second, *political incentives* influence local government officials to prioritize energy generation from SHP plants, due to cadre promotion criteria, the potential to earn revenues from SHP plants, and the possibilities to use SHP for local industrial development. In practice, this means that many SHP stations have a high installed capacity, are in cascade systems, and operate during periods of water scarcity, which can limit water available for irrigation and harm river and riparian ecosystems. In what follows, I detail these profit motivations and political incentives and show how they can create consequences for local water access and environments in Xinping.

3.5.1 Profit motivations

Since the electricity sector in China was opened to market competition in 2002, nearly all new SHP plants have been constructed and operated by private enterprises. Many county-level governments that constructed SHP stations in previous decades sold them to private investors; others retained shares in existing plants and partner with hydropower companies to build new facilities on remaining streams (Kong et al., 2015). In Xinping, data from the Bureau of Water Resources show that out of the 25 existing SHP plants in the county, 19 are fully owned and operated by private enterprises, and the remaining 6 are managed by a state-owned subsidiary of the energy giant Datang Corporation. None of these plants count local officials as investors. All plants are connected to the CSPG. Thus, the main goal for investors is to bring in a steady profit through electricity sales to the grid, spurring them to construct multiple plants with a high capacity that can be operated continuously throughout the year. The initial reason for this approach in the mid-late 2000s was the ease and financial attractiveness of SHP investments, but in the last 2-3 years has been influenced structural constraints that squeeze profits, particularly the initial transaction costs of building new SHP plants, the need to obtain a quick return on investment, and competition from other renewable sources.

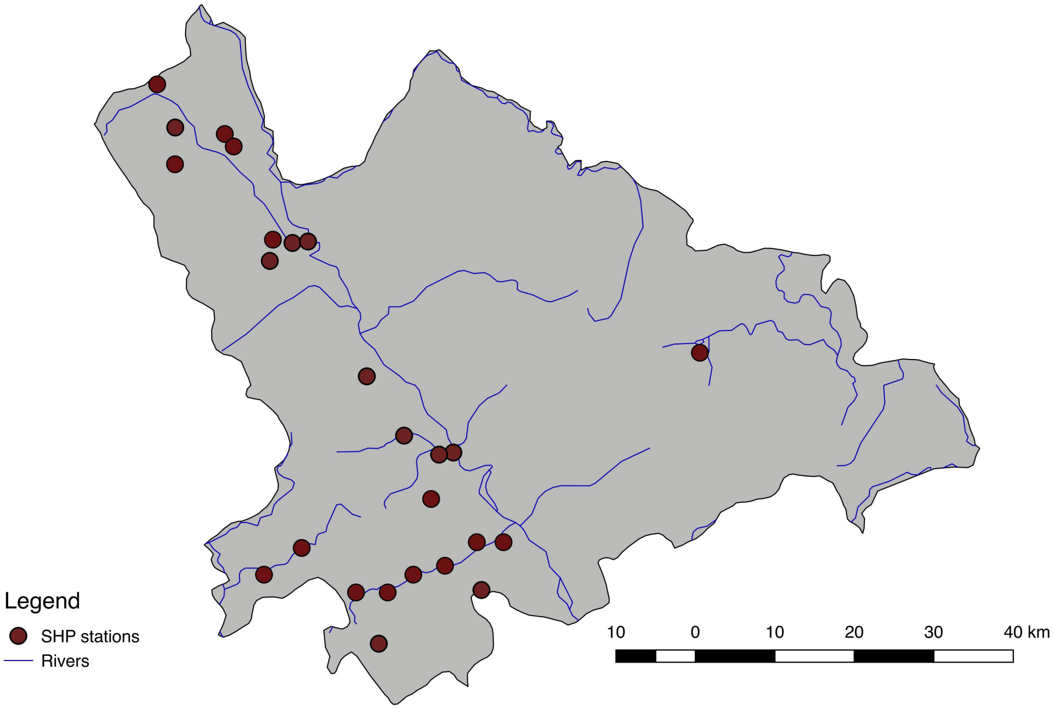


Fig. 3.5: *Map of SHP stations in Xinping*

The period 2002-2015 were the boom years of SHP development in Xinping. According to one investor, the county and prefectural governments at the time were highly encouraging of SHP construction, and sought to attract capital-rich investors from eastern China (particularly Zhejiang and Fujian provinces, where SHP in China originated). Local officials in Xinping would point out favorable sites to potential investors, then assist with streamlining approvals through the county or prefectural Development and Reform Commission. One company manager mentioned that the government guaranteed his plant a 'good' feed-in tariff price during these early years (he would not say how much), which lowered the financial risk of investment. The actual size and number of plants depended both on the site and the ability of the investor to raise capital. In Xinping, five of the six companies that invested in plants since 2000 constructed more than one plant; of the 15 plants that were built, 13 are in multiple cascade-type systems of two stations or more (the longest is seven stations). This scaling-up trend was not confined to Xinping: Li et al. (2013) note that the number of cascaded systems and average installed capacity of SHP rose across Yunnan during this period. Given China's rapid growth and the favorable policy environment during this years, investors could construct larger plants and still expect to earn back their investment in 8-10 years.

More recently, however, investors have experienced a profit squeeze, due to higher construction costs, a lower feed-in tariff, and competition from other sources. First, many investors spoke in interviews of the high costs of SHP plant design, construction, and management, as well as a much longer process of gaining approvals from the local government than in the past. Before construction can begin, investors must establish a limited liability corporation and register with the county; then, the company seeks the services of an SHP consultancy to provide design, procurement, testing, and maintenance services. Even for a small plant, these services can cost tens of millions of yuan. After purchasing utilization rights from the county government, the investment company must also apply for and fund an environmental impact assessment and water resources assessment, as well as a feasibility study – reports which are much more comprehensive today than during the early boom years. Moreover, according to the manager of one company, daily wages for construction workers had risen from 30-40 yuan a few years ago to 100 yuan, adding to the initial costs of building a plant. Taken together, this gives incentive to investors to seek out sites with high capacity and multiple-plant potential, and to operate existing plants for as many hours as they can.

Second, private SHP enterprises seek to earn back their initial investment as soon as possible, given growing uncertainties in the policy environment for SHP and an increased risk of prolonged dry seasons. Investors in Xinping grumbled that SHP plants constructed during the mid-late 2000s could recoup costs in 8-10 years, but that new facilities require up to 15 years of operation before turning a profit. This is due to rising initial costs of construction, but also to the current low feed-in tariff price for selling SHP electricity to the grid. The SHP feed-in tariff in Yunnan is currently 0.2 yuan/kilowatt hour (kWh), down from a peak of ~0.3 yuan/kWh several years earlier when the SHP boom was in its early stages.[2] Such a price drop puts a squeeze profit margins, so much so that several private SHP companies in Yunnan banded together to write a letter to the provincial government to protest the current tariff rate. This issue is unlikely to be resolved in their favor, and energy experts in the provincial capital believe that the tariff rate for small hydropower may drop further in the next few years. Moreover, in addition to changing feed-in tariff, investors in Xinping are faced with longer and more severe drought, which affects their ability to operate plants at full capacity year-round. Xinping (and Yunnan province) suffered a prolonged drought between 2009-2014, and given that SHP plants in Xinping have little or no storage capacity, plants were forced to reduce output during the driest months of March-June. One operator stated that his company would be satisfied with running only one of two generators for 4,500 hours per year (or just over 12 hours/day), but even this goal is difficult to obtain. Such pressures mean that investors will try to continue operating plants during water stressed periods if they are able to do so.

Third, SHP is steadily losing ground as the favored renewable energy source for rural areas to solar and wind, and is also unable to compete on costs with large hydroelectric dams. This competition takes the form of subsidies from the central and provincial governments and differentials in feed-in tariff rates. In the late 1990s, Xinping was included as a ‘rural electrification’

---

[2] According to a CSPG employee, this reduction in the feed-in tariff for SHP was due both to an over-supply of SHP electricity that could not be transmitted through existing infrastructure, and to government support for other renewable energy types (particularly solar and wind).

county, and SHP plants were eligible to receive subsidies of up to 20% of the costs of construction. However, except for one 4MW plant enrolled in the ‘SHP Replacing Fuel Wood Program’, SHP stations in Xinping built after the mid 2000s are not subsidized. This contrasts with the recent increase in solar and wind installations in Yunnan, which are promoted at the highest level of government and offered construction and feed-in tariff subsidies. Currently, the feed-in tariff for solar in Yunnan is 0.95 yuan/kWh, and for wind it is 0.61 yuan/kWh, both much higher than the 0.2 yuan/kWh for SHP. In addition, SHP investors have little political power compared with state-owned hydroelectric firms that dominate Yunnan’s energy sector and receive low-interest loans backed by government guarantee. The result is that investors construct bigger SHP plants in cascades, which offers more stable generation than wind or solar and is more competitive with large dams on price.

Other than Datang Corp., investors in Xinping do not have unlimited sources of capital; most companies draw on a combination of personal savings of multiple investors and bank loans. For them, recouping investment costs within 8-10 years has become difficult, and in some years, plants do not earn a profit at all. Thus, private companies are pressured to operate multiple stations with a high installed capacity, and to keep generators running even during the dry season and droughts. In Xinping, given that SHP plants are all grid-connected, increasing size and extending operating time does not offer benefits for local residents – electricity is merely transmitted to the grid for sale. Residential and industrial customers in Xinping pay electricity prices like those elsewhere in Yunnan, and receive no subsidies for using SHP (except for in one township, as detailed in the next paragraph). Thus, privatizing SHP has led plant operators to place profit first, such that the industry prioritizes the production of electricity for sale.

3.5.2 Political incentives

Since the early 2000s, the central government's main motivations for promoting SHP have been the 'SHP Replace Fuelwood' program and renewable energy generation, with the latter gaining in importance over time. In Xinping, forest cover and quality had steadily declined during the Mao era and early reform period, and the county was enrolled in national-level efforts in the early 2000s to protect remaining forest and plant trees on steep cultivated slopes (Wang and Huang, 2006). In addition to these ongoing forest measures, the county government also promoted SHP as a fuelwood substitute, particularly in mountainous villages located above 1,000 meters in elevation. Only one SHP plant in Xinping, however, has received central government subsidies specifically earmarked for the 'SHP Replacing Fuel Wood' program, and this plant only provides discounted electricity to residents in one township. Other townships in the county were already connected to the China Southern Power Grid before SHP expanded in the 2000s. In practice, then, the major driver of government support for SHP in Xinping today is not fuel wood replacement, but renewable electricity generation for sale. This privileging of the renewable energy function of SHP is influenced by cadre promotion criteria, potential taxation revenues from SHP, and the availability of carbon offset funding. This incentivizes Xinping officials to exploit all available SHP potential in the county and approve cascaded systems.

First, since environmental protection criteria were included in the 11th Five Year Plan (2006-2010), local officials in Xinping have sought out ways to promote ecological protection and 'green' local industries. In the mid-2000s, the county government encouraged SHP to bolster its forest protection credentials, and reducing fuel wood collection through electricity provision became a promotion criteria for cadre officials (also see J.-H. Wang et al. 2015, p. 9). More recently, however, emissions reductions through renewable energy have been included in county government targets, prompting the local Development and Reform Commission to approve plants in areas that already have high electricity uptake. While the county government did not receive fiscal transfers from the province or central levels for SHP construction, officials were highly encouraged to attract outside investment and boost the share of renewable energy in the county's energy portfolio. Thus, Xinping officials see the remaining 32 GW of 'exploitable' SHP potential in the county as a source of renewable energy revenue, even if potential sites are in fragile environments or have potential to disrupt water uses and hydrology.

Second, in addition to promotion criteria, local officials also approve SHP plants because they provide taxation revenues for the county and the prefecture. The county collects tax from the initial land sale, from the allocation of water extraction permits, and from the ongoing operation of SHP. Even though SHP has preferential taxation rates – 3% value-added tax (instead of 6% for conventional power plants) and 10% income tax (instead of 25%) – this still adds up to a considerable revenue for the local government. I was unable to obtain actual taxation data for Xinping county, but was told in several interviews that it is substantial; one informant estimated that one plant could generate 3 million RMB (~$450,000) in revenue each year. Moreover, an SHP expert familiar with Xinping officials suggested that investors and operators also provide 'informal' services to the government – such as financing New Year celebrations. This aligns with the findings of J.-H. Wang et al. (2015), who note that officials and investors in another Yunnan prefecture would often ask each other for informal favors to streamline SHP development. Thus, it is in the local government's interest to approve as many plants as possible, and allow them to operate throughout the year.

Third, like other counties in Yunnan and southwest China, several SHP projects in Xinping received funding from the CDM. The heyday of funding availability occurred between 2002-2011, after which CDM credits rapidly lost value in the global market. To apply, investors in Xinping hired a carbon offset consultancy (generally based in Beijing or Guangzhou) to determine the internal rate of return and additionality[7] of the proposed project. These reviews examined potential capacity of the SHP site, expected operating time per year, financing requirements, and anticipated revenues; all project documentation is available to the public. In theory, CDM finance should be provided to projects with an internal rate of return of less than 10%, in which case the sale of carbon credits would make the proposed plant economical. This approach favors smaller SHP stations that obtain a low feed-in tariff for electricity. In practice, however, CDM funds in Xinping mainly accrued to larger or multiple-cascade stations, owing to the high initial costs and expertise required to apply for funds. Bigger stations constructed in a cascade are also attractive to the buyers of offset credits, since their transaction costs are lower than those of small plants. In total, of the 15 plants constructed in Xinping after 2000, 6 are CDM projects; the largest, the Dachun River cascade, consists of three plants that together have 56 MW of installed capacity. This is greater than the combined installed capacity of all non-CDM plants in Xinping constructed after 2000.

The result of these political incentives in Xinping is an SHP industry that is ‘green’ by virtue of its contribution to renewable energy production, a major goal of Chinese leadership. Officials still pay lip service to the role of SHP in rural electrification and forest protection, but in private conversations admit that it does very little of either. In Xinping, only one SHP station transmits discounted electricity directly to households to substitute for fuel wood, and no county-wide study has been conducted on the effects of SHP on forest cover. The real trend has mirrored that of private SHP investors: to build projects with a high installed capacity, to string stations together in a cascade system, and to require plants to operate for at least 4,500 hours per year. Moreover, the Xinping government has approved an additional seven SHP projects totaling 67MW of installed capacity. This intense focus on energy production contributes to significant water stress and hydrological impacts in rural Xinping.

3.6 Conclusion: Small hydropower as a green industry

This chapter has argued that the transformation of small hydropower in China from a rural utility to green industry is characterized by the construction and operation of large-scale SHP plants in rural areas that exacerbate water scarcity. This process is grounded in the history of rural electrification and energy policy in China. In its early years, off-grid SHP plants generated electricity for rural lighting and industry, and are credited with providing initial electricity connections to hundreds of millions of rural residents. After national forest protection measures were instituted in the late 1990s, SHP took on the function of local ecological protection, and the government shifted subsidies for plant construction to remote areas of southwest China. At the same time, these areas became suppliers of renewable electricity, and the SHP industry and electricity sector were privatized to attract investment in new stations. This rapid development of SHP in the 2000s is framed as renewable energy production for low-carbon growth: not only do stations generate electricity, but also emissions reductions, thus contributing to China's overall climate change mitigation targets. In places like Xinping, however, profit motivations and political incentives have spurred the construction of multiple high-capacity cascade systems, which often continue to operate in water-stressed periods. In many cases, this can reduce water available for irrigation and harm aquatic species and riparian vegetation. Only plants subsidized with government funds in Xinping provide discounted electricity for local residents, and even these can cause negative impacts in the absence of government oversight and attention to farmers' needs. Xinping offers a representative case study because its SHP development and consequences mirror that of other counties in China; it can thus serve as a benchmark for future comparison.

The findings of this chapter suggest a need to be skeptical about the benefits of privatizing and scaling-up rural renewable energy to try and achieve multiple goals simultaneously – a conclusion shared with studies of green development programs more broadly (Adams, 2009; Blom et al., 2010; Bumpus and Liverman, 2011). This is especially the case because of the nature of renewable energy generation: that it can lead to the intensification of resource use that can exacerbate water and land scarcity under certain conditions. Yet, while this chapter illustrates this process in China's SHP industry, it is not unique to SHP, nor to China alone. Recent studies of rural large-scale solar installations and biofuel crops in China (Chen, 2013; Rousseau, 2014) analyze how agricultural land is repurposed for manufacturing and for generating green electricity, and the impacts on rural livelihoods that result. Unlike SHP, solar and wind installations do not affect water resources and availability, but can alter land uses in ways that privilege energy production over local agricultural and economic production. The Chinese government's plan to rapidly increase solar and wind installations by 2020 (He et al., 2016), many of them located in rural areas, has the potential to exacerbate these consequences. Outside of China, scholars have documented the expansion of SHP plants in India and Nepal, some of which are grid-connected and privately owned and operated (Bergner, 2014; Gurung et al., 2012; Nautiyal et al., 2011). As in China, profit motivations and political incentives may influence SHP investors, plant operators, and government officials in these regions to prioritize electricity generation over local needs.

But what is to be done about small hydropower in China? Can the consequences of large-scale SHP for local areas be managed? I make three recommendations for SHP regulations in China, some of which are already being put into place. First, government officials should comprehensively assess new projects and regulate existing projects, such as through evaluation criteria, enforcement provisions, and funds for alternative energy sources and industries. The

Yunnan government recently required all SHP plants to be approved at the provincial level, which is a step in the right direction. Such a regulation should also require comprehensive, in-depth scientific studies of SHP potential, so that only sites with appropriate (hydrological and geological) features are developed, and that their damage to the local ecology is reduced. Second, the government should make a discursive and policy distinction between SHP plants for electrification in remote areas, and those constructed in areas already connected to the grid. Such a move would acknowledge the potential impacts of SHP on water resources and promote better oversight of SHP operators. Third, SHP engineers and design firms should aim to limit interbasin diversions that artificially increase the potential capacity of SHP plants, and limit the size of new stations so that they can operate continuously most of the year without disrupting water uses and hydrology. This approach could also potentially mitigate negative environmental impacts and water diversions in parts of watershed that reduce water access. More broadly, both the government and observers must recognize the trade-offs that often result from privatizing and scaling-up SHP, and that the aims of rural renewable energy production should take local communities' needs into account.

CHAPTER 4

Is Small Beautiful? Social Impacts of Rapid Small Hydropower Development in Xinping

4.1 Introduction

The previous chapters demonstrate how state and private actors drove a boom in China's small hydropower construction in the early 2000s. Compared to older plants, SHP stations built in the last decade have a larger installed capacity, are situated in cascades, and tend to continue operating during dry periods. My interviews with officials, plant operators, and farmers in Xinping county revealed that SHP can limit water available for irrigation, without providing any clear livelihood benefits for rural households. In a sense, this is the opposite of the original intention of SHP in China: to be a driver of rural development and conservation.

Yet while these interviews highlight some of the impacts of SHP that *can* occur, they do not tell us whether or when these impacts *will* occur, or their implications for agricultural production and rural livelihoods. Moreover, it is not clear how the benefits and consequences of SHP are distributed between different communities and households. SHP plants are unlike large dams in that their impacts can vary significantly within the same watershed and power supply network, even between villages that are adjacent to the same cascade. Thus, to evaluate the impacts of SHP in China, we need to identify the factors that shape them in different contexts.

This analysis comes at a time when the perceived benefits of SHP schemes are increasingly questioned by the policy and academic communities (Abbasi and Abbasi, 2011; Bakken et al., 2012). Traditionally, SHP has been viewed as a 'green', pro-poor technology because of its small environmental footprint and ability to generate reliable electricity for rural households (Bakis and Demirbas, 2004; Nautiyal et al., 2011). Unlike large dams, which tend to be built for regional- or national-scale purposes, SHP plants privilege local energy provision and economic development (Mainali and Silveira, 2011; Mishra et al., 2015). However, recent work in China's Nu River valley (Kibler and Tullos, 2013) has shown that the cumulative ecological impacts of cascaded SHP plants can equal or surpass those of large dams. Moreover, Hennig and Harlan (2017) argue that overdevelopment of SHP can reduce irrigation water access for farmers. Still, no studies examine the types of social impacts that can result from SHP, nor the factors that determine how, where, and when impacts occur. Such analysis is essential to ensure that SHP remains a green alternative to large hydropower, and this chapter aims to fill this gap.

In this chapter, I analyze two social impacts of SHP that are prominent in scholarly literature and in Chinese policy documents: its positive contribution to reducing fuelwood collection, and its negative effect on restricting irrigation water access. The first, reducing fuelwood collection, occurs when households replace the burning of biomass with electricity generated from SHP (Nautiyal et al., 2011). Combined with other forest conservation measures, SHP can thus help to prevent deforestation and land degradation (Gamser, 1980; Heltberg et al., 2000). Reducing fuelwood collection has been a key goal of China's SHP policy since the early 2000s, exemplified by the 'SHP Replace Fuelwood' program (Cui and Qu, 2008). This chapter analyzes the conditions in which SHP increases electricity take-up and reduces fuelwood collection at the local level in China today.

The second impact, irrigation water access, can affect communities situated alongside cascaded SHP systems (Hennig et al., 2013; Hennig and Harlan, 2017). Reduced access occurs when SHP plants divert streamflow from the natural river course and/or existing irrigation canals during the dry season (or dry periods). SHP plants do not actually consume this water, but through diversions they can make it unavailable for farmers who depend on gravity-fed irrigation. This, in turn, affects crop yields and the income derived from them. This chapter examines the conditions in which irrigation water restrictions are likely to occur, and their impacts on smallholder agriculture.

To analyze these two impacts, I and students from Yunnan Normal University conducted a survey of 122 households living adjacent to SHP plants in Xinping county. Eight different village clusters were surveyed, each located next to a different SHP plant and with varying topographical, economic, and social profiles. Survey questions focused on electricity use and fuelwood collection, irrigation water use and access, and changes to agricultural production (such as cropping patterns and the renting of land to agribusinesses).

The results of the survey reveal, first, that increased electricity use in Xinping corresponds with reduced fuelwood collection. However, electricity uptake is largely a function of its price per kilowatt-hour[1], not the existence of an SHP plant per se. Thus, while fuelwood collection has decreased county-wide, *only households that receive subsidized electricity report benefiting from SHP*. Second, results show that *irrigation water access is limited for households with farmland situated below a plant's diversion canal*. The severity of this water scarcity differs based on the size of the plant, the village's irrigation infrastructure, and whether plant operators release water in dry periods. These impacts can force farmers to change their crops or construct water-saving irrigation systems to overcome water restrictions. Overall, these findings suggest that, in the absence of electricity subsidies, SHP plants today provide few benefits, and can have negative consequences for smallholder agricultural production.

The rest of this chapter is organized as follows. First, I review the literature on the social impacts of large and small hydropower projects, focusing on electricity and irrigated agriculture.

---

[1] In China as in other countries, the price of electricity is measured in kWh. In Chinese, a kWh is commonly referred to as a unit (度).

I argue that while the social impacts of large dams are relatively well known, the impacts of SHP projects – which are often viewed as a ‘green’ alternative – are less known. Second, I describe my survey design and selection methodology, and provide an overview of the case study village clusters in Xinping. Third, I analyze changes to household electricity use and fuelwood collection in Xinping, and draw on qualitative data to argue that these changes are mainly a function of price, rather than the existence of an SHP plant alone. Fourth, I analyze reduction in irrigation water access due to SHP diversions and identify the relative location of farmland and plant water management practices as main explanatory factors. I then conclude with broader social implications of the use of SHP systems in China and other parts of the world.

4.2 Social impacts of hydropower: Is small beautiful?

4.2.1 Social impacts of large hydropower

The scholarly literature is replete with studies of the environmental and social impacts of large dams and hydropower schemes (see Kirchherr et al., 2016) Proponents of large hydropower point to enhanced water quality and security, the reduced loss of life and property from major floods, increase in cropland productivity, and stable energy generation as positive benefits that contribute to economic and social development (Billington and Jackson, 2006; ICOLD, 2017). While studies from this perspective recognize the social impacts of large dams, they suggest that impacts can be mitigated through rigorous social and environmental impact assessments and integrated rural development programs that compensate those affected (Frey and Linke, 2002). Here, the view is that the benefits to the economy and society at large outweigh the costs borne by rural communities. National governments have signed on to this perspective, resulting in a boom in large hydropower construction in the last decade, many of which are funded and constructed by Chinese policy banks and state-owned enterprises (Zarfl et al., 2015).

Other studies, in contrast, argue that the environmental and social costs of large dams far outweigh any benefits that they might provide (Ansar et al., 2014; Tilt et al., 2009; Ziv et al., 2012). The World Commission on Dams (WCD) report, published in 2000, stated that "in too many cases an unacceptable and often unnecessary price has been paid to secure benefits," including resettlement, loss of productive farmland, loss of ecosystem diversity, and negative impacts on rural livelihoods (WCD, 2000). Richter et al. (2010) estimate that 472 million people worldwide have impacted by dam-induced changes to river flow, while Scudder (2011) finds that up to 200 million people have been displaced. These social impacts fall disproportionally on rural people living adjacent to and downstream from dam sites and cascades (Lerer and Scudder, 1999; Tilt and Gerkey, 2016).

Not only do rural communities bear the brunt of impacts, but they also receive few of the benefits that hydropower is supposed to provide. Siciliano et al. (2015) argue that, particularly in developing countries, large hydropower projects are built to increase electricity access in urban areas, and rural residents may not receive any electricity benefits. In the Chinese case, Magee (2006) shows how hydropower construction in Yunnan province – an area with high levels of poverty – is aimed at generating energy for industrial and urban development in southeastern China. A detailed study of the Manwan hydropower project in Yunnan found that rural areas adjacent to the dam experienced higher electricity costs and chronic energy shortages (Tilt et al., 2009, p. S255). In this case, the electricity generated by the dam project is transmitted through high voltage lines directly to other parts of China; it is not transformed and dispatched for local use. A recent review of dam scholarship (Kirchherr et al., 2016) concludes that large hydropower projects tend to do little to increase electricity access or stability in adjacent areas, though the broader benefits to the national economy (including electricity and revenues) can be substantial.

Similar distributional problems plague the provision of water for irrigation from large dams. Many hydropower and/or water storage dams also manage and release flows to coincide with downstream irrigation needs (Kadigi et al., 2008). In a widely-cited study, Duflo and Pande (2007) show that agricultural productivity increases downstream from large irrigation dams while vulnerability to rainfall shocks declines. However, agricultural productivity in the vicinity and upstream of the dam is often reduced due to submerged cropland, waterlogged or saline soils from dam seepage, and restrictions on water uses (2007, pp. 607–608). In addition, Barbier and Thompson (1998) argue that irrigation dams also impact floodplain communities further downstream, due to productivity losses from agriculture and aquaculture and the reduction in fuelwood. Dams that generate power and release water for irrigation complicate matters further, since times of peak energy demand (and thus water release) do not always coincide with irrigation needs or natural flow cycles of rivers (Kadigi et al., 2008; Lacombe et al., 2014). Overall, it is rural communities living upstream, adjacent to, and far downstream from dams are the most affected by their consequences, and the least likely to benefit from enhanced electricity access and irrigation control.

4.2.2 SHP and rural electrification

Given the unequal distribution of the benefits of large hydropower, there is a long-standing (and still growing) movement to prioritize small hydropower schemes (Dursun and Gokcol, 2011; Frey and Linke, 2002). There is a considerable variety of these types of projects. Some schemes with small dams mainly serve water storage and irrigation purposes; others may be primarily used for electricity generation. Moreover, certain diversion-type 'run-of-river' SHP projects do not have a dam at all, instead using a diversion channel to draw flow through the plant and release it back into the original stream channel (Paish, 2002). Some scholars and policy-makers prefer small projects because their social and environmental impacts are considered much less severe (Ansar et al., 2014). Indeed, small schemes are generally designed to provide water storage, flood control, irrigation, and/or energy benefits to adjacent communities – the same areas that are most negatively affected by large hydropower.

The local electricity benefits of SHP schemes have received considerable attention in the literature on rural renewable energy (Biswas et al., 2001; Cabraal et al., 2005; Zhang et al., 2009). Much of this work focuses on the use of off-grid SHP systems as a replacement for traditional fuels, such as agricultural residues, fuelwood, and/or charcoal. Studies have shown that burning traditional biomass causes exposure to indoor air pollution (Mishra, 2003), is inefficient and time-consuming to collect (G. Liu et al., 2008), and can exacerbate deforestation and land degradation (Heltberg et al., 2000). Moreover, research suggests that without modern electricity, poor households have difficulty raising their incomes because they cannot access modern services or devote time to employment and education (Cabraal et al., 2005).

SHP offers a potential way out of this spiral without the high costs associated with grid extension or reliance on diesel generators (Byrne et al., 2007; Urmee et al., 2009). In some cases, poor villagers can also form rural cooperatives and purchase a small-scale system, which they then use to generate electricity for sale to wealthier villagers and pay off the initial loan (Biswas et al., 2001). Scholars recognize that SHP is not a ‘silver bullet’ solution to poverty – it must also be affordable and situated within a broader rural development framework – but that it does provide means to replace traditional fuels, improve productivity, and enable rural people to access modern services. For these reasons, and despite reservations about cost and intermittency, SHP has gained mainstream recognition as a rural electrification and forest protection tool in the Global South (Haines et al., 2007; Ottinger and Williams, 2002).

4.2.3 Is small hydropower beautiful?

Yet recent work also shows that the social benefits of SHP can be somewhat limited, and its negative impacts at times quite severe. The major limitation is electricity generation itself. Unlike large hydropower, SHP schemes (especially diversion-type run-of-river) have little water storage capacity, and thus cannot regulate power supply to meet peak demand (Bakken et al., 2012; Paish, 2002). Conversely, most SHP plants cannot store water during periods of high rainfall, so that excess flow is not utilized. This is a significant problem for plants that are not connected to the wider grid infrastructure because they cannot fill generation gaps with electricity imports or exports. Overall, such instability can lead to power cuts for SHP-dependent communities and higher electricity prices to smooth out fluctuations in generation (Bakis and Demirbas, 2004). Some areas have used a combination of mini-grids and government subsidies to ensure greater stability, but results are mixed, with some households continuing to use diesel generators and/or fuelwood (Mainali and Silveira, 2011; Urmee et al., 2009).

To avoid generation instability altogether, some areas have constructed multiple, larger SHP plants along the same watershed, often (but not always) regulated by a dammed reservoir at the head of the cascade. Due to their inherent connectivity, cascaded SHP projects can more easily respond to changes in rainfall and electricity demand by controlling the output of multiple turbines. Moreover, SHP cascades with a reservoir can continue to operate during dry periods when many diversion-type run-of-river plants must switch off entirely. Examples from China (Zhang and Kumar, 2011; Zhou et al., 2009) show that SHP developers often seek out existing water storage and/or irrigation dams that can be repurposed for hydropower regulation. In these cases, SHP schemes become part of multi-purpose local water management infrastructure.

Along with larger SHP plants and cascades, however, comes the potential for greater environmental and social impacts that begin to resemble those of large hydropower projects. Cascaded SHP systems can limit streamflow or de-water entire river sections if several plants merge directly into each other.[2] While the effect of moderate de-watering from one SHP plant is almost negligible, the consequences of de-watering over an entire cascade or sub-catchment can be severe (Kibler and Tullos, 2013; Pang et al., 2015). These impacts from flow reduction include reduced aquatic biodiversity (Fu et al., 2008), barriers to fish migration (Shen and Diplas, 2010), channel erosion – due to changes in the natural flow regime (Baker et al., 2011) – and effects on riparian vegetation. Recent work (Abbasi and Abbasi, 2011; Kibler and Tullos, 2013) highlights that the cumulative impacts of cascaded SHP can equal or surpass those of large dams.[3] In addition, as the previous chapter showed, water diversions and stream de-watering can lead to reduced water access for local farmers that may depend upon SHP systems for irrigation.

Yet, although scholars have identified the potential impacts described above, no research has examined the factors that determine when and whether they will occur, nor how they are distributed between communities. This is important for at least two reasons. First, the definition of SHP encompasses a wide range of plant types, from mini facilities of <1 MW installed capacity to cascade systems made up of multiple 20-50 MW plants that are regulated by a dam. Isolating the factors that reduce water availability can thus shed light on the types of SHP schemes most appropriate for different types of communities. Second, though SHP projects are clearly smaller than large dams, their positive and negative impacts may still not be evenly dispersed.

---

[2] This means that the water that flows out of one plant (the 'tailrace') immediately enters the diversion canal of the next plant, without re-entering the main stream.

[3] Though the type and degree of impacts is dependent upon local conditions, such as flow volume, gradient, substrate, species diversity, vegetation and soil type, and other factors.

Understanding how these costs and benefits are distributed, and what causes them, will enable better planning and management of future SHP facilities, in China and elsewhere.

4.3 Methods

4.3.1 Field sites and selection methodology

Data for this chapter were primarily derived from a survey of 122 households conducted over two weeks in Xinping county. The aim of this survey was twofold: first, to quantify the livelihood impacts (positive and negative) of SHP plants in Xinping, and second, to isolate the key explanatory variables that determine the degree or severity of impacts *at the village level*. Because the number of households surveyed was relatively small, and limited to one county, the results are not in the conventional statistical sense representative of all villages in China with SHP. There are simply too many factors – environmental, political, economic – that affect the construction and operation of plants, the impacts that they can have, and the community response to them. Instead, I use the survey to compare villages in the same study area, which enables me to identify the village-level household, community, and institutional factors that shape SHP implementation and impacts. I then triangulate these survey results with qualitative interview data collected before, during, and after the survey itself.

Achieving these aims required selecting multiple survey sites adjacent to SHP plants in Xinping. On one hand, all survey sites needed to have electricity access and be agricultural communities with gravity-fed irrigation. Nearly all villages located in Xinping's Red River Basin fit these general characteristics.[4] On the other hand, survey sites needed to differ in many respects, including: elevation above sea level, size and length of adjacent plant/cascade, types of crops

---

[4] 99.9% of households in China have electricity access as of the end of 2016. In Xinping county, the last community to gain an electricity connection did so in 2008.

grown, extent of agricultural area, date of electricity connection, and household characteristics (including education and income). My goal was to ‘thread the needle’ between selecting sites based on variables that I deemed to be important – which I derived from qualitative interviews – and selecting sites at random. Relying on the former method would potentially cause selection bias; relying on the latter might make the sample less representative of Xinping as a whole.

In the end, I used a spatial methodology to select eight clusters of villages adjacent to eight different SHP plants. First, I separated all SHP plants in Xinping’s Red River Basin into six categories based on the township in which they are situated. Three of the townships (Jianxing, Mosha, and Shuitang) had more than twice as many plants as the other three townships (Yaojie, Gasa, and Zhelong). Thus, I chose two village clusters in each of the first three townships, and one village cluster in two of the other three townships (Gasa township does not have an SHP plant). This method provided a spatial distribution of sites north-south along the entire length of the Red River watershed in Xinping county.

To select the actual village clusters *within* these townships, I subdivided SHP plants further into stand-alone and cascade-type systems, larger or smaller than 10 MW installed capacity, and those located at a higher elevation (> 800m) and lower elevation (< 800m).[5] I then selected plants in each township so that these characteristics were evenly distributed.[6] Finally, once the plants themselves were selected, I visited the main administrative village adjacent to the plant and obtained basic information about the surrounding natural villages, including number of households. Based on these data, I then randomly selected 1-3 natural villages located within the administrative

---

[5] In Jianxing township, which is entirely located above 800m, I selected one village cluster at 2,100m elevation, and one at 1,700m elevation.

[6] I selected two plants each in Jianxing, Mosha, and Shuitang townships that together covered all four of these characteristics. I then did the same for the remaining two plants in Yaojie and Zhelong townships.

village for the survey itself. The number of natural villages selected depended on the density of settlement in the area adjacent to the plant. The number of total households in the selected village clusters ranged from 87 (Dingcun village) to 520 (Shangfeng village).

The site characteristics of each of the administrative villages is given in Tab. 4.1, and their locations are shown in Fig. 4.1. Note that the per capita income of upland villages is smaller than that of lowland villages. This is due to the higher land fertility and better connectivity of lowland villages in Xinping. Village names have been changed to pseudonyms to protect identities.

Administrative village	**Elev. [m]**	**Pop.**	**Adjacent plant**	**Date plant built**	**Plant installed capacity**	**Common crops**	**Cultivated land (*mu*)**	**Per capita income (¥)**
Upland Villages								
1. Fukang	2025	1596	Malu	2010	4MW	Corn, Tobacco, Walnuts	2121	4235
2. Cuiheng	1700	1397	Wajiao #3	1991	10MW	Corn, Tobacco, Peaches, Bamboo, Walnuts	1782	4352
3. Nanjie	835	1680	Nabanqing	2006	10MW	Bananas, Sugar Cane, Corn, Walnuts	3195	2173
4. Shangfeng	1130	3058	Dachun #1	2008	30MW	Sugar Cane, Corn, Walnuts	930	1764
Lowland Villages								
5. Wantang	666	3657	Wajiao #7	2005	8MW	Bananas, Chili Peppers, Lychees	3192	5772
6. Beiye	551	3454	Nanjian #1, #2	2006	2.5MW 2.5MW	Bananas, Sugar Cane, Mangos, Lychees	8043	9204
7. Dingcun	615	1955	Dachun #2	2007	20MW	Citrus, Sugar Cane, Rice	1539	9760
8. Zhufan	770	1350	Yaocun #2	2013	3.2MW	Bananas, Citrus, Sugar Cane, Corn	1433	7979

Tab. 4.1*: Survey site characteristics*

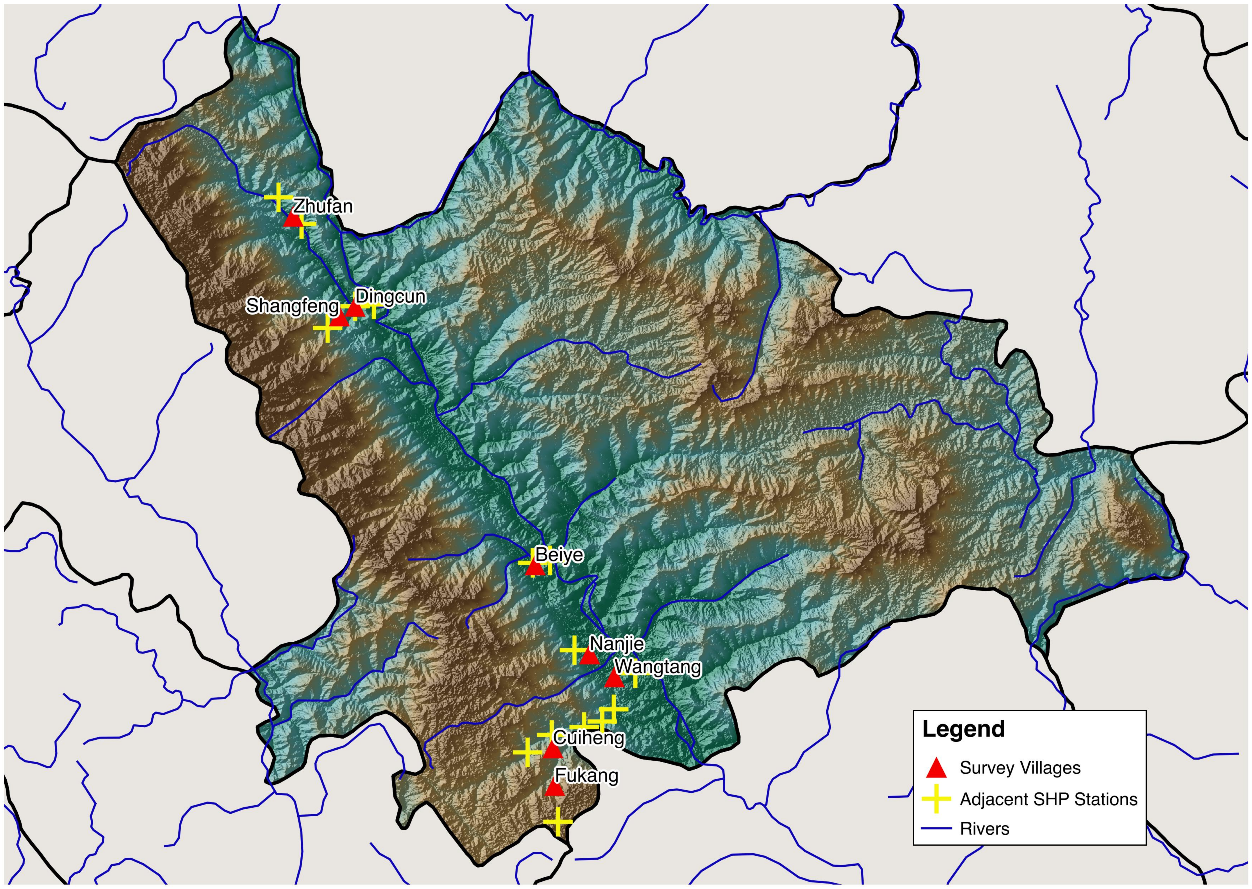


Fig. 4.1*: Map of survey sites and adjacent SHP stations*

4.3.2 Survey administration

The survey was designed, piloted, and administered in October-December 2015. My collaborator at Yunnan Normal University, Prof. Xu Rui, recruited four Masters students to assist with survey administration and coding. My research assistant who accompanied me on previous trips to Xinping also joined the survey team, for a total of six administrators. In October 2015, my assistant and I made two week-long trips to Xinping to select survey sites and pilot the questionnaire. We conducted ten pilot interviews in five different villages that I had selected as field sites using the methodology described above. Following the pilot phase, we revised the questionnaire. I then reviewed the questionnaire exhaustively with each of the survey administrators, and each administrator practiced a survey simulation in front of the entire group before conducting on-site interviews. English and Chinese versions of the survey are provided in the appendix.

In December 2015, we returned to Xinping to conduct the survey over two weeks, returning to Kunming during the weekend. We split into three teams of two people each. At each natural village, we aimed to survey just over 10% of households (our average was 12.5%, or one in every eight households). We were unable to access an up-to-date list of names or maps of homes from the village committee or village head.[7] Instead, we went door-to-door contacting respondents. Administrators were instructed to approach every eighth house; if no one was present, they were to approach the adjacent house. Each team was assigned a different area of the village to minimize overlap.

We attempted to interview residents of both genders and of a range of ages; however, this was largely dependent upon chance. If both a male and female were present, the male tended to answer questions for the household, even if the survey team initially approached the female household member. Overall, 22.8% of respondents were female, and the median age was 48. We conducted surveys from the morning until the early evening, returning each evening to the main township to debrief about the day's activities and any issues that had arisen. Of all surveys administered, two (out of 122) are incomplete due to respondents requesting that the interview be terminated.[8] Basic household data for each village cluster are given in Tab. 4.2.

---

[7] Such lists and maps do exist and are generally held by the administrative village committee. However, they do not contain information about which households are still present in the village (rather than just holding a residence permit, while living elsewhere), and often do not contain accurate addresses.

[8] In both cases, the respondent said that they were busy and needed to return to their work.

Village cluster / Natural village	Total households	Households surveyed	% sampled	Median household size	Median highest education	Mean age	% Female	Median Household Income
Upland Villages								
1. Fukang	**176**	**15**	**8.5%**	**5**	**2**	**57**	**33.3%**	**5500**
1.1 Zhongzhaicun	77	8	10.4%	4	2	58	37.5%	5250
1.2 Hongpotou	72	4	5.6%	5	2	52	25.0%	5250
1.3 Yanzijiao	27	3	11.1%	6	1	60	33.3%	9000
2. Cuiheng	**186**	**18**	**9.7%**	**5**	**2**	**55**	**16.7%**	**15000**
2.1 Wajiao	186	18	9.7%	5	2	55	16.7%	15000
3. Nanjie	**88**	**11**	**12.5%**	**5**	**3**	**40**	**27.3%**	**15250**
3.1 Nabang	27	4	14.8%	5	3	43	0.0%	20000
3.2 Yakou	27	3	11.1%	5	2	38	33.3%	2250
3.3 Liangzitian	34	4	11.8%	5	3	41	50.0%	12500
4. Shangfeng	**520**	**21**	**4.0%**	**5**	**2**	**41**	**33.3%**	**20000**
4.1 Nanda	520	21	4.0%	5	2	41	33.3%	20000
Lowland Villages								
5. Wangtang	**129**	**15**	**11.6%**	**5**	**3**	**50**	**20.0%**	**21500**
5.1 Shangmangui	37	5	13.5%	4	3	52	0.0%	20000
5.2 Xiamangui	48	5	10.4%	5	2	55	20.0%	20000
5.3 Shanghuiqu	44	5	11.4%	5	3	43	40.0%	46500
6. Beiye	**98**	**14**	**14.3%**	**5**	**2**	**48**	**0.0%**	**25000**
6.1 Xiaokai	25	4	16.0%	6	2	49	0.0%	25000
6.2 Tianfang	16	3	18.8%	4	3	45	0.0%	20000
6.3 Nan'en	57	7	12.3%	4	2	48	0.0%	30000
7. Dingcun	**87**	**12**	**13.8%**	**5**	**2**	**48**	**25.0%**	**22500**
7.1 Dawopu	48	7	14.6%	5	2	45	28.6%	25000
7.2 Xiaohebian	39	5	12.8%	6	2	52	20.0%	20000
8. Zhufan	**135**	**16**	**11.9%**	**6**	**2**	**47**	**50.0%**	**20000**
8.1 Xiaoguolin Pingzhang	135	16	11.9%	6	2	47	50.0%	20000

***Tab. 4.2**: Household characteristics*

4.3.3 Coding and analysis

Data were coded in Excel by the survey team in January 2016, and all anomalies were checked with survey administrators. Team members also transcribed qualitative responses to survey questions into a separate Word document, and made note of this response by coloring the appropriate Excel cell in yellow. I then reviewed all qualitative responses and translated them into English.

Most respondents provided answers to all survey questions, with a few exceptions. First, many either did not know or could not recall how much electricity they use in kWh (Q3 & Q4.1). This is because the electricity fee is generally deducted from a household's rural benefit card (惠农卡), so that while the respondent might know their average bill per month, s/he might not know how many kWh the household used. If the respondent answered questions about the average electricity price (Q1 & Q2.2), I would simply divide the electricity bill by the price to arrive at an average kWh per month used. If the respondent could not provide an average price or electricity bill, the answer was left blank.

Second, many respondents were unable to answer how many cubic meters (m^3) of fuelwood they collected in the past year or ten years ago (Q7.2 & Q8.2). I flagged this as an issue during pilot interviews, and tried other ways of asking the question, but found that specifying collection in m^3 was still the most appropriate since it is convertible to other measurements. Following the completion of the survey, I instructed the team to code one three-wheeled truckload (三轮车) of firewood as four m^3, and serendipitous collection as one m^3.[9] As this is a relatively unscientific means of conversion, the amount and changes to fuelwood collection described in this chapter should be read as a general trend rather than a specific accounting.

Finally, a few respondents were unwilling to divulge specifics of their annual income. This reticence to provide income details is a common issue with rural survey administration in China (see Clarke-Sather, 2012; Zinda, 2013). In general, we could obtain a total net income figure from most respondents, and data about income from specific activities from about half of all respondents.

---

[9] Using a similar rationale, I instructed the team to code the response "serendipitous collection" to questions about time spent collecting fuelwood (Q7.3 & Q8.3) as one full day. The response 'often' was left blank, since this could not be translated into a numeric amount of time.

These data are sufficient to summarize and compare average incomes between natural villages, but insufficient to compare incomes from specific activities.

4.3.4 Variables

This section describes the variables tested in this analysis and the phenomena that they aimed to measure. Binary variables were coded 1 for yes, 0 for no, and 9 for "don't know". Nominal and ordinal variables were coded according to a pre-set rubric for each question, and are explained further below. Continuous variables were input directly into the spreadsheet.

Electricity use: The survey began a question (Q1) about the current price of electricity per kWh, followed by a question set (Q2-2.2) about the electricity price prior to rural grid renovation (农网改造). Then, respondents were asked identical questions (Q3-4.1) about their current electricity use in kWh and their use prior to rural grid renovation. The purpose of these questions was to determine changes in electricity price and household use before and after grid renovation, and subsequently identify any correlations between price and use. I chose grid renovation as the key node in this timeline because qualitative interviews revealed that this was the major determinant of electricity price. Because grid renovation occurred at different times in each village, simply asking about a time in the past (i.e. '10 years ago') would not adequately capture the driver of change. Moreover, qualitative interviews established that the construction of a new SHP plant had no effect on electricity price if the plant began operation after grid renovation.[10]

---

[10] The effect of SHP plants on the electricity price was, unfortunately, difficult to measure. Seven of the eight plants adjacent to surveyed communities were constructed post-2002 and began operation after grid renovation, so respondents could not isolate the effect of SHP. In the one village that is adjacent to an older plant (Cuiheng village, adjacent to Wajiao #3 plant), older respondents could recall when the plant provided the village's first electricity connection, but could not recall price changes over time. Interviews with county-level officials confirmed that SHP plants constructed before grid renovation generated relatively less expensive electricity for rural households, but that since grid renovation the price has been set by the prefectural Development and Reform Commission.

This section of the survey ended with a question set about the existence of government electricity subsidies (Q5-5.2) and SHP electricity subsidies (Q6-6.2). Both question sets asked about the subsidy amount and how they are transmitted to households.

Fuelwood collection: With these variables, the goal was to measure changes in the amount of fuelwood collection and the purposes for which it is used. The first question set (Q7-7.3) asked about current uses of fuelwood, average amount collected in 2015, and time spent collecting it in 2015. A second question set (Q8-8.3) was identical except that it asked about fuelwood use and collection ten years prior (approx. 2005).

Irrigation system: These variables aimed to identify common irrigated crops in the village and the existence of drip or spray irrigation systems. The first question (Q9) asked about the number of *mu* of irrigated farmland (田) cultivated by the household, and a second question (Q10) asked which crops are irrigated. We then asked if the household had constructed its own irrigation system, either by themselves or in partnership with another household (Q11). If the respondent answered affirmatively, we asked about the type of system, persons involved in construction, extent, cost, and subsidy availability (Q11.1-11.6).

Irrigation water availability: These variables represent the bulk of the survey, and aimed to identify the degree, timing, drivers, and impacts of water availability for irrigation. The order of questioning was particularly important here. Even though respondents were aware that the survey was about SHP, we did not want to bias responses by asking leading questions about water access. Thus, this section survey began with two sets of questions about changes to water use (Q12-12.2) and availability (Q13-13.2) and their drivers. Then, we asked if their water use situation had changed after the SHP plant began operation (Q15), and followed up with a question set (Q16-

16.1) about whether they must inform plant operators when their household requires irrigation water.

We then homed in on the effects of the plant itself, asking two sets of questions about reduction in water access due to the SHP plant (Q17-17.5), and the existence of conflict with the SHP plant (Q18-18.5). These question sets included variables about the timing, agricultural impacts, and resolution of these water availability issues and conflicts with the SHP plant. Finally, we asked a question set about conflict within and between villages over irrigation water use (Q19-19.3).

SHP impacts (positive and negative): These are qualitative variables that aimed to determine villagers' overall opinions toward the SHP plant, and any additional positive impacts of SHP on local job creation. The first question asked about the effects of the SHP plant on the local watershed (Q20). A second question asked if the respondent's household had been consulted about plant construction, and if so, by whom (Q21). The following two questions asked about the number of villagers employed in plant construction (Q22) and current operation (Q23). Finally, a binary variable question asked if the SHP plant had led to any changes to their household livelihood (Q24). If yes, qualitative responses were recorded, which I then coded into a new variable as either positive impacts, negative impacts, or both.

Agricultural practices: These variables aimed to establish a baseline of agricultural practices in the surveyed villages to determine the types of communities in which impacts of SHP might occur. These variables are not included in any statistical analyses, but rather help to establish the types of farm practices currently used in Xinping, and their distribution across different sites. The first two questions (Q25-26) asked about the number of *mu* of paddy land (田) and dry land (地) cultivated by the household. Next, respondents were asked to fill out a table of the crops that they currently grow, the extent of cropland in which they are grown, and their average price per kilogram (kg) in 2014 and 2015 (Q27).[11] The next question (Q28) asked about general changes to the crops cultivated over time; this was transcribed as a qualitative variable.

Forest management and cultivation: Like the variables above, this set of questions aimed to establish a baseline of forest management practices and cultivation. The first question set (Q29-29.1) asked if forest land in the village had been distributed (分) to households[12], and if so, how many *mu* of forest land the household managed. The next question set (Q30-30.1) asked if the household grew any tree crops (known as 'economic forest', or 经济林), and if so, to list them in a similar manner to agricultural crops in Q27 (number of trees and price of product in 2014 and 2015). The last question (Q31) asked if households received Sloping Land Conversion Program (退耕还林) subsidies, and if so, the number of *mu* of farmland that they converted to forest land.

Renting of land: This question set sought to determine the extent of land rentals among surveyed villages in Xinping. These variables primarily provide a baseline for comparison between villages. Questions in this set (Q32-32.9) asked about the amount and type of land rented, type and origin of renter, amount of rental income, and qualitative responses about why the household rents land and whether they believe this trend will continue (or pick up) in their village.

Household demographics: Finally, the survey concluded with basic household demographic data, including age of respondent (Q33), ethnicity of respondent (Q34), education level (Q35, coded ordinally), number of household members (Q36), and a question set on the number, location, and

---

[11] For tree crops, the number of *mu* cultivated was input into the spreadsheet as number of trees cultivated (棵树). For sugar cane, price per kg was input as price per ton.

[12] Beginning in the mid-2000s, the central government instituted a new policy of subdividing community-held forest land into individual plots. This policy has been progressively rolled out across forested villages in China, and has only been partially implemented in Yunnan (He, 2014). All villages in this survey had subdivided some of their forest land and kept a portion under communal management.

income derived from household members working outside the village (Q37-37.3). The last question then asked respondents to list their total net household income and income from specific activities (Q38). The survey ended with an open-ended question (Q39) about their opinions of the survey and any additional comments.

4.3 Electricity and fuelwood

This section reports on and analyzes changes to electricity use and fuelwood collection in Xinping. As described in earlier chapters, SHP has long been promoted by the state as an electricity source for remote, mountainous villages without access to reliable energy. In the Red River Basin in Xinping, where the survey sites are located, many lowland villages received their first electricity connection in the early-mid 1970s. This electricity was exclusively generated by SHP and distributed via low-voltage township grids to rural households. Upland villages, due to their more remote location, were not fully electrified until the early 2000s.[13] These upland villages are poorer than their lowland counterparts, and receive more monetary assistance from the state. Location-based subsidies, described further below, are the major determinant of whether villagers report livelihood benefits from SHP.

4.3.1 Electricity price and usage

Xinping, like rural China more broadly, has experienced significant changes in its electricity price in the last 15 years. Before this period, electricity connections and pricing were the responsibility of the township power supply bureau. Each township in Xinping managed its own mini-grid along with one or two SHP stations. Prices for rural household electricity were set so that the bureaus could recoup costs and re-invest in new infrastructure. These prices tended to be quite high and prohibitive for poor households to use more than a few kWh for lighting and some agricultural

---

[13] Yanzijiao village, part of Fukang administrative village, did not receive an electricity connection until 2004.

processing. Surveyed households report a wide range of electricity prices during this period, from ¥0.3/kWh to ¥2.5/kWh, with a mean of ¥0.62/kWh.

These prices began to converge in the early 2000s with the establishment of the central government's 'rural grid renovation' program (农网改造). This program aimed to unify urban and rural electricity prices and management by integrating rural power grid infrastructure with prefectural, provincial, and national grids. At the national level, the government invested ¥290 billion to renovate rural grids, which decreased rural wire losses of high-voltage grids to less than 10% (Peng and Pan, 2006, p. 82). This investment was accompanied by reforms to electricity management that transformed local power supply bureaus to wholly-owned subsidiaries of provincial electricity companies (which themselves are subsidiaries of the regional grid utility). The electricity price within this institutional structure is set by the prefectural Development and Reform Commission, not the township government.

As a result of this program, electricity prices in Xinping have been de-coupled from the local electricity infrastructure. Even as Xinping added new SHP plants throughout the 2000s, the electricity price was set by the prefecture. Grid renovation in Xinping is 85% complete and has reduced the electricity price for residents of surveyed villages by an average of ¥0.46/kWh (n=74). This price is the same for nearly all households, regardless of which SHP plant they receive electricity from. We can therefore conclude that the existence of an SHP plant has no effect on household electricity use (or by extension, fuelwood collection) for villages that have undergone grid renovation. In other words, once villages are fully integrated into the national grid infrastructure, they are no longer affected by a single SHP plant or township grid.

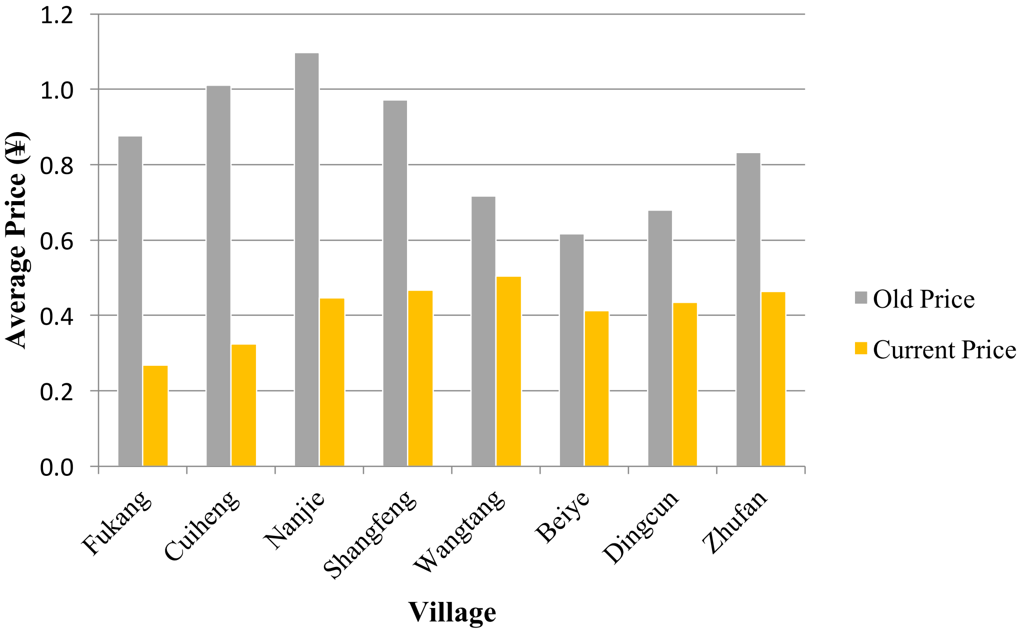
There is, however, one major exception to this rule. In the early 2000s, at the same time as rural grid renovation, the central government instituted the 'SHP Replace Fuelwood' program.

This program aimed to reduce deforestation resulting from fuelwood collection in the upper watersheds of major rivers by subsidizing electricity in poor, upland villages (Tang et al., 2012). This program provides two subsidies: 1) a subsidy to the SHP developer covering half of all construction costs, and 2) a subsidy to households in the target area that reduces the electricity price by 50%. This second subsidy may also be combined with the provision of discounted appliances (such as televisions and refrigerators) to households to encourage electricity use. SHP plants that are not part of the 'SHP Replace Fuelwood' program are not subsidized.

Of the 25 SHP plants in Xinping, only one is subsidized by the 'SHP Replace Fuelwood' program. This plant, called Malu River SHP, has 4MW of installed capacity and generates electricity for industrial and residential use in Jianxing township, which includes the surveyed upland villages of **Fukang** and **Cuiheng**. Jianxing township was chosen for the program because it is poor and considered to have a serious problem with deforestation (Interview with Xinping SFA official). Residential users in Jianxing receive an electricity subsidy of ¥0.22/kWh, a reduction of 50% of the original price. All other residential electricity users in Xinping pay the 'normal' price of approximately ¥0.45/kWh.

Changes to electricity price before and after renovation are shown in Fig. 4.2. Some 90% of respondents report a change in electricity price following grid renovation (n=112), and 93% report that the price decreased (n=99). The current electricity price in the 'SHP Replace Fuelwood' villages of Fukang and Cuiheng are lower than the other villages.

Fig. 4.2: *Electricity Price Before/After Grid Renovation*[14]

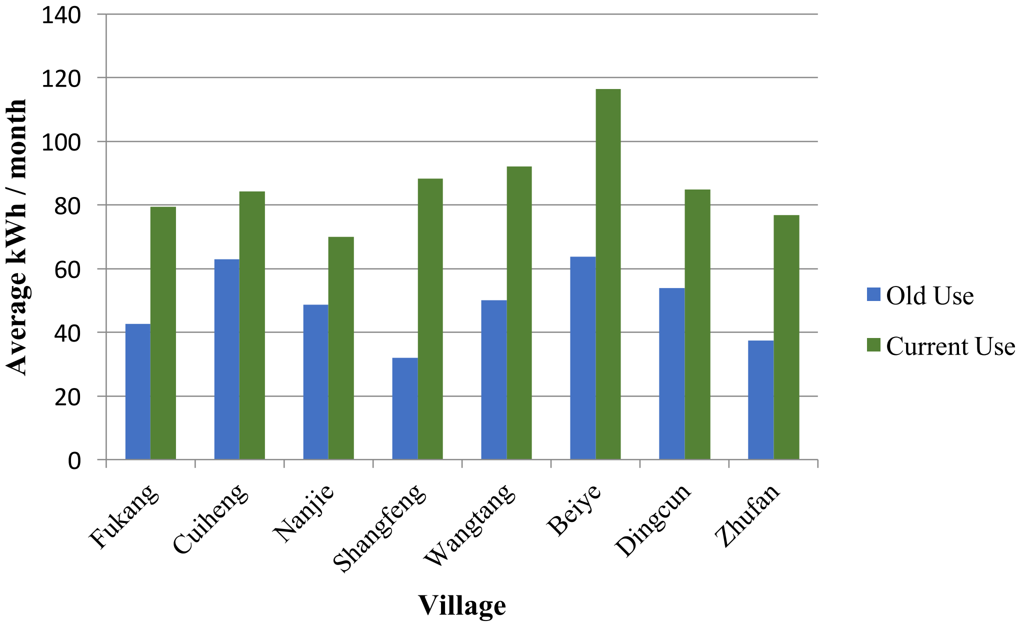


Given the reduction in electricity price in the last 10-15 years, we would expect a corresponding increase in electricity use across all surveyed villages, regardless of which SHP plant their electricity is generated from. For Fukang and Cuiheng villages, which have subsidized electricity, we would also expect increased usage. Use changes by village are displayed in Fig. 4.3. Since grid renovation, rural electricity consumption has risen in all surveyed villages, with an average increase of 52.8 kWh/month per household (n=42). Some 89% of surveyed households report a change in electricity use since grid renovation (n=102).

---

[14] For old price, n=85. For current price, n=104.

Fig. 4.3: *Average Electricity Use Before/After Grid Renovation*[15]



Of course, the price of electricity is only one factor that determines how much each household consumes. Others include family size, number and type of appliances, and household income, which vary between respondents and villages. The small sample size of this survey precludes any ability to control for these factors in a statistical analysis. We must instead examine the broad contours of the data, which show no significant difference between villages in their change in electricity use. Moreover, electricity use in the 'SHP Replace Fuelwood' villages of Fukang and Cuiheng shows a similar increase to non-subsidized villages. This suggests that subsidies in these two villages have been helpful in raising their electricity use to the average of unsubsidized villages in the Red River Basin.

Qualitative responses provide further evidence that subsidies have exerted a positive effect on electricity use. Q24 was an open-ended question that asked about any positive or negative

---

[15] For old use, n=48. For current use, n=96.

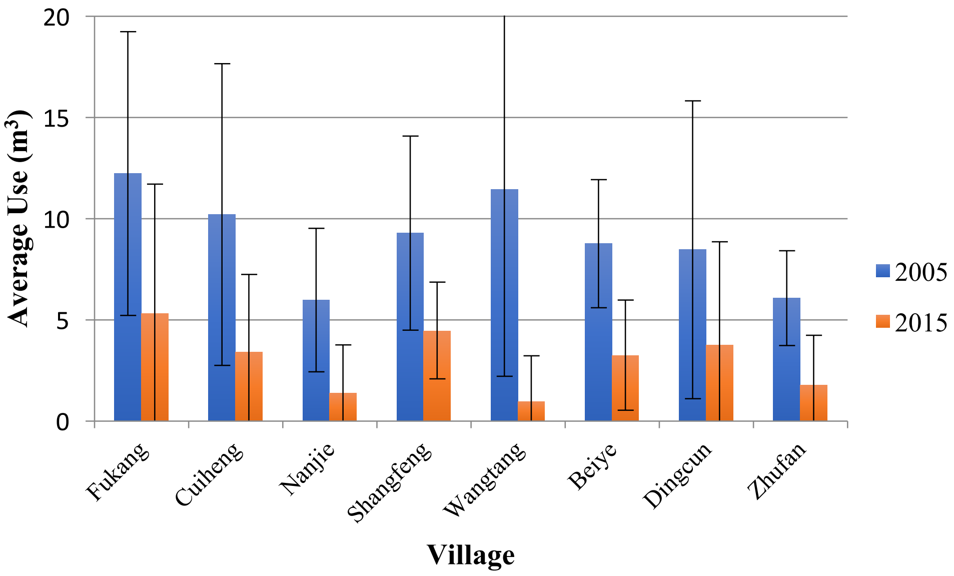
changes to a household's livelihood due to the SHP plant. In unsubsidized villages, only 11.4% (n=89) of respondents reported positive electricity benefits, and four of these households had received subsidies from a plant because their land had been used for SHP construction. This answer is unsurprising given that SHP plants have no effect on electricity prices in these villages. In Fukang, however, 33% (n=15) of households stated without prompting that electricity use is cheaper and/or more convenient because of the SHP plant. In Cuiheng, 50% of households (n=18) stated the same. Here, we can conclude that the positive electricity benefits of SHP are mainly confined to areas subsidized by the 'SHP Replace Fuelwood' project. This finding contrasts somewhat from the views of local officials, several of whom expressed that SHP provides electricity benefits county-wide. This was certainly true during the early years of rural electrification, but is no longer the case in the post-2002 SHP boom period.

4.3.2 Fuelwood usage and collection

Why is it that central and local governments aimed to increase rural household electricity use? For SHP, the main reason was to reduce reliance on fuelwood collection. As described in Section 2, collecting fuelwood is time-intensive, difficult work that reduces households' available labor-time for other income-generating activities. Moreover, burning fuelwood in poorly ventilated homes can cause respiratory illness. Our survey team conducted several interviews in the dark, mud-brick homes of upland villages while our hosts added wood to an open fire to keep warm. Even after a few minutes, my eyes and throat would burn from smoke inhalation. In contrast, the modern brick-and-tile homes of many lowland villagers had dedicated areas for burning wood, and were generally only used during large celebrations. Here, using electricity instead of fuelwood has clear health and livelihood benefits.

In Xinping, the increase in electricity use described above is mirrored by a decrease in fuelwood use since 2005. In the survey, 99.2% of households said that they used fuelwood in 2005, while 75.4% responded that they use fuelwood in 2015. Fig. 4.4 shows the average amount of fuelwood used by each village. Note that even with high standard deviations within each village sample, fuelwood use in 2015 is much less than in 2005 across all villages. The 'SHP Replace Fuelwood' villages of Fukang and Cuiheng experienced a similar percentage reduction to the other villages over the past ten years, even as they started from a slightly higher average base. That these subsidized villages display a similar trend to others is unsurprising, since the electricity subsidy has simply smoothed out differences that we might otherwise see.

Fig. 4.4: *Average Fuelwood Use, 2005 & 2015*[16]



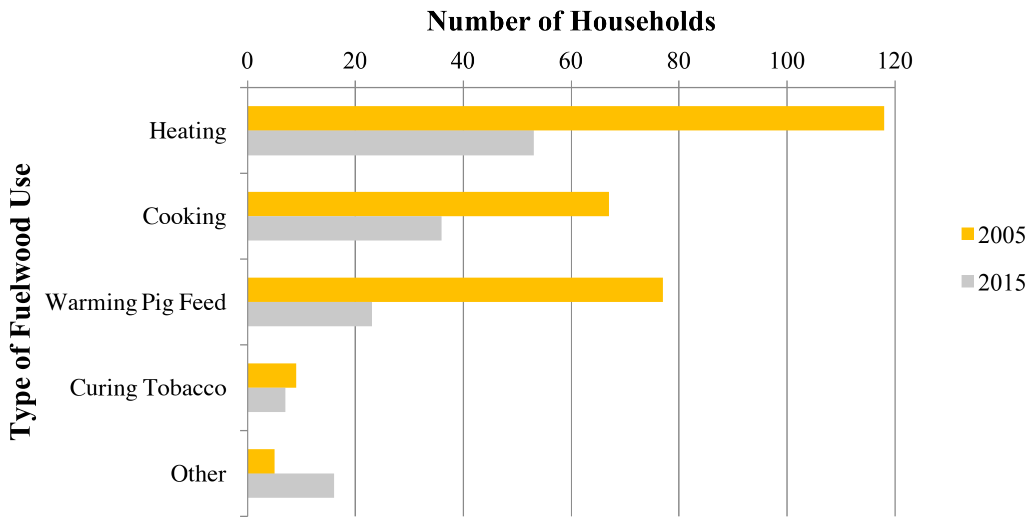
Moreover, households that still use fuelwood in 2015 report that the reasons they use it have changed. In the decades before grid renovation, households in Xinping used fuelwood mainly

---

[16] For both categories, n=122.

for heating and cooking. Those with livestock also used fuelwood to warm pig feed. However, with the reduction in electricity prices, households are now more willing to replace fuelwood with electric heaters and cooking appliances. Fuelwood use for heating and cooking have both reduced by approximately 50%, and households that burn fuelwood for cooking report that it is mostly for boiling water or big events (such as weddings or new year celebrations). Changes to the types of fuelwood use between the 2005 and 2015 are shown in Fig. 4.5.

Fig 4.5: *Types of Fuelwood Use, 2005 & 2015*[17]



Let us examine fuelwood for heating and cooking in more detail, as these two uses are proxies for dependence upon burning biomass for daily activities.[18] Here, we would expect a drop in both categories across all villages, but a persistence in these activities in the 'SHP Replace Fuelwood' villages of Fukang and Cuiheng (and potentially Shangfeng, though it does not receive subsidized electricity). This is not only because they are poorer than the other villages, but because

---

[17] For both categories, n=122.

[18] This is more the case for heating than for cooking, since 'cooking' might include the few meals per year that coincide with large celebrations.

they are higher in elevation and therefore colder. The percentage of households in each village that use fuelwood for cooking and heating are shown in Figs. 4.6 and 4.7. From Fig. 4.6, we can see that households in Fukang and Cuiheng use fuelwood for cooking in 2015 more than households in other villages. Fig. 4.7 shows a similar trend for the use of fuelwood for heating.

Fig. 4.6: *Fuelwood Use for Cooking, 2005 & 2015*[19]

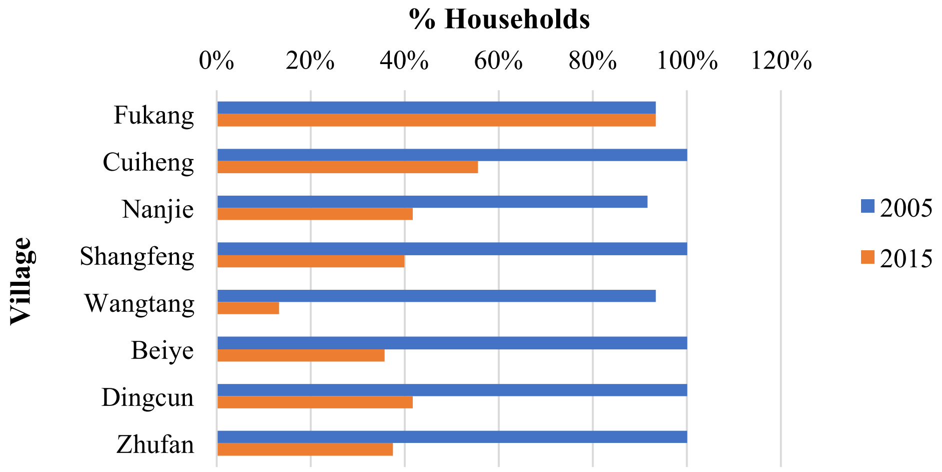
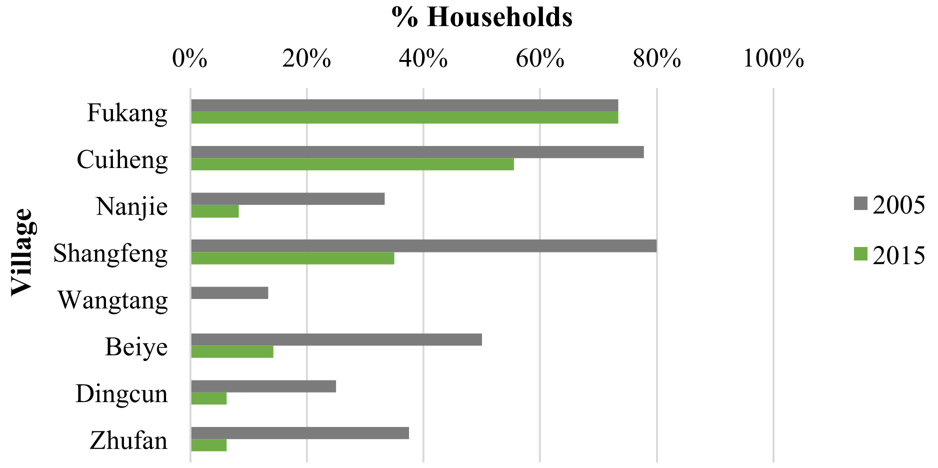


Fig. 4.7: *Fuelwood Use for Heating, 2005 & 2015*[20]



---

[19] For both categories, n=120.

[20] For both categories, n=120.

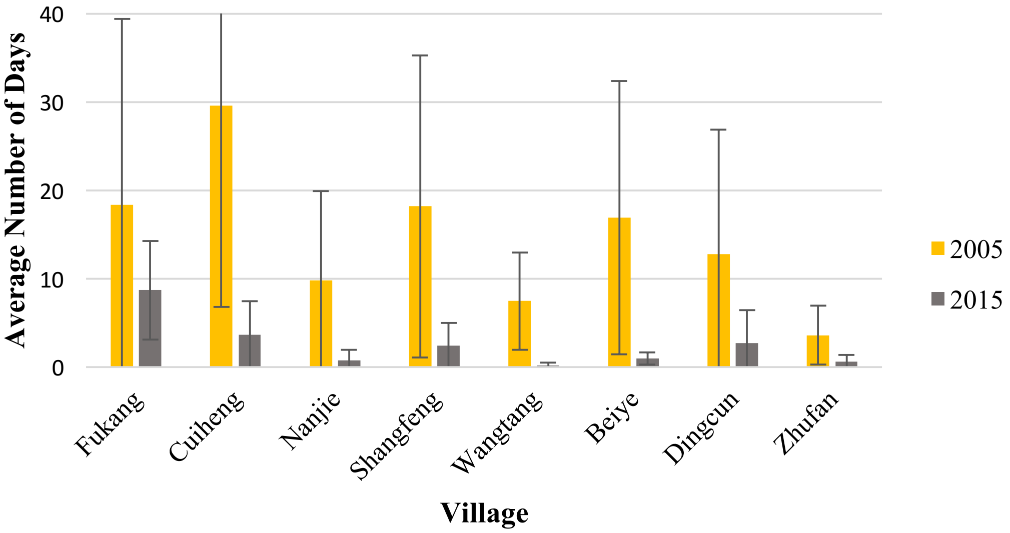
These two figures seem to tell a contradictory tale to the one depicted in Fig. 4.4, which shows a reduction in fuelwood use across all surveyed villages. Why is it that burning fuelwood for cooking and heating persists in 2015 in over half of the households in Fukang and Cuiheng? The main reason is because some poor households in these villages cannot afford to use electricity to meet all their cooking and heating needs, even though their electricity is subsidized. In qualitative interviews, several respondents in Fukang and Cuiheng said that they supplement electric appliances with fuelwood, especially on cold nights. The 'SHP Replace Fuelwood' program has reduced fuelwood use for these activities in the two villages, but it has not eliminated use altogether. This suggests that the subsidy has been well-targeted to villages in Xinping that are the most reliant on fuelwood, and stand to benefit the most from its reduction. Nonetheless, subsidized electricity cannot fully reduce dependence on fuelwood for the poorest households.

Finally, beyond fuelwood use alone, we must also examine changes to labor-time required for its collection. In 2005, before rural grid renovation in Xinping, surveyed households reported spending an average of 15.7 person-days per year collecting wood (n=84).[21] By 2015, the average had fallen to 2.6 person-days per year (n=90). Fig. 4.8 shows changes to time spent collecting fuelwood by village between 2005 and 2015.

---

[21] One 'person-day' is equivalent to 8 hours of labor.

Fig. 4.8: *Number of Days Collecting Fuelwood, 2005 & 2015*[22]



From this figure, we can see that the average amount of time spent collecting fuelwood varies between villages. In 2005, households in Cuiheng village spent an average of 29.6 person-days collecting wood, while the villages of Fukang, Shangfeng, and Beiye spent approximately 18 person-days. All other villages expended significantly less time collecting wood in 2005. By 2015, all villages report a significant reduction, with only Fukang (8.7 person-days), Cuiheng (3.7), Dingcun (2.8) and Shangfeng (2.5) spending more than one day of labor-time collecting wood. Here again, we can interpret this persistence of fuelwood collection as a function of poverty, with households collecting wood to supplement electricity use. That the subsidized villages of Fukang and Cuiheng reduced fuelwood collection by 88% and 53%, respectively, suggests that the 'SHP Replace Fuelwood' program has had some positive effect on household livelihoods.

Nonetheless, we must once gain place these gains in the broader context of SHP expansion in Xinping. As argued earlier in this section, it is only the 'SHP Replace Fuelwood' villages of

---

[22] For 2005, n=84. For 2015, n=90.

Fukang and Cuiheng that receive subsidized electricity from an SHP plant. Villages outside this zone pay the ‘normal’ electricity price, which is set by the prefectural government. Thus, while the county-wide reduction in fuelwood collection and use is a positive outcome, it is mainly the result of rural grid renovation and electricity reforms, not SHP. We can then conclude that SHP affects fuelwood collection only if it controls the price of electricity. Programs like ‘SHP Replace Fuelwood’ that subsidize electricity for poor villages can induce households to reduce wood collection beyond what might occur otherwise.

4.5 Water access and irrigation

This section reports on and analyzes the impacts of SHP on irrigation water availability and smallholder agriculture in Xinping. As described in previous chapters, all but one of the 25 SHP plants in Xinping are in the Red River Basin, which flows ~120km northwest to southeast through the county. The river is bounded by the Ailao mountains to the west, and the Yunnan-Guizhou plateau to the east. SHP plants in the basin are situated between 800-2000m elevation on tributaries of the Red River flowing from the Ailao range. The climate is subtropical with strong monsoonal influence; rains typically occur from August-November with April-June being the driest months. Xinping has 139 million m^3 of reservoir storage; the largest reservoir is Huangcaoba with 41.7 million m^3 of storage, which is located at the head of the Wajiao River SHP cascade. Annual precipitation in the basin is approximately 730 mm/year.

Farmers in the basin use both irrigation and dry-cropping methods. Xinping contains 6.4 million *mu* of land not classified as mountainous (also called ‘wasteland’, or 荒地); this includes 860,000 *mu* of paddy land (耕地, also called 田), 786,000 *mu* of dry fields (园地), and 4.4 million *mu* of forest land (林地). All surveyed households have use rights over a certain amount of paddy land, dry fields, and forest land. These use rights were distributed at different periods in history.

During the Maoist and early reform eras, all farmland in Xinping was cultivated by communes organized as ‘production teams’ (小组). In 1982, the communes were disbanded, but rural land was retained under communal ownership organized at the township (乡镇), administrative village (新政村), and natural village (自然村) levels. Parcels paddy land and dry fields were then leased to each household based on family size.[23] Farmers were still required to grow rice to meet national grain quotas, but could use a portion of their land to cultivate crops to sell on the private market. These quotas were gradually reduced and finally abolished in the early 2000s. Today, very few households in Xinping still grow rice; most cultivate cash crops such as bananas, sugar cane, corn, and mangoes. Due to the basin’s subtropical climate, many species can be double-cropped or cultivated year-round. The average amount of paddy land per surveyed household is 3.1 *mu*, or about half an acre; the average area of dry fields per household is 7.9 *mu*.

The most productive land cultivated by farmers in Xinping is paddy land. Paddy land located on the gently sloping banks of the Red River is generally not terraced, while paddy land higher in elevation is terraced. Some 26.4% (228,000 *mu*) of paddy land is cultivated using traditional gravity-fed flood irrigation, and 0.41% (3,500 *mu*) is cultivated with other irrigation systems. Approximately half of irrigated paddy land is classified as ‘water-saving’, which includes three-sided and enclosed cement canal, drip, and spray irrigation systems (discussed later in this section). The other half of irrigated paddy land is serviced by older earthen canals that were constructed decades ago. Areas classified as dry fields are not irrigated and are typically planted with more drought resistant crops.

Gravity-fed irrigation systems in Xinping are regulated in one of two ways. First, if there is a reservoir at the head of the stream, then villages in the catchment area receive irrigation water

---

[23] Forest land in Xinping is organized somewhat differently. The Chinese government maintained control over forest land until the early 2000s, when it began to implement a policy of distributing land to households.

deliveries that are controlled by the dam. These reservoirs are managed by the township water supply bureau, which also must consider drinking water storage, flood protection, and SHP power generation in timing water releases. The villages themselves construct their own irrigation infrastructure to divert water from the main stream into channels that deliver it to paddy land. Second, for streams that are not dammed, villages will construct 1-2 small irrigation holding ponds (灌溉池塘) to store water during dry periods. Water is then released from these ponds into irrigation channels. Though infrastructure today is built with modern materials such as concrete, this system of irrigation has been used in China for thousands of years.

This irrigation infrastructure is managed by the village collective and varies greatly in quality between the surveyed villages. Six villages (Wangtang, Fukang, Cuiheng, Dingcun, Zhufan, and Beiye) have constructed three-sided or enclosed cement canals that help to reduce leakage. These improvements were funded by the county-level government as part of a water-saving agricultural development plan. In the two other villages (Nanjie and Shangfeng), the irrigation canals are earthen and in a state of disrepair. There are no current plans to upgrade this infrastructure. As a result, farmers in Nanjie and Shangfeng cultivate their paddy land with little to no irrigation.

4.5.1 Irrigation water and SHP

We now turn to the impacts of SHP plants on irrigation in Xinping. Interestingly, SHP diversion canals are very similar in appearance to irrigation infrastructure, and in some cases, can be used for both purposes. This was common for older plants constructed during the 1970s-1990s that were managed by township governments. Newer plants, however, do not generally allow farmers to use its infrastructure unless an agreement is stipulated in the contract. One of the villages surveyed, Fukang, was able to secure access to the new diversion canal constructed by the Malu River 'SHP

Replace Fuelwood' plant. Another village, Zhufan, negotiated with the plant operator to upgrade its earthen irrigation canal into a cement canal. All other surveyed villages are only able to use their own irrigation canals and storage ponds. Thus, the main relationship between SHP and irrigation is one of competition.

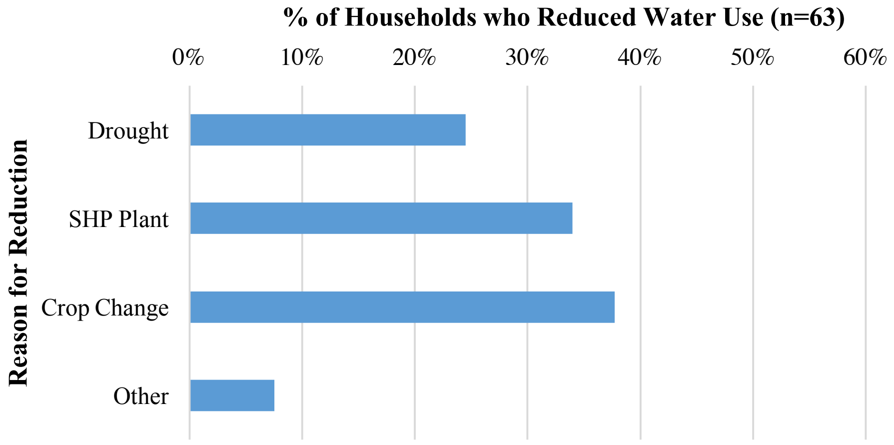
Moreover, this competition occurs at a time of significant water stress in Xinping and much of southern and eastern Yunnan. Yunnan is China's most water-rich province, but its rainfall is unevenly distributed. Areas of southwest Yunnan (near the border of Myanmar) receive as much as 3,000mm of rain per year, while more arid valleys in the south and east might only see 500mm (Xinping's Red River Basin receives an average of 750mm). Since 2009, winter and spring droughts have plagued Xinping, prompting the county and township governments to find new ways to store and save water. Water-saving irrigation systems have made some headway, but only cover less than half a percent of Xinping's paddy land and are not generally a replacement for gravity-fed systems. Reservoirs in Xinping have also been quickly exhausted during the driest period of April-June. This ongoing drought reduces available water resources for irrigation and hydropower generation.

To elucidate the various drivers of irrigation water availability in Xinping, the survey first asked if households' irrigation water use had changed in the last five years, to which 65% responded that it had (n=117). Within these households, 89% reported that their water use had decreased (n=71). Fig. 4.9 displays the reasons provided by respondents for their decrease in irrigation water use; multiple responses were permitted.[24] These responses were coded post-survey administration.

---

[24] 7 households (11%) responded that their irrigation water use had increased, but for different reasons. Two households in Wangtang said that water access had become easier following the construction of a new three-sided cement irrigation canal, which was funded by the county government. Two other households said that there was a

Fig 4.9: *Reasons for Reducing Irrigation Water Use*



From Fig. 4.9, we can see that changes to cropping patterns, ongoing drought, and water diversions by the SHP plant are all stated reasons for reducing irrigation water use. These reasons are somewhat interrelated. As stated earlier, Xinping experienced several years of drought beginning in 2009, from which it has only recently recovered. During this period, many households were induced to switch from growing paddy rice – which requires flood irrigation – to less water-intensive cash crops. Among surveyed households, 69% (n=122) changed their cropping patterns in the last five years, and only 17% continue to grow rice for their own consumption. These cropping changes have reduced the amount of water required for irrigation.

Even with these changes, however, a significant number of households cite SHP plant diversions as reasons for using less water. At first glance, it would seem that SHP should have no impact on irrigation water access, since water merely flows through plant (or multiple plants in a cascade) and is released back into the stream. However, because SHP systems divert flow away from the original watercourse, and potentially away from existing irrigation canals, they can reduce

---

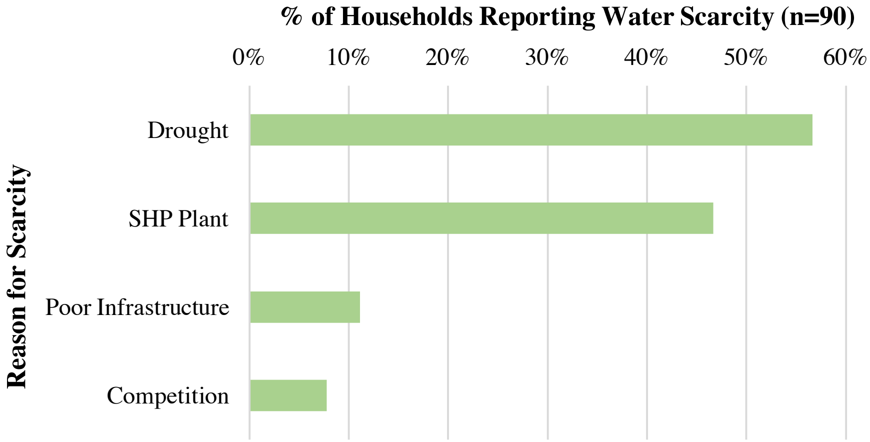
large drought five years ago, and that there was relatively more water in 2015. The remaining three households did not provide a reason.

water access for farmers with land situated below a plant's diversion intake. When survey respondents say that the SHP plant 'diverted their water away' (把水引走了), they mean that their irrigation canals have been left dry or depleted due to power generation by the plant. This is primarily an issue during the driest months of April-June.

The county and township governments are aware that SHP plants can reduce irrigation water access, and thus require the SHP operator to sign a contract with the village stipulating that the plant will release water when farmers need it. All the surveyed villages have co-signed this kind of contract. In practice, this means that farmers in these villages are dependent on the SHP plant to release irrigation water, and must communicate with the plant operator when water is required. In the survey, 59% of respondents said that they must either ask the plant directly for water, or recruit the village head to make a request on their behalf (n=115). These requests are not always successful, as we will see below.

To further examine the issue of water availability, the survey asked respondents if irrigation water is more or less scarce in 2015 than five years earlier. Some 76% of households reported that water is scarcer (n=119). Fig. 4.10 displays the reasons provided by respondents for increased water scarcity; multiple responses were permitted. These responses were coded post-survey administration.

Fig 4.10: *Reasons for Irrigation Water Scarcity*



Unsurprisingly, drought is the leading reason provided by respondents for irrigation water scarcity in Xinping. Other responses include poor irrigation infrastructure (11%), particularly in Nanjie and Shangfeng villages, and competition between competing uses (8%). Yet most important for our purposes is the degree that SHP contributes to water scarcity; among the 90 households that report scarcity, 42 households (47%) blame it on the adjacent SHP plant.

This irrigation water scarcity inflicted by SHP does not occur evenly across all villages in Xinping's Red River Basin. To analyze this variability, the survey asked respondents three series of questions about the impact of SHP on water availability. These questions were structured progressively to determine the severity of the plant's impact. First, respondents were asked if their water use situation changed after the SHP plant began operation. Second, the survey asked if there are times when the household needs water for irrigation, but there is not enough owing to plant diversions. Finally, respondents were asked if there have been any conflicts between their household and the SHP plant over water availability. Responses to these three questions are shown in Fig. 4.11, coded as 'change', 'divert', and the most severe, 'conflict'.

Fig. 4.11: *SHP Impacts on Irrigation*[25]

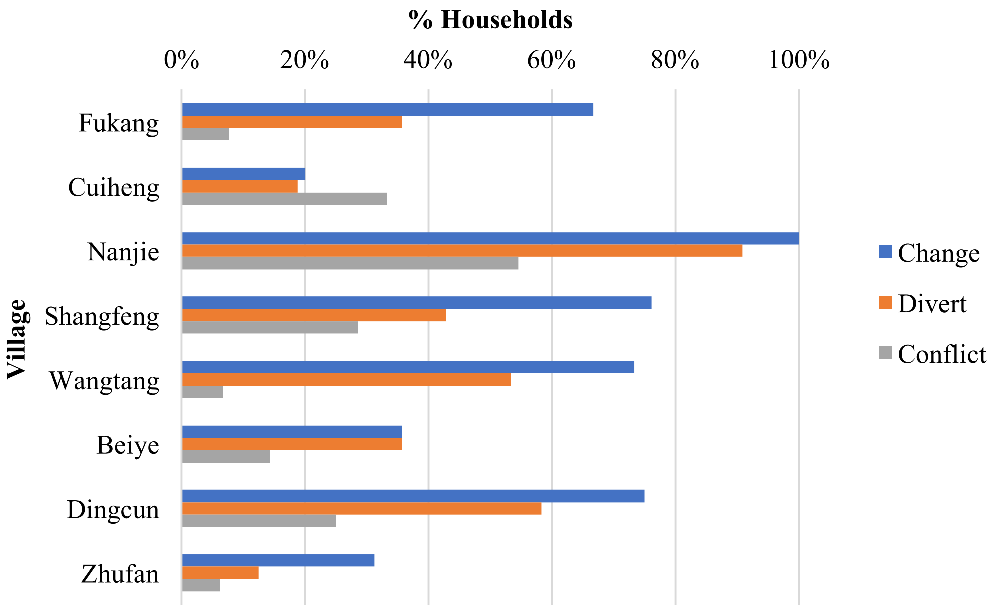


Fig. 4.11 requires some further analysis to explain the differences between surveyed villages. Let us first examine those that report few impacts from SHP: Cuiheng and Zhufan. Cuiheng village is situated between the intake and the powerhouse of the Wajiao #3 plant, constructed in 1991. At the time the plant began operation, SHP was managed by the Jianxing township government, not private investors. Cuiheng village was serviced by irrigation canals that were decades old, and some villagers would drill holes into the new SHP diversion canal to draw water from their fields. When the SHP plant would patch the holes, the villagers would drill them again, which eventually caused a conflict between the farmers and the township government (which accounts for the 33% of households who reported that there had been conflict). Today, however, Cuiheng residents have adjusted to plant diversions; only 20% of Cuiheng households report negative impacts of SHP on irrigation water.

---

[25] For all categories, n=122.

Zhufan village is a somewhat different scenario. The village is situated below the intake of Yaocun #2 plant, which was constructed in 2011 along with Yaocun #1. As mentioned earlier, the plant investors chose to turn an existing irrigation canal into their diversion canal, and paved it with cement. While villagers now must depend on the plant for water delivery, their access to irrigation has improved because of the infrastructure upgrade. As shown in Fig. 4.11, few respondents reported that the SHP plant diverts water away when it is needed for irrigation. When we asked the village head about relations with the SHP plant, he mentioned that there are negotiations that take place behind the scenes, such that residents are unware of them. Thus, residents of Zhufan are relatively unaffected by the plant and benefit from upgrades to the canal. This is due to a reciprocal relationship between the village and the plant.

These two scenarios contrast greatly with those of the three most affected villages: Nanjie, Dingcun, and Shangfeng. Nanjie sits below the intake of the Nabanqing plant built in 2006. Here, 100% of surveyed households reported that the plant had changed their irrigation water access, and 91% said that the plant diverts water away when it is needed. Respondents complained plant operations had almost completely dried up the village's existing earthen irrigation canal; one older resident said that it had 'changed the watershed' (改变流域). Like the villages described above, residents of Nanjie must communicate with the plant when they need water, but grumble that the amount released is never enough. Five households (50%) said that they had petitioned the local government to resolve the issue, and four (40%) spoke to the plant on their own. However, the issue has not yet been resolved, and the conflict is still simmering.

Similarly, the large village of Shangfeng faces dual problems of an unmaintained irrigation canal and regular SHP plant diversions. The village is located directly below the 30 MW Dachun #1 plant, the first in a three-station cascade. Approximately 150 households have resided in the village continuously, and farm sloping land adjacent to the villages in two narrow valleys.[26] The valley south of the village contains an earthen irrigation canal constructed in the 1960s, which has not been upgraded, while the northern valley contains a three-sided cement canal: both draw water from different streams in the same watershed. However, since 2008, the Dachun River #1 station has diverted water from both valleys for electricity generation. Thus, when farmers irrigate their fields during the dry season, water that originally flowed into the canals instead flows to the SHP plant. In the southern valley, farmers have abandoned irrigation altogether; in the northern valley, the village head must contact the station operator to release water for irrigation.

Dingcun, another affected village, is situated in the Dachun River watershed below the Dachun #2 plant. The village draws irrigation water into its canal directly from the Dachun River. Here, 75% of villagers report a change to water access after SHP operation, and 58% say that the plant diverts water away. Respondents spoke of regular plant diversions during the dry season that left their crops without adequate water; one middle-aged woman said that “we peasants have to eat, but we don’t eat enough when the plant is generating” (我们农民还要吃，但你们发电水不够就吃不够). Indeed, while the plant was being constructed in 2007, it entirely cut off village access to irrigation. More than 100 villagers in the Dachun watershed protested in response. While these overt conflicts have lessened somewhat, problems with water access remain.

As we can see from Fig. 4.11, all surveyed villages suffer to some degree from reduced irrigation water in the dry season due to an SHP plant. The differences we see between villages are a function of local irrigation infrastructure and plant management. In Nanjie and Shangfeng villages, for example, irrigation infrastructure is poor and unmaintained, and thus suffers from

---

[26] The total population of Shangfeng is 520 households, but 370 of these were relocated in the last 5-10 years from villages higher in the mountains. Relocated households still cultivate land near their old village, outside of the Dachun River watershed.

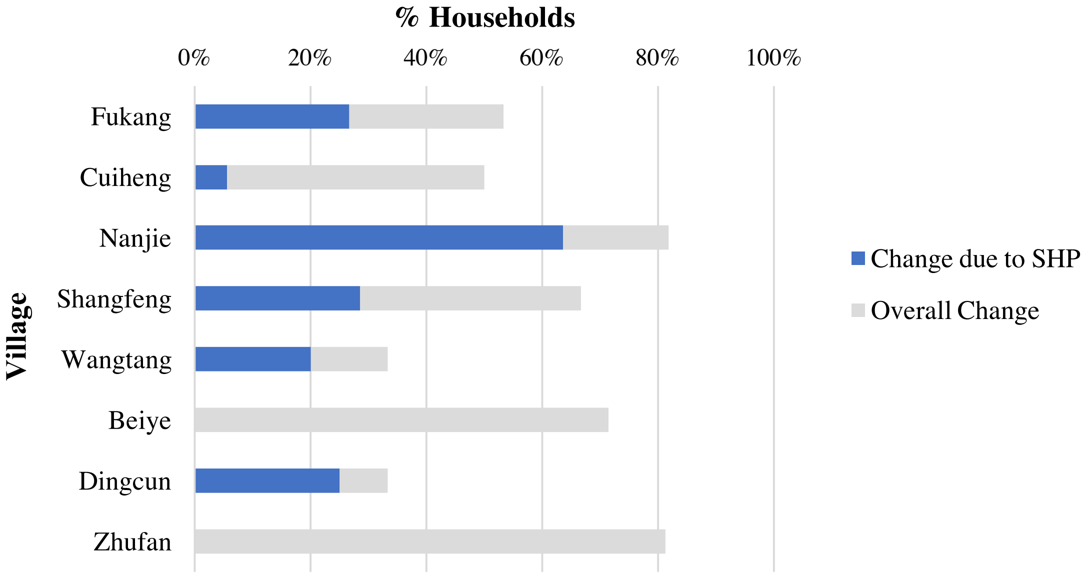
overflows and leakages. This, in turn, reduces the incentive for the SHP plant to time water releases for irrigation. In contrast, villages like Dingcun and Wangtang boast better irrigation infrastructure, which slightly reduces the potential for conflict with the plant (though conflicts still occur). Yet all four of these villages differ from Zhufan, where village leadership has negotiated regular water releases with plant management, and residents have few complaints about water availability. Indeed, the Yaocun #1 plant manager stated that the station shuts down for nearly a month every year during the dry season to allow for irrigation; this is much longer than any other plant in the Basin. Larger plants like those in the Dachun cascade continue operating during dry periods for fear of losing valuable revenue.

4.5.2 SHP agricultural impacts and change

To what extent do these irrigation water reductions have long-term effects on smallholder agriculture? To examine this issue, we must analyze both direct and indirect impacts. A direct impact would mean that farmers must change the type of crops that they grow or irrigation system due to reduced water access from SHP. In the case of large commodity price swings or poor harvests, such crop shifts and large cost outlays could negatively affect household incomes and food security. An indirect impact, in contrast, would include the renting of farmland to others and exiting agricultural production altogether. Since it is difficult to determine from the survey data whether indirect impacts are influenced by SHP operation, we will supplement analysis with qualitative interviews.

Fig. 4.12 displays the percentage of households in each village who changed the crops that they grow between 2010-2015. Here, ‘crop change’ refers to a major shift in crops grown, not just adding or subtracting a certain crop from rotation. The light bar shows the total percentage of households that changed crops; the dark bar shows the percentage that cited water scarcity due to the SHP plant as the main reason for the change.

Fig. 4.12: *Change in Crops Grown, 2010-2015*[27]



This figure reveals, first, that a significant number (20%) of households have changed the crops that they cultivate because of water restrictions imposed by the SHP plant. These households are concentrated in the villages that reported higher-than-average water diversions and conflicts with the plant (see Fig. 4.12), in particular Nanjie (64%), Shangfeng (29%), and Dingcun (25%). Most of the households affected by SHP shifted from wet rice or corn cultivation to a cash crop, mainly bananas or sugar cane. In Nanjie, villagers first shifted from rice to less water-intensive sugar cane, but SHP water diversions caused several seasons of stunted crop growth. As a result, households shifted a second time to cultivate bananas. These are not trivial matters; changing crops entails purchasing new seeds and equipment, employing new and unfamiliar techniques, and exposing one’s livelihood to the fluctuations of cash crop commodity prices.

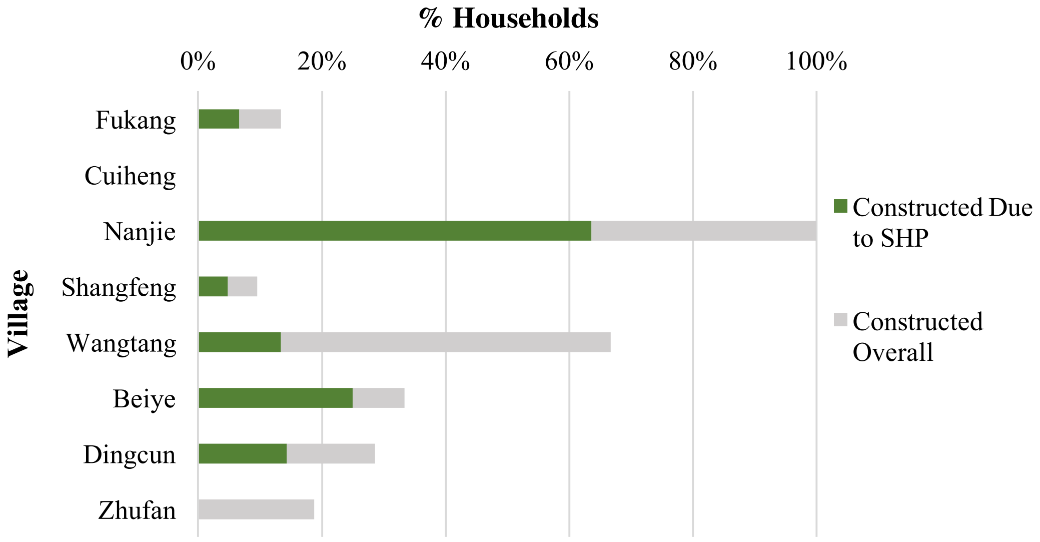
---

[27] For both categories, n=122.

Second, we can see that more than half of all surveyed households (57%) have changed the crops that they grow in the past five years. As with those households affected by SHP, respondents who changed crops mainly shifted from water-intensive wet rice (64%) and corn (19%) to cash crops like bananas and sugar cane (n=62). Households cited two main reasons for this decision. For those not affected by SHP, the first reason for changing crops was persistent drought, particularly in the dry years since 2009. The second reason was the potential to earn a higher income from cash crops. In Shangfeng village, for example, households with fields at a low enough elevation were induced by the local sugar factory in Gasa to switch to sugar cane cultivation. Similar village-wide shifts occurred in Beiye (to sugar cane) and Wangtang (to bananas). In the last year, however, the price of bananas collapsed to approximately half its 2014 value, leaving many households over-burdened. Such price reductions hit poor households the hardest, as they have no alternative income to fall back on.

We can see a similar pattern at the village level of households who construct water-saving irrigation systems. Fig. 4.13 displays the percentage of households in each village who built a sprinkler or drip irrigation system between 2010-2015. The light bar shows the total percentage of households that constructed a system; the dark bar shows the percentage that cited the SHP plant as the main reason for constructing it.

Fig. 4.13: *Construction of Water-Saving Irrigation, 2010-2015*[28]



As shown in Fig. 4.13, some 39 households (29%) built their own water-saving irrigation system, and 16 households (13%) did so due to water restrictions imposed by the plant. Like what we saw with crop change due to SHP, households affected by the plant who built irrigation systems are clustered in Nanjie (64% of residents) and Dingcun (25% of residents). Households in Nanjie use the system to irrigate their banana crop that most switched to after the SHP plant began operation. Households in Dingcun use their system to irrigate sugar cane for the same reason. In Shangfeng village, where nearly one-third of residents changed crops because of the SHP, there are still few households who use water-saving irrigation. Overall, nearly all (84%, n=31) of these systems use sprinklers that draw water from a tank. The average extent of these water-saving systems is 3.3 *mu*, which includes both paddy land and dry fields. All but 4 households constructed

---

[28] For both categories, n=122.

their own system without assistance from others.[29] The median investment in such a system was ¥3,000, or just under ¥1,000 per *mu*.

The prevalence of water-saving irrigation systems that we see in this figure is both a response to the impacts of SHP, and to the kinds of factors described earlier that influence crop change. Moreover, as with the kinds of crops cultivated in each village, the decision to construct water-saving irrigation is often made at the level of the production team or natural village. Smallholders in southwest China may farm independently, but it is also common for village leaders to make land use decisions for the entire collective. As we saw above, households in each of the surveyed villages in Xinping grow the same crops and varieties; the only difference is that some will also cultivate vegetables and/or tree crops for consumption or extra cash. Growing the same crops enables villagers to purchase the same seeds and equipment, share knowledge, and pool resources. This collective decision-making also applies to irrigation, since adjacent households can share the same farm dam or water tank and pressurized pumping system. Indeed, in three of the natural villages that we surveyed (Shanghuiqu, Nabang, and Yakou), all households used the same type of water-saving irrigation system.

In the case of both crop change and water-saving irrigation, the risk is that poor villages and households will be pushed into cash crop cultivation and burdened with the costs of constructing and maintaining water delivery. The data show no significant relationship between household income and either crop change or irrigation system construction; both activities are undertaken by wealthy and poor households. Given that no government subsidies are available for new equipment or irrigation, the household must account for all expenses. Several respondents

---

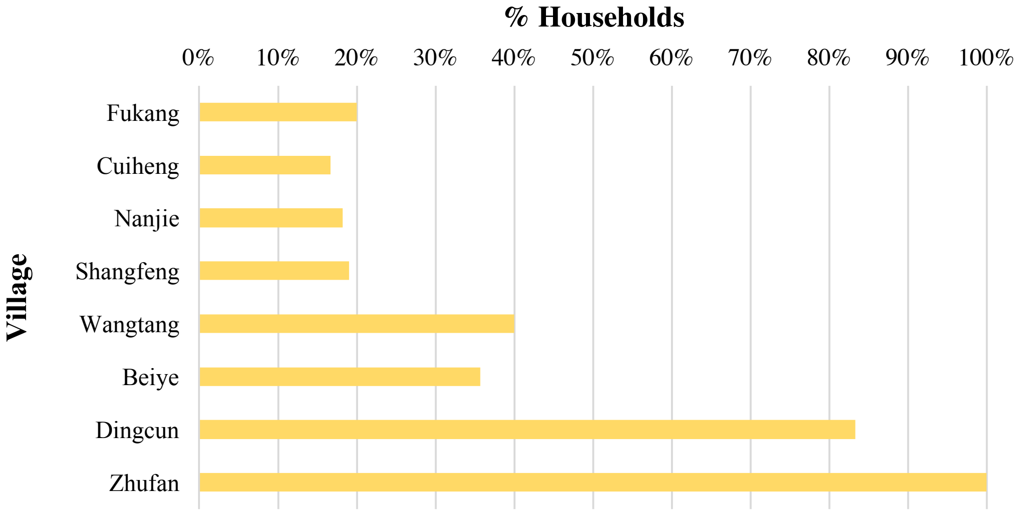
[29] Several respondents mentioned that the government provides a subsidy of ¥300 per *mu* for water-saving irrigation. However, the system must have an extent of at least 50 *mu* to be eligible for the subsidy. Thus, in practice it is only available to large landholders such as agribusinesses.

expressed anxiety about the rising costs of cultivating their land amidst ongoing drought and yearly swings in cash crop prices.

A broader response to these difficulties, which is picking up pace China-wide, is the renting out of farmland to large landholders or agribusinesses. Rural households were granted the ability to rent, transfer (流转), or mortgage their land use-rights in 2013; prior to this, many rural collectives had already formed shareholding agribusinesses to farm land on a larger scale (Yuen, 2014). The logic behind this policy is to rationalize agricultural production by consolidating farmland and enabling rural households to more easily move into off-farm work. In theory, allowing households to rent or transfer land rights will provide them with a steady income while increasing agricultural output. This policy has been widely adopted in north and east China, where land is flatter and more easily consolidated, but has also been implemented to varying degrees in mountainous areas like Yunnan.

In surveyed villages in Xinping, 42% of households rent out some of their land (n=116). Of these, 57% rented to an agribusiness, and 38% to another landowning household (n=47). Approximately a third of these transactions were with households or businesses native to Xinping. Most respondents chose to rent out their dry land (71% of households) rather than their more productive paddy land (35% of households). The average amount of dry land rented is 5.9 *mu*, and the average amount of paddy land rented is 1.8 *mu*. For more households who rent, land rentals account for 60-70% of their total farmland holdings. The average income per *mu* is ¥400-500 / year. Fig. 4.14 shows the percentage of households in each village who rent out their land.

Fig. 4.14: *Renting Out Land by Village*[30]



Like crop change and irrigation system construction, renting out farmland in Xinping shows a spatial clustering pattern. In Zhufan village, where all households rent their land, an agribusiness offered ¥500 per *mu* of dry land to grow oranges over a 30-year period. In this case, all households signed the contract to transfer their land-use rights, though several said that they felt forced into the decision. 11 of the 16 households in the village continue to cultivate the land as wage laborers for the agribusiness. In Dingcun village, households have also rented out dry land for orange cultivation, but it was not a village-wide decision. Respondents stated that their main reason for renting was their lack of labor-time or ability to squeeze profit out of marginal land. Indeed, among all households who rented their land, 76% said that they did so because it was too difficult to farm it themselves, with five explicitly mentioning water scarcity (n=46). Yet the ability to rent land is not evenly distributed; less than 20% of households in upland villages (Fukang, Cuiheng, Nanjie, and Shangfeng) have done so. This is mainly because land at lower elevations is more sought after as it can support banana and fruit tree cultivation.

---

[30] n=116.

How are we to interpret the impacts of SHP on land rentals? Households did not cite SHP as a factor in land rental decisions in response to qualitative survey questions. Instead, as described above, respondents emphasized the increasing difficulty of farm work and inability to make a profit. For households residing in areas most affected by plant diversions, SHP-induced water scarcity might provide yet another reason for reducing one's land holdings. This can bring a steady income, but also effectively separates farmers from their means of livelihood. Moreover, land rentals are mainly an option for lowland households; upland villages rarely have this option. For example, in Nanjie and Shangfeng villages, where land rentals stand at less than 20%, farmers may be stuck with land made less productive because of the SHP plant. Thus, while SHP is not a direct driver of land rentals, the impacts of SHP must be examined within this broader context of smallholder agricultural change, which is becoming more and more difficult in China over time.

4.6 Conclusion

The Chinese government has long promoted small hydropower as a driver of rural electrification and development for poor, mountainous areas like Xinping. And indeed, in the years before grid renovation and SHP privatization, many households in southwest China received electricity from SHP. One should not negate the numerous public benefits of SHP plants during this period. Since the early 2000s, however, SHP plants have become larger, cascades have become longer, and private operators are incentivized to generate electricity year-round. In effect, SHP has mostly lost its function as a public good in rural China; it is now just a means to generate electricity and local government revenues. This chapter analyzed the social impacts of SHP on rural households when such a change of function occurs.

The first impact, reduced fuelwood collection, was found to have little relationship with SHP outside of villages subsidized by the central government's 'SHP Replace Fuelwood' project.

In the early 2000s, much of rural China, including Xinping, underwent grid renovation and electricity management reforms that normalized the price of electricity, which severed the ability for SHP plants to set a sale price. As a result, any increase in electricity consumption in Xinping, and corresponding drop in fuelwood collection, cannot be tied to SHP. Rather, these reductions are a result of fewer family members remaining in the village, rising incomes (for some households), and a cheaper electricity price after grid renovation. It is only the villages of Fukang and Cuiheng, which receive subsidized electricity, that report major livelihood benefits from the SHP plant. Thus, while the ‘SHP Replace Fuelwood’ project has had a positive impact on energy use, all other plants in Xinping constructed post-grid renovation have had no impact (which includes all the privately-owned plants). Thus, we must be highly skeptical of claims that SHP today still improves village livelihoods; in most cases, it does not.

The second impact, increased water scarcity, was found to affect nearly all villages that are situated below the intake to a plant’s diversion canal. Yet the degree to which farmers experience scarcity differs significantly between villages, owing to the installed capacity of the plant, quality of irrigation infrastructure, and willingness of the plant to release water. The most affected villages were Nanjie, Shangfeng, and Dingcun, whose irrigation canals are dry or severely depleted during the dry season, are adjacent to plants with an installed capacity greater than 10 MW. These plants divert water from a greater area of the watershed, and are less willing to coordinate releases with farmers’ irrigation needs. In contrast, the villages of Zhufan, Beiye, and Cuiheng are adjacent to smaller plants that generally provide water when it is required. Residents of Fukang and Zhufan villages also report some improved water access due to SHP upgrades of existing irrigation canals (though they are now dependent upon the plant for water). Because of these impacts, farmers in the most affected villages have changed crops and, if possible, constructed water-saving irrigation systems. This exposes households to higher capital costs and commodity price swings, which are increasingly burdensome as smallholder farming in China becomes less and less profitable.

This chapter is the first comprehensive study of the social impacts of SHP, in China or elsewhere, and its findings raise further questions in need of analysis. First, given the small sample size of surveyed households, it is unclear how effective electricity subsidies have been in reducing fuelwood collection (and therefore deforestation) in Xinping and other parts of southwest China. While surveyed residents report benefiting from subsidies, and have reduced fuelwood use, these changes could also be driven by other factors. A large-sample survey conducted across a broader geographical scale would enable researchers to better elucidate this relationship. Such a survey could also be paired with LANDSAT remote sensing data to compare forest cover change in 'SHP Replace Fuelwood' zones with change in unsubsidized areas.

Second, while this chapter has isolated the variables that determine irrigation impacts of SHP, the *extent* of the impacts of one plant or cascade is still unknown. The Dachun River cascade, for example, has reduced irrigation water access for farmers in both Shangfeng (Dachun #1) and Dingcun (Dachun #2). There are many other villages scattered throughout this township. Further analysis is needed to determine how many households might be affected. This is especially important for those areas of Yunnan, such as Wenshan and Dehong prefectures, that contain more large-scale SHP plants of up to 50MW installed capacity.

Third, and finally, this chapter was not able to compare the impacts of diversion-type run-of-river SHP plants with those that have a dam and reservoir. While we might expect the latter to cause more livelihood impacts, given the potential need for resettlement and land inundation, these plants might also provide valuable irrigation water storage and control. In Xinping, the Wajiao River cascade (made of up 7 plants) is regulated by a dam, but its reservoir was built more than three decades ago, before SHP plants were privatized and increased in size. More work is needed to determine whether dam-type plants are likely to impact rural households and communities as much or more than diversion-type systems.

SHP is not a ‘good’ or ‘bad’ technology in it of itself; it is shaped by the conditions in which it is constructed and managed. Across the world, SHP plants have provided steady electricity to communities who previously had no access, including tens of millions of households in China. In these times and places, SHP is a green, pro-poor driver of rural development, and it should continue to be deployed in areas lacking electricity and grid infrastructure. In China today, however, SHP has ridden on its past coattails for too long. Plants may provide valuable revenue to local governments – and potentially replace polluting activities – but they are not the small-scale, green energy sources that they are made out to be. As Hennig and Harlan (2017) put it, SHP in China has been ‘overdeveloped’. This chapter has shown that the social impacts of SHP are no less dramatic than the ecological consequences previously identified in the literature (Abbasi and Abbasi, 2011; Kibler and Tullos, 2013). Future expansion of SHP thus must be limited to small plants that have tangible livelihood benefits.

CHAPTER 5

A Green Development Model: Transnational Model-Making in China's Small Hydropower Training Programs

5.1 Introduction

Since the announcement of China's 'Go Out' policy in the early 2000s, Chinese foreign direct investment and overseas development assistance has increased dramatically (Cheung, de Haan, Qian, & Yu, 2012; Frost, 2004; Gu, Zhang, Vaz, & Mukwereza, 2016; Wang & Elliot, 2014). While some have pointed out the potential benefits of Chinese capital and aid (Li et al., 2012; Sautman and Yan, 2007; Yang, 2006), others have emphasized reports of poor labor and environmental standards, unequal resource deals, and corruption (Alves, 2013; Davies, 2008). Recent articles in the Western media (Kuo, 2016; Lagon and Fried, 2016; Moyo, 2014) paint a picture of a Chinese state 'exporting' a model of development that prioritizes economic growth at the expense of democratic freedoms and environmental protection. China's infrastructure investments planned through the 'One Belt One Road' initiative have only amplified concerns about the environmental consequences of the 'China model' (Ferdinand, 2016).

At the same time, this dissertation highlights that China is seeking to shift its own economy to a green, low-carbon growth trajectory. Chinese President Xi Jinping, in a recent address, called for a development mode based on 'ecological civilization', with reforms aimed at reconciling the contradiction between the economy and the environment (Xinhua, 2016a). As described in Chapter 2, these reforms are mandated in China's most recent 13th Five Year Plan, which sets targets for resource efficiency, clean energy generation, and the protection of arable land and water resources (China State Council, 2016). The aim of these reforms is not just environmental protection, but economic advantage, by bolstering China's global competitiveness in emerging green industries –

particularly clean energy. This not only raises the question of whether China's own development can be 'greened', but how environmental reforms might influence Chinese overseas aid and investment.

Small hydropower offers an example of how China's 'green development' is beginning to be exported elsewhere. The previous chapters in this dissertation document how SHP transformed from a tool of rural electrification to major renewable energy source, aided by state policy and the profit motivations of the SHP 'green industry'. Following electricity reforms in the early 2000s, SHP installed capacity in China more than doubled to 74.3 GW, turning China into the world leader in SHP construction (Cheng et al., 2015, p. 47). This expansion occurred as SHP was re-framed as a 'green' technology capable of reducing deforestation and generating clean energy. Today, the Chinese government upholds SHP as a model of local green development, and has trained thousands of foreign engineers and officials in SHP policy, management, and technology.

Of course, SHP is a relatively small instance of green development in China, situated amidst a broader growth trajectory that has caused extensive pollution and natural resource degradation. So why promote SHP as a green model? For the Chinese government, SHP is useful because it situates environmental protection as an outcome of state-led modernization in poor, ecologically fragile regions of China. That is, SHP represents the notion that development can *improve* livelihoods and environments. It shifts attention, however slightly, from the environmental consequences of China's economic growth to its environmental benefits in specific contexts. This allows the government to highlight a 'greener' aspect of China's development to low-income countries without abandoning its commitment to its modernization project. Moreover, it enables China's SHP industry to situate itself as an early pioneer of green development, helping it to sell goods and services to other countries. Thus, it is in the best interest of the Chinese government and enterprises to shift the ‘China model’ discourse to examples like SHP.

The ‘China model’ of development is the subject of much recent academic work (Breslin, 2011; Huang and Wang, 2011; Zhao, 2010). Scholars have debated whether China’s rapid growth is due to a unique set of economic policies, or only a result of existing conditions that cannot be replicated elsewhere (Chen and Goodman, 2012; Naughton, 2010). Others have focused on the diversity of China’s experience, arguing that defining a model of development is inevitably a political act (Ferchen, 2013). Largely absent from this work, however, is an attention to the practices that actors and groups employ to advance models of success, and the local politics in which they are embedded. Moreover, while studies have examined how overseas investment and aid promote discourses or ideologies of China’s development (Davies, 2008; Scoones et al., 2016; Tugendhat and Alemu, 2016), none have investigated their role in advancing green policies or models. This chapter seeks to fill these gaps by analyzing the practices that cast SHP as a green development model, and the political and commercial relationships that this process helps to facilitate. At stake in this work is China’s influence over global development discourse and its role in environmental and economic trajectories in other low-income countries.

This chapter has two aims. The first is to trace how SHP is promoted as a model of green development through Chinese-hosted training programs. I particularly highlight the ‘success factors’ emphasized in presentations and site visits that situate SHP as an example of state-led modernization and environmental protection. The second is to draw out the political and commercial advantages that training programs provide for Chinese actors, and analyze how these advantages shape modes of SHP technology transfer. At a broader level, this chapter seeks to infuse academic discussions of the China model and China’s low-carbon transition with attention to the transnational politics and practices of model-*making*, linking China's development discourse with the actions and outcomes of its overseas activities.

To make these arguments, I draw on participant observation in two SHP training programs in Hangzhou, China, as well as interviews with Chinese officials, SHP company managers, and training course participants. This chapter is structured as follows. First, I examine the literature on the China model of development and draw attention to the politics and practices of model-making. I then place this work in the transnational context of Chinese overseas aid and investment, noting the lack of scholarly attention to China's 'green' aid. Second, I outline how SHP is promoted by different actors – the Chinese state, SHP companies, and multilateral institutions – as a green development example. Third, I trace the practices of model-making that occur through SHP training programs, and identify the main success factors that are emphasized, including self-reliance, flexible policy-making, a strong government, and technological expertise. Fourth, I examine how aspects of the SHP model are 'exported' through different modes of technology transfer. I conclude by highlighting implications of this work for studies of the China model and Chinese overseas investment and aid.

5.2 Transnational model-making

5.2.1 The politics of model-making

Since China's reforms began more than thirty years ago, scholars have aimed to isolate the variables that have driven the country's rapid economic growth – what some refer to as the China model (Callick, 2007; Chan et al., 2008). This literature asks two related questions. The first is whether China's success is a result of state policy – producing a 'China miracle' – or whether it merely arose from existing factors such as reserve labor, a large internal economy, and a centralized state (Kennedy, 2010; Naughton, 2010). While there is no consensus, studies have singled out the importance of flexible policy-making and innovation, a hierarchical governance structure, and a combination of economic liberalization and state control as explanatory factors (Ramo, 2004; Zhao, 2010; Zhou et al., 2016). A second question is whether China's path to modernization is distinctive at all, and by extension, whether it can serve as a model for other countries (Chen and Goodman, 2012). Studies differ on the degree that China's mix of authoritarian politics and market liberalization challenges perceived wisdom about economic development and Western capitalism (Fligstein and Zhang, 2015; Peck and Zhang, 2013). China's mounting economic and environmental crises have only intensified these debates, as scholars grapple with the costs of China's mode of development (Lam, 2015; Lynch, 2015).

Why are there such a wide range of interpretations of the China model? A key reason, Ferchen (2013, p. 391) argues, is that China's policy approach has varied significantly over time, space, and economic sector. To ask whether a China model exists, and what its features might be, is to make a choice about the aspects that one chooses to study. This does not mean that all interpretations are equal, or that there are no high-level characteristics that can describe China's development path. Rather, it suggests that defining the China model is inherently political; that it is shaped by power relations beyond those of elite academic and policy circles. Here, Ferchen notes that the China model has been a subject of debate between leftist and pro-reform factions *within* China, both whom seek to exercise influence over the government's economic reforms. That is, by clearly defining the nature of China's development success, powerful actors can make claims about the country's future trajectory, and with it the ability to prescribe solutions. Thus, scholars should not only analyze the content of the China model, but also the politics of its definition – what Mulvad (2015, p. 201), quoting Jessop, calls the "processes of ideational contestation." At stake is the discursive power to promote a version of China's development success, and the lessons that it may provide for other countries.

Domestic debates about the China model are not confined to policy makers and Party elites. Rather, they also involve sub-national institutions and actors who promote their own experiences as models and best practices. Here, a well-known example is the 'Chongqing Model', an approach based on domestic consumption and investment that was advanced by Chongqing Party Secretary Bo Xilai (Mulvad, 2015). Through the efforts of Bo and others, the Chongqing Model came to represent an economic alternative to the export-oriented manufacturing of the Yangtze and Pearl River Deltas, as well as an ideological alternative to liberal reform (Lafarguette, 2011). At the city scale in China, leaders in Shenzhen (Yeung et al., 2009), Wenzhou (Parris, 1993), and elsewhere have marketed their cities as examples of modernization in different time periods. Such cases acquire legitimacy by pointing to past achievements, but also by situating their policies and activities as part of China's future trajectory. Moreover, China's leaders and the media elevate specific places, policies, and projects as exemplars of development success. It is these diverse practices of promotion, contestation, and connection that reinforce the idea that China's experience is worthy of study, and perhaps even offers lessons for others. In short, they are model-*making* practices.

To what extent does the environment factor into these model-making practices? To be sure, many Chinese regions and industries are now seeking to market themselves as green, from eco-cities, to organic agriculture, to low-carbon manufacturing. This process is partially described by Hoffman (2011), who documents how officials in Dalian advertise the city as an example of 'green urbanism' in order to gain influence and attract foreign investment. At the same time, she shows how this formulation constructs certain characteristics as 'desirable' and 'green', and in doing so shapes citizen behavior around broader state goals. Here, Dalian is at once a case of local place-marketing and of green model-making, representing both the achievements of China's modernization and its potential future low-carbon development path. Likewise, Chang et al. (2016) analyze how local officials promote the Tianjin-Binhai Eco-City as a model of 'ecological civilization' so as to attract eco-businesses and compete for lucrative urban development projects. Chinese leaders also reference Tianjin-Binhai as a model for other eco-cities, lending it national legitimacy as an example that others can learn from.

Yet, besides these studies, few scholars have analyzed how local green models in China are promoted at different scales, or how they are invoked in the broader discourse of China's development experience. Nor has sufficient attention been paid to what model-making practices *do* for these actors, beyond the influence and financial benefits that may accrue to local elites. Perhaps the biggest gap, however, is that most work on the politics of green model-making is confined to China's domestic sphere, leaving the transnational context of China's investment and aid relatively unexplored.

5.2.2 Model-making practices in training programs

Indeed, much has been written about the 'export' of the China model to other countries and its potential to disrupt conventional aid paradigms (Davies, 2008; Tan-Mullins et al., 2010; Woods, 2008; Zhao, 2014). Here, scholars tend to use the term 'China model' rather loosely, referring both to China's own domestic development experience, and to its mode of aid and investment delivery in other countries. According to Dehart (2012), this situates the China model in opposition to a perceived Western aid approach, since China is viewed as promoting its own authoritarian, ecologically destructive path to modernization through large-scale investment projects. In contrast, the Chinese government frames its foreign aid and investment as South-South cooperation, in which both countries are equal partners (Alves, 2013; Amanor and Chichava, 2016). Chinese leaders have distanced themselves from the China model concept, pointing out that the country's domestic experience is not necessarily applicable elsewhere, nor is it a focus of China's foreign policy (DeHart, 2012; Wen, 2016). Recent work on Chinese investments in Africa (Bräutigam & Tang, 2011; Corkin, 2013; Wang & Elliot, 2014) complicates these overarching narratives by highlighting differences between state and private capital and the fragmented, competitive interests of different Chinese actors and their host country partners. As Lee (2014, p. 64) argues in the case of Chinese mining in Zambia, "Chinese state investors have no capacity to undermine the prevailing neoliberal order, nor any interest in replacing it."

Yet, though this suggests that Chinese state does not seek to replicate its model elsewhere, China's leaders still emphasize their unique development path and remark that lessons can be learned from China's experience (Xinhua, 2015; Yeh and Wharton, 2016). This is the basis for China's development assistance programs that fit the more conventional description of 'aid', such as training programs, technology transfer, and scholarships for host country students to study in China (Bräutigam, 2009). According to China's recent White Paper on Foreign Aid (2014), between 2010-12 China delivered 1,951 training sessions for 49,148 officials and technicians in low-income countries, completed 170 technical cooperation projects, and provided scholarships to 76,845 students. These programs focus on areas in which China considers itself to have been successful, particularly agriculture, health care, and education. Like China's other forms of aid and investment, training and scholarship programs are framed as 'cooperation' and 'sharing of experiences' between China and the host country (Xinhua, 2016b, 2011). That said, scholars who conduct fieldwork on these programs highlight that many participants believe that their countries can learn from China, particularly given China's status as a fellow developing country (Bräutigam, 2009; King, 2013).

Two recent studies on Chinese agricultural training courses provide some insight into this process. Tugendhat and Alemu (2016, p. 78) describe training for African officials that includes a mix of technology, policy, and management methods, including "a fairly standard narrative about Chinese success in moving from a 'developing country' to a modernized one." However, they find that there is no attempt to push China's experience or techniques onto other countries, and no singular 'model' to be replicated. Likewise, Xu et al.'s (2016) study of Chinese Agricultural Technology Demonstration Centers (ATDCs) in Africa highlights how Chinese aid workers construct narratives and perceptions of development and technology transfer in their training and extension activities. The authors frame these activities as 'knowledge encounters', in which ATDC staff draw upon an entrenched 'technocratic rationality' that prioritizes productivity improvements through technology and a strong role for the state in national development (2016, p. 84). Thus, they argue that Chinese training programs not only transfer technology, but also a broader technocratic development ideology rooted in China's experience (2016, p. 84). This ideology is "delivered, frustrated, and negotiated" in interactions between Chinese experts and host country counterparts, with effects on the operation and success of ATDCs (2016, p. 89).

This research reveals that training programs do indeed promote certain narratives or ideologies of development, though it is not framed as a China model that can be replicated. Moreover, it shows that the ideas and technologies that are transferred are shaped by interactions between Chinese and host country actors. In a way, these training programs are themselves model-making practices: they derive legitimacy from China's overall development experience, while also promoting specific examples and best practices from that experience. Yet largely absent from these studies is an attention to the politics of model-making, including how various actors and agendas shape the aspects of China's development that are emphasized. For example, given the commercial nature of ATDCs, we might expect Chinese experts to promote technologies (such as hybrid seeds) as playing a key role in China's agricultural productivity gains. In a similar way, we might expect these courses to emphasize environmental reforms in China's agricultural sector as evidence that Chinese food production can be green and benefit local farmers. These issues are ripe for scholarly analysis.

China's green training programs, I suggest, can offer a window into the politics and practices of model-making that aim to position China as an environmentally sustainable development partner. Indeed, China's 2014 Foreign Aid White Paper devotes an entire section to climate change mitigation programs, including technology transfer and training courses on clean energy, forest management, desertification, and other topics – areas in which China is seen to have some expertise. Like agricultural training, these green programs aim to promote China's experience and provide commercial opportunities for Chinese companies in foreign markets. Yet they also offer the Chinese government a way to improve its international image by emphasizing examples in which it has had success. These training programs are still small-scale, and can do relatively little to change the overall discourse of the China model as environmentally destructive. Nevertheless, given the paucity of green success stories in China, these programs highlight how Chinese actors and institutions – including the SHP industry – can shape green development discourse, and the potential benefits that this can produce.

5.3 Small hydropower as a green model

5.3.1 SHP in China

How has SHP become a Chinese model of green development? Despite its name, SHP has little relationship to large hydropower in China. SHP plants are a local affair: they were constructed by local governments (and later, private investors), are approved by local officials, and produce electricity and tax revenues for local use. Large hydropower plants, in contrast, are dominated by state-owned firms and generate electricity for urban centers. This difference allows Chinese officials and companies to promote SHP as a green technology with its own, unique place in China's development narrative.

Yet, as described in earlier chapters, the promotion of SHP into a green model domestically has been accompanied by a rapid expansion and scaling-up of privately-operated plants. Investors formed SHP development enterprises and allied themselves with local governments who promised attractive feed-in tariffs (Liu et al., 2015). To increase profit and government revenues, developers constructed larger plants than in the past, and situated them in cascade systems in which different river sections were controlled by different companies (Wang, Tseng, & Zheng, 2015). As a result, SHP has reduced stream flow and water access in a number of areas in southwest China In irrigated agricultural basins, SHP can also limit water access for smallholder farmers. SHP plants do not generally require any resettlement (since reservoirs are either small or nonexistent), but larger SHP plants can divert multiple watercourses to the extent that agricultural production diminishes. Indeed, because of these factors and SHP over-capacity, the provincial governments of Yunnan and Sichuan have restricted any further SHP construction as of 2016 (see Liu, 2017).

Yet, these negative impacts have not dented the promotion of SHP as a green development model, for two main reasons. First, SHP advocates claim that impacts are the result of poor local implementation and unscrupulous private investors, not issues with policy or the technology itself. This view fits a common narrative in China of blaming local governments and small enterprises for environmental problems (Tilt, 2010). While the actual drivers of SHP are far more complex, focusing on implementation alone allows SHP proponents to frame negative impacts as deviations from an ideal model. Second, the green development model that SHP embodies is based on using SHP for rural electrification and clean energy generation, not industrial development and private profit. This has implications for the types of SHP that are transferred to other countries through aid and investment, which are described in section 5.

5.3.2 Exporting China's SHP

How is SHP 'exported' to other countries, and who does this 'exporting'? The most prominent advocate of SHP has been the Chinese government itself, often in collaboration with the United Nations (UN). In 1981, China's Ministry of Water Resources established the National Research Institute for Rural Electrification (国家农村电气化研究所) in Hangzhou, with the aim of conducting training, research and development, and plant design for low-income countries. Almost immediately, the new SHP research institute received sponsorship from the United Nations Development Program – which China had only recently invited into the country – and began referring to itself as the Hangzhou Regional Center for Small Hydropower (HRC). HRC organized its first training program in 1983 for 14 hydropower engineers from South and Southeast Asia, which focused on SHP technology. Since then HRC has, by its own account, held 63 training courses for 1,334 participants from more than 100 countries (HRC, 2009). It has also been recognized by the Chinese Ministry of Commerce as a model of South-South technological and economic cooperation.

Following the establishment of HRC, in 1994 the Chinese government and United Nations Industrial Development Organization (UNIDO) created the International Center for Small Hydropower (国际小水电中心) (ICSHP), also in Hangzhou. ICSHP also organizes training courses in SHP technology and management for international participants, often in collaboration with HRC. Unlike HRC, however, ICSHP receives some base funding from UNIDO and is officially registered as a UN organization in China. ICSHP also coordinates an international small hydropower network, allowing member companies and government organizations to gain access to technical knowledge and potential project opportunities. Over the past two decades, ICSHP has situated itself as the global leader in SHP expertise, recently publishing a new edition of the *World Small Hydropower Development Report* (UNIDO and ICSHP, 2016) that analyzes the current and future situation of SHP in 160 countries. Together, HRC and ICSHP provide the Chinese government with a global stage to promote SHP as a green development model. At the same time, despite their relationships with UN agencies, HRC and ICSHP are Chinese entities, staffed wholly by Chinese nationals and ultimately directed the ministries in which they are situated.

However, these organizations are not just international training centers. They are also commercial enterprises offering engineering, procurement, and construction management (EPC), technical consulting, and financial services for SHP projects in China and other countries. The impetus for commercialization was the Chinese government's restructuring of many public research institutes in the late 1990s, which turned them into either non-profit entities or for-profit companies (Xue and Zhou, 2011, p. 7). HRC and ICSHP remained government research institutes, but their state financial support was cut and replaced with profits from commercial ventures. HRC began providing technical services for local governments and SHP investors in China, and established a new for-profit legal entity (the Hangzhou Yatai Hydropower Equipment Completing Company) that shares the same director and staff as HRC. Similarly, ICSHP established commercial relationships with Chinese SHP manufacturing and consultancy enterprises, designating them as 'demonstration bases' and encouraging ICSHP network members to use their services. While HRC and ICSHP continue to provide research support for their affiliated government ministries, commercial activity now accounts for a significant portion of their revenue.

The blurred boundary between Chinese overseas aid and business projects is well documented (Tan-Mullins et al., 2010) and not unique to SHP. But what makes SHP representative of transnational model-making? I argue that different training activities – lectures, site visits, technology transfer – all serve to situate SHP as a green example that can be studied as part of China's broader development transformation. This model-making is not necessarily explicit: the staff of HRC and ICSHP readily admit that each country is unique, and provide no step-by-step instructions for implementing a Chinese version of SHP in other countries. Rather, by sharing China's SHP experience, Chinese actors implicitly reinforce the idea that China holds lessons for others, and moreover, that China's political and economic system can deliver a green development outcome. They do this by highlighting certain characteristics of China's overall development – namely self-reliance, flexible policy-making, strong government, and technology – and situating SHP as part of and building on China's successes. Put differently, drawing specific lessons from China's SHP policies, technologies, and best practices is both a promotion of China's modernization achievements and of its future green development trajectory.

5.4 SHP model-making through training programs

What are these training programs like? What aspects of SHP and its green development role are emphasized? This section answers these questions by describing the day-to-day interactions between Chinese experts and program participants. Each year, HRC and ICSHP offer approximately seven training courses, half of which are organized jointly. Training sessions are between one and three weeks in duration and focus on a specific topic related to SHP. Some sessions focus solely on SHP technology or management; others focus on water resources management or clean energy more broadly.

I attended two of these programs in 2015. The first was entitled "Training Workshop on SHP Technology for South and Southeast Asian Regions" and was two weeks in duration: HRC hosted for the first week, and ICSHP for the second. The 33 participants in this program hailed from government ministries, utilities, power companies, and non-governmental organizations (NGOs). The second program was a week-long "Ministerial Workshop" for high-level government officials from developing countries, and focused on water resources management and development. All but two of the 19 participants who took part in this second course were from African countries. For both programs, the Chinese Ministry of Commerce provided funding to cover participants' expenses, including flights from their home countries. Both programs included a mix of presentations, discussion forums, and site visits. I was invited to participate in any program hosted by HRC and ICSHP, and I selected these two sessions based on schedule alone. As such, and because these sessions included a range of participants and topics, I believe they are broadly representative of the training offered by Chinese SHP organizations.

My attendance in both sessions was as a foreign researcher, and the organizers and participants understood that I was studying China's model of SHP. I was invited to attend after I met with and interviewed the directors and several managers of HRC and ICSHP and discussed my research project. Because the sessions were conducted in English, I also acted as a volunteer, conducting *ad hoc* translation, correcting grammatical and spelling mistakes in English-language materials, and helping to direct participants to different activities. This provided numerous opportunities to interact with both Chinese trainers and participants. In addition, I returned to

ICSHP in 2016 to attend a conference on “Small Hydropower and Green Development” and conversed with several the SHP manufacturing and investment enterprise managers in attendance.

In what follows, I highlight two means by which these training sessions are sites of transnational model-making: presentations about SHP policy and management, and visits to demonstration sites. For each, I draw out the main ‘success factors’ emphasized by Chinese trainers in their promotion of SHP as a green development model.

5.4.1 SHP policy and management presentations

Both training sessions began with a formal opening ceremony followed by several days of lectures and presentations. In the SHP Technology course, presentations focused on the history and different functions of SHP in China, SHP policies and regulations, and the role of hydropower in rural electrification, poverty alleviation, and economic development. In the Ministerial Workshop, presentations covered a broader range of topics related to water resources management and hydropower in China, including SHP.

Three themes emerged from these lectures. The first is that China is not blessed with abundant water or land resources, and that the country’s SHP and water resources development were exercises in *self-reliance*. Self-reliance is framed as the reason that the early Communist government promoted SHP construction for water storage, irrigation, and electricity for rural communities. One of the directors of HRC, Ms. S, described how local governments in hilly areas used their own water resources to develop SHP for rural electrification in the 1950s-70s, since the central government did not have the means to extend the grid. She also stressed the policy at that time of ‘self-construction, self-management, and self-consumption’, under which county and township-level governments were encouraged to re-invest revenues in additional plants. As another presenter stated in the Ministerial Workshop, “We [China] did not have any help from other countries; we had to rely on ourselves.”

A second theme of these presentations was *flexible policy-making*. Trainers stressed that SHP policy has changed over time in response to local and national conditions. Ms. S explicitly divided China’s SHP development into the three stages of rural electrification, industrial development, and environmental protection discussed earlier in this chapter, noting that electrification rates increased along with SHP installed capacity. She then followed with a table showing changes to the definition of SHP in China – from <0.5MW in 1950, to ≤50MW today – to emphasize the government’s flexible policy approach to how SHP electricity could be used, and the benefits that it could supply. This current definition of SHP in China struck many participants as being abnormally high, or as one South Asian attendee noted, “more like a medium-sized plant than small hydropower.” In the discussion following the presentation, however, several participants mentioned that increasing the definition of SHP in China enabled it to be deployed for purposes beyond rural electrification, such as renewable energy production. One Southeast Asian utility manager suggested that using SHP in this way would benefit his country’s low-carbon energy portfolio.

The third, and perhaps most evident, theme was that of a *strong government and SHP management system*. Here, the focus of the two training programs diverged somewhat. In the SHP Technology course, an entire presentation was devoted to standards and regulations for SHP plants in China, which HRC is currently developing for the Ministry of Water Resources. Mr. Z, an HRC director, noted that the government approved 58 new ‘green’ standards in 2008, and an additional 32 standards in 2014, which include a minimum ecological flow for all SHP plants in China. He also mentioned that SHP plant construction standards were the first of their type in China to be translated into English and made available to host country governments where SHP companies are active. In the Ministerial Workshop, presentations instead focused on the broader river basin management structure and environmental regulations for all water infrastructure projects. Here, Mr. M, an ICSHP director, detailed the various national, provincial, and basin-level 'red lines' for water conservancy and ecological protection that have been integrated into development planning and officials' promotion criteria. Mr. M promoted SHP as a centerpiece of these efforts, but also mentioned large hydropower and urban water provision – in effect, linking them to the established green reputation of SHP.

Somewhat surprisingly, Chinese trainers did not shy away from talking about the negative ecological impacts of SHP described in the previous section. Mr. Z, in his presentation on SHP standards, mentioned that SHP in some parts of China did not develop in a 'comprehensive manner', and that private plant operators did not pay attention to ecological flow requirements. Similarly, a high-level official from Zhejiang province noted that China faces water shortages, water pollution, and ecological deterioration caused by rapid economic development, which include the effects of small and large hydropower plants. At the same time, these problems were largely framed as a failure of local management and private investors, not broader policy. Such rhetoric blames any negative impacts of SHP on local officials and operators, leaving the overall narrative of SHP as a green development model intact. Course participant reactions to this assessment varied; many expressed concern about China's overall environmental record, but tended to focus more on the developmental benefits of SHP and water resources infrastructure rather than their ecological impacts.

5.4.2 Hydropower technology and site visits

In addition to presentations on SHP policy and management, participants listened to lectures on hydropower technology and visited ‘demonstration sites’. The sites chosen were different for each program. Those in the SHP Technology course spent three days at ICSHP’s manufacturing base in Jinhua, a city 180km south of Hangzhou. Once there, participants were given tours of SHP plants and a turbine manufacturing facility operated by an ICSHP member company and supplier. Ministerial Workshop attendees visited much larger water infrastructure projects, including a two-day trip to the Three Gorges Dam. The stated purpose of these visits was ‘spot teaching’, or demonstrations, in which Chinese experts would explain the workings and applicability of different pieces of equipment and infrastructure. About one third of the participants in both programs had an engineering background and asked technical questions; these tended to revolve around turbine types and control room equipment.

The SHP Technology course devoted an entire day of presentations to the technical details of SHP plants. Mr. L, an HRC director and mechanical engineer, lectured on the different types of turbines manufactured in China and their suitability for various sites. This was partly a technical presentation, and partly an introduction to Chinese equipment manufacturers; Mr. L mentioned several companies by name that specialize in specific types of turbines, and noted that equipment accounts for 30-40% of SHP project costs. The presenters that followed Mr. L focused on site selection and design of SHP plants, including different exploitation types, underlying geology and slope stability, and the design of the flow intake and powerhouse. Course participants asked questions during the discussion period, but most appeared to have a strong existing knowledge of SHP design and technology – one attendee, from South Asia, was a university hydropower professor. Thus, rather than teach participants new skills, these sessions mainly served to highlight Chinese technological expertise, particularly the capabilities of China's SHP industry.

The site visits taken by the 'SHP Technology' group at the Jinhua manufacturing base aimed to bolster these positive perceptions of the SHP industry. Participants visited three SHP plants: one stand-alone diversion-type plant, and two plants in a cascade system regulated by a reservoir. Of the latter two plants, one was built during the 1960s, and another during the 2000s, providing a comparison between technologies used in those two eras (and evidence that Chinese equipment has a long operating life). At each plant, the station manager gave a detailed account of operating conditions and noted that they abide by minimum ecological flow requirements. Strong emphasis was also placed on the safety of the equipment, underscored by giant red workplace safety banners hanging on the walls of the powerhouse. The following day, participants visited a turbine factory in Jinhua, one of several in the greater Hangzhou region. As a large manufacturing enterprise, the factory offered HRC and ICSHP staff a means to show off high-quality turbines built in China, comparing them favorably to those of Western companies like Siemens and Voith.

Participants in the Ministerial Workshop, in contrast, did not visit any SHP plants or factories. Mr. L mentioned that this was due to a lack of time and because course attendees would be more interested in large-scale water management infrastructure. Indeed, the centerpiece of the entire week's activities was the Three Gorges Dam trip, a seven-hour journey from Hangzhou via high speed rail. I was not invited to attend this portion of the course, but learned in follow-up conversations that participants toured the facility and met with representatives from SinoHydro and the Three Gorges Dam Corporation, two major state-owned hydropower enterprises. Upon returning to Hangzhou, participants then toured several large-scale water projects in and near Shanghai, including an irrigation pumping station, a control room for urban water delivery, and a

1km-long sluice gate that creates an artificial barrier between saltwater and freshwater in the Huangpu estuary. Here, training course attendees were exposed to a variety of infrastructure projects much bigger than those constructed by the SHP industry – projects that provided evidence for China's prowess in water management and electricity production.

The purpose of these lectures and site visits, then, was more than just training. They also served as demonstrations of the capabilities of China's SHP industry, and of the technological feats of the Chinese state. Such activities highlighted the belief among the Chinese experts that technology is all-important; that "if you have good site specifications and good equipment, then you can develop SHP" in the words of Mr. L. They situate technological expertise alongside self-reliance, flexible policy-making, and a strong government as the factors that led to the green development achievements of SHP. As such, they are model-making practices, positioning SHP as a green outcome of China's modernization and an example that other countries can learn from.

Nonetheless, while Chinese trainers emphasized the same themes in both training courses, the infrastructure projects that participants visited were very different. SHP Technology course attendees only saw small plants; Ministerial Workshop participants traveled to large hydropower and water resources projects. These site visits were selected based on the kinds of projects that foreign attendees (and their organizations or governments) wanted to learn about, and the projects that the Chinese state and firms hoped to deliver. Here, the green development model of SHP is flexible enough to be applied to a variety of small and large projects, even those that are not SHP at all. Thus, SHP is not a static model that is merely recited by trainers and absorbed by participants; it is continually shaped by broader governmental and commercial interests, in China and host countries. These interests, and the types of technology transfer that result, are the subject of the next section.

5.5 SHP model-making through aid and investment

On the surface, SHP training programs are venues for teaching and knowledge sharing. But what do they actually *do*? And what are the politics, broadly conceived, that shape how SHP technology is transferred? Training participants were keenly aware that HRC and ICSHP have political and commercial motivations for hosting these courses. The first of these is to foster closer ties between China and other countries, with China as a development partner. The second is to open new markets for Chinese hydropower firms, both the SHP companies represented by HRC and ICSHP, and large state-owned enterprises with close ties to the government. Indeed, several attendees explicitly asked for Chinese assistance in developing SHP, while an official from East Africa suggested that China could assist his country with river basin management. These new markets are of increasing importance to Chinese SHP firms who face intense domestic competition and restrictions on further plant construction. Here, training programs help facilitate new aid and investment projects – what Chinese officials call technology transfer – while framing them in the context of the green development example of SHP. These acts of technology transfer are also model-making practices; they uphold SHP as a model worthy of study, but highlight (and transfer) specific aspects of the model that align with the political and commercial goals of China and host countries. Below, I describe four types of technology transfer that emerge out of SHP training programs: direct aid provision, sales of equipment and services, SHP investment, and large-scale infrastructure investment.

The direct provision of SHP technology and expertise is a small, but important, part of the HRC and ICSHP portfolios. For HRC, this includes delivering tailored courses for specific countries and hydropower projects, including an annual three-week workshop on SHP technology in Rwanda. ICSHP, meanwhile, is the lead agency for “Lighting Up Rural Africa”, a joint project of the Chinese Ministry of Commerce and UNIDO launched in 2007. This project aims to install 100 mini (≤1MW), micro (≤100 kilowatts (kW)), or pico (≤5 kW) hydropower plants in rural areas of ten African countries that do not have an electricity connection (14 have been installed so far). ICSHP staff compare these areas to rural China many years ago, when small-scale SHP was first deployed for rural electrification and as a fuelwood replacement. In this case, Chinese actors stress the role of SHP in poverty alleviation and local environmental protection, rather than clean energy production or economic development. These projects are still ongoing, but are funded entirely by grants; they do not offer a long-term approach to SHP technology transfer.

A more common outcome of training programs is the sale of SHP goods and services. These range from transactions involving single turbines or containerized plants, to contracts for the entire EPC management of a plant. Here, HRC and ICSHP operate as consultants for training program participants seeking to construct or refurbish plants in their own country, and can provide specialist advice from site selection and pre-impact evaluation to SHP maintenance. Both organizations procure turbines and electrical equipment from the same network of manufacturers, including those mentioned in presentations and included in site visits. HRC and ICSHP staff involved in training programs made themselves available for individual meetings with participants to discuss commercial opportunities, including additional site visits. Indeed, more than half of participants in each program visited additional SHP plants and factories based on their own needs and site specifications. Here again, the model of SHP espoused in training programs is adaptable to different contexts, whether mini-SHP for remote villages, off-grid plants powering a specific industry, or grid-connected plants (both SHP and medium-sized hydropower) used for clean energy production. Nonetheless, these sales are generally targeted to potential investors and governments that can afford them, rather than lower-income countries.

A third category of technology transfer is Chinese investment in overseas SHP projects. In the SHP Technology course, participants were asked to list the major barriers to developing SHP in their country; five of the eleven countries present mentioned financing and investment. Indeed, Mr. L noted that independent power producers in host countries are often unable to provide a bank guarantee when engaging Chinese firms in an SHP project. One solution, which HRC and ICSHP can facilitate, involves a Chinese SHP investor setting up a local company and applying for a project-based guarantee from a host country bank. Another solution, generally for larger SHP projects, is financing from a Chinese commercial bank, in which Chinese developers are the sole shareholders. However, for any of these projects to earn revenue, they must have a power purchasing agreement (PPP) with a local utility, which means that plants are generally grid-connected or send power directly to an industrial facility. Such plants can replace dirtier fuels with clean energy, but are also incentivized to earn profit, much like SHP plants in China today.

Finally, training programs also facilitate Chinese investment in large-scale water infrastructure projects, such as hydropower and irrigation pump stations. These projects are rarer, and generally undertaken by state-owned enterprises with access to loans or export buyer's credits from Chinese policy banks.[1] HRC and ICSHP do not have a stake in these large-scale projects, and most of their suppliers do not manufacture equipment suitable for them. Thus, the two organizations act as a facilitator rather than a service provider; during training programs, Chinese hosts offered to assist participants to set up meetings with government officials and state-owned hydropower enterprises (like SinoHydro). Such activities highlight the fact that HRC and ICSHP are government organizations, delivering training programs on behalf of their parent ministries that do not necessarily produce direct benefits for the SHP industry. Yet, these institutions derive

---

[1] According to HRC, Chinese policy banks like the Export-Import Bank of China (EXIM Bank) and the China Development Bank (CDB) will generally only consider financing hydropower projects >100MW.

some advantage from associating large-scale water projects with SHP: it situates the former in the context of China's success in green SHP, and the latter as a key part of China's overall development narrative. This mode of transfer occurs even though large-scale infrastructure has little in common with the green development model of SHP espoused in training programs, and can have negative social and environmental impacts.

Tab. 5.1: *Modes of SHP technology transfer*

Relationship Type	**Project Type**	**Financing**	**Potential benefits**	**Potential cons**
Direct Aid	Small-scale, usually off-grid plants for rural electrification	Chinese government grant (some support from UN)	Provides electricity connection to remote communities	Once-off projects, not long-term business model
Sales	Turbines, equipment, design, construction, management	Direct payment from overseas buyer	Project driven by host country/org., can use Chinese expertise	Mainly for countries/ organizations that can afford to pay
SHP Investment	SHP, usually grid-connected plants that sell electricity	China or host country bank loan & investors	Generates clean energy, is long-term business model	Needs PPP & oversight, may not benefit local people
Large Investment	Large hydropower or water management infrastructure	Chinese policy banks (EXIM, CDB)	Potential electricity generation, flood control, irrigation, etc.	Social & env. impacts, unlikely to benefit (& may harm) local people

The revenue and investment opportunities that arise from the training programs are difficult to measure, and I was not able to access data about agreements or contracts that may have been established. I was, however, told of more than ten meetings between program attendees and Chinese staff about potential commercial opportunities, and met with a South Asian participant who later returned to purchase equipment from HRC. Mr. L noted privately that HRC and ICSHP continue to follow up with participants, and that more than half will either return to Hangzhou or send a colleague from their institution to receive further training or establish a business relationship. Another HRC staff member mentioned that their organizations maintain a good relationship with the Ministry of Commerce to continue deliver training courses, since they bring in money and potential clients. Indeed, HRC's 2015 annual report lists EPC contracts with Turkey, Pakistan, Nepal, Vietnam, and Indonesia for small hydropower plants, while ICSHP reported consultation visits (which include site selection, financing, and EPC) to 46 countries over the last five years. Further research is needed to assess the links between training programs and the business arms of these organizations, and their impacts for host countries.

5.6 Conclusion

This chapter describes China's SHP training programs as acts of green model-making that combat prevailing notions of the China model as environmentally destructive. Of course, SHP is not fully representative of China's overall modernization path – the country continues to burn coal – but it does provide a model of using clean energy for green development that Chinese actors can deploy. International training programs offer a means to share this experience, offering SHP legitimacy as a key part of China's developmental achievements, and as an example of China's future low-carbon trajectory. SHP is thus a discursive tool that shifts attention away from negative interpretations of the China model to a model of green development. As ICSHP's literature states, "China's SHP provides a model worldwide of local sustainable development", which can "guide the green development of China and of global small hydropower."

In training programs, HRC and ICSHP highlight self-reliance, flexible policy making, a strong government, and technology as key factors in achieving green development through SHP. These themes are similar to those identified in other recent studies of Chinese training programs (Tugendhat and Alemu, 2016; Xu et al., 2016). Here, however, they tie SHP to the broader characteristics associated China's modernization, making it clear that the Chinese state can deliver a green development outcome. At the same time, this model of SHP is adaptable to different contexts, as evidenced by the different types of infrastructure visited by SHP Technology and

Ministerial Workshop attendees, not all of which were SHP plants. Similarly, technology transfer projects that emerge out of training programs are also crafted according to China’s (and host countries’) political and commercial interests, which in turn influence the aspects of the SHP model that are emphasized. Training programs thus benefit the Chinese government and SHP enterprises, while also offering an entry point (among many) for state-owned enterprises to construct infrastructure overseas.

More broadly, the results of this chapter highlight the need to examine the politics and practices of model-making, in which different actors define, promote, and contest models of development and the policies that they might inform. I argue for closer examination of green model-making in China, from the broader discourse of green development to specific models that are emphasized. On a more empirical level, this chapter adds to studies that contend that there is no one China model being ‘exported’ through aid and investment. However, I argue that training programs can still be model-making activities, in that they stress examples and best practices that are worthy of study. The ideas and techniques promoted as a model are drawn from a specific context – such as SHP – but still serve to underscore China’s achievements. As China seeks to transition to a green development path, it is imperative to analyze attempts to shift the discourse of the China model to ‘greener’ examples, and how these articulate with broader political and commercial interests.

CHAPTER 6

Conclusion: New Frontiers

6.1 Small hydropower and green development

The preceding pages document how state, private, and community actors have shaped the rapid growth of small hydropower on China's western resource frontier. They also describe how certain types of SHP technologies, policies, and practices are packaged and 'exported' as a model for other countries through training programs. Taken together, these analyses reveal a distinct historical and geographical trend in the evolution of SHP: from a small-scale, off-grid energy source for rural electrification in eastern China, to an expanse of high-capacity cascade systems that generate electricity for profit in western China. Yunnan province, the center of hydropower development in China, experienced a three-fold increase in SHP installed capacity between 2000-2010, a phenomenon mirrored in China's other western provinces and regions. SHP offered rural areas like Xinping a path to industrialization and economic growth, seemingly without the ecological consequences of other energy systems. Yet, the combination of over-allocation of permits, lax enforcement of regulations, and profit incentives have negatively impacted local communities and environments in many areas of Yunnan. The Chinese state's decision to draw down SHP construction – primarily due to concerns about SHP inefficiency – has prompted investors to turn to overseas markets, potentially leading to another SHP boom outside of China's borders.

But this dissertation is not just about small hydropower. It is also about how renewable energy technologies like SHP – and indeed, many other 'green' programs or interventions – act as vehicles for different (and often competing) ideas and visions about green development. Green development, like 'sustainable development' or the 'green economy', is effectively a buzzword; it holds different meanings that vary according to the time, place, scale, and type of environmental and economic problems that are being addressed (Adams, 2009; Lélé, 1991). Moreover, because there is no agreed-upon definition, green development discourse is easily co-opted by different groups and actors to achieve their own aims, whether these aims are ‘green’ or not. The varied struggles and negotiations over what green development entails are not confined to policy or theory; they are played out on-the-ground through the design, implementation, and potential ‘export’ of specific technologies, infrastructure, and management practices. This dissertation used SHP as a lens because it encapsulates, in one technology, the different priorities of how, where, and for whom renewable energy is meant to drive green development. As I have shown, these different priorities have real material consequences for regions and communities on the SHP frontier.

And yet, while SHP is shaped by many different ‘green’ and ‘development’ priorities, it is the central state that sets broader narrative and goals of SHP that other actors must work within. To capture this narrative, I proposed the concept of ‘logics of green development’, which refers to the political-economic rationale for how the state manages the tension between environment and development in different times and places. The ‘state’ is not a unitary entity; it is comprised of multiple, competing ministries and power centers, which are themselves made up of individual actors who may work together or disagree about the goals of development projects (see Sharma and Gupta, 2006). Still, in China, the state has guided the development of SHP over time and space through varied policies and pronouncements, which in turn shed light how state logics of green development can shift and/or conflict with each other. In this dissertation, I identified two distinct logics of green development: the logic of preserving green economic value through conservation-based rural development, and the logic of producing green economic value through renewable energy generation. I showed that these logics are inherently spatial because they focus on ‘frontier’ regions as places that are both in need of green development (due to ecological degradation believed to be caused by poverty) and that are important resource providers for national low-carbon development. These logics are important to identify, I argued, because they produce very different incentives for how local officials and investors implement SHP plants, which can lead to the local consequences that I describe in Xinping and elsewhere in Yunnan.

This dissertation produced two major empirical findings. The first is that small hydropower, despite the stated intentions of its proponents, has contributed to economic volatility and water scarcity in the regions and communities that it was originally supposed to benefit. To capture this geography, I introduced yet another concept: that of the ‘low-carbon frontier’. The low-carbon frontier describes how the state reformulates resource-rich areas as stores of low-carbon value that must be extracted to achieve national green development. It is a useful analytic device because it highlights how large-scale renewable energy systems – including SHP – are subject to the commodity price fluctuations, infrastructure and geographical constraints, and flurries of speculative loans and investment that characterize traditional extractive industries. It also draws attention to a general lack of regulation and enforcement that accompany resource booms, even when the resource in question is renewable. And moreover, the low-carbon frontier enables us to place SHP (and other green technologies and programs) in the broader context of state aims to increase its control over peripheral territories and enable economic growth to continue. As I have documented, the transformation of SHP into an industrial energy source has brought few benefits to adjacent communities that do not receive subsidized electricity, and in some cases, has harmed their livelihoods. Thus, while SHP and renewable energy are certainly better than fossil-fuel alternatives, they are not automatically green or equitable.

The second major finding of this dissertation is that there is a disjuncture between the decline in support for SHP within China, and efforts to promote SHP as a green development model for other countries. As I described in Chapter 2, in 2016 the provincial governments of Yunnan and Sichuan announced restrictions on all new SHP construction, followed by a national reduction in SHP targets in the 13th Five Year Plan. The main reason for this about-face, I showed, is that the state sees SHP as an inefficient producer of the renewable energy needed to meet national mitigation targets and electricity needs. Yet, while domestic investment in SHP has nearly vanished, government officials and investors actively market SHP as a green example that other low-income countries can follow. For investors, the international promotion of SHP is intimately tied to interfirm competition and diminishing returns from domestic SHP projects. For government officials, SHP provides evidence that the Chinese state can deliver a green development outcome, and is thus a trustworthy aid and investment partner. This dissertation thus highlighted that state and private sector support for SHP – and indeed, SHP's reputation as a tool of green development – are shaped by broader economic and geopolitical goals, within and outside China's borders.

6.2 Answering the research questions

The dissertation began by situating small hydropower in the broader context of China's renewable energy expansion and its aid and investment in other countries. I chose SHP as an example because, in addition to being under-studied, it also offers a specific case of how green development in China is conceptualized, implemented, and 'exported' elsewhere. The research design of the dissertation aimed to follow this path of SHP through these various stages, and thus required fieldwork across several research sites. In addition to my main field site of Xinping county, Yunnan, I also conducted research in two other Yunnan prefectures (Wenshan and Nujiang), one prefecture in Zhejiang province (Lishui), and the cities of Beijing, Kunming, and Hangzhou. This 'distended case approach' (Peck and Theodore, 2012) offered a means to explore how SHP plants – and the technologies, ideas, practices alongside them – are shaped by Chinese state logics and by local conditions. In short, this approach enabled an understanding of the geography of green development in China.

The four research questions posed in this dissertation each corresponded with a substantive chapter. Below, I revisit each of these questions and summarize my results and their implications.

1. What policies and institutions govern SHP in China and Yunnan, and what logics of green development do they reflect? (Chapter 2)

Since the beginning of the Maoist period, when the state first began constructing SHP, individual plants have been the responsibility of local governments at the prefecture or county level, while SHP policy has been coordinated by the Ministry of Water Resources. Yet, the state's aims and rationale for SHP plants have changed dramatically since the early 2000s. In Chapter 2, I described what I referred to as the 'boom and bust' period of SHP in the post-2000s era, which was concentrated in water-rich regions of Yunnan and western China that I previously identified as a 'low-carbon frontier'. I argued that the 'boom' in SHP was driven primarily by electricity sector reforms and preferential state policies that allowed private enterprises to invest in and operate SHP. The 'bust', in contrast, was caused by a reversal in state support for SHP because it was viewed as 'overdeveloped' and an inefficient generator of renewable energy, especially in contrast to solar and wind installations. These changes in policy had not yet occurred when I began researching this project and influenced how I ultimately answered this research question.

Why, then, did the state change its mind about SHP? I argued that, in the early 2000s, SHP became enrolled in two different state logics of green development: the need to conserve forests and achieve rural electrification, and the need to meet carbon mitigation and energy production targets. But by the mid 2000s, producing renewable had become the main state rationale for SHP, since SHP was a proven technology that was far cheaper (and at the time, more efficient) than other technologies. Moreover, in the prefectures in Yunnan where I conducted research, local governments viewed SHP as a means to generate electricity for tax revenue and for new industries, particularly mining and mineral processing. All the while, the central state and local officials could label SHP as a tool of green development because it boosted the local economy while contributing to national low-carbon goals. The state's eventual restrictions on the SHP sector were a signal that it no longer views small hydropower as part of green development, a decision which has resulted in local governments and investors saddled with devalued infrastructure.

SHP, then, is a window into the broader economic and environmental priorities of state, and how these priorities shape and are shaped by conceptions and realities of the 'frontier'. Yunnan and western China are key sites where the conflicts between different logics of green development are laid bare. The results of this analysis thus help us to understand why the state implements certain green development schemes over others in particular times and places.

2. How do local politics, economic considerations, financing channels, ecological conditions, and ideas about green development shape how SHP is implemented in Xinping? (Chapter 3)

While the first research question examined SHP policy and governance, this question and Chapter 3 focused on implementation: the construction, operation, and management of plants 'on the ground'. Here, I focused on what I called the SHP 'green industry', or commercially-oriented firms that generate economic value through some sort of environmental activity (for example, by generating low-carbon electricity). In rural western China, this 'green industry' is made up of private investors – many hailing from eastern China – and of local officials seeking to boost tax revenues and their own environmental credentials. Xinping county provided a useful case study because it is topographically and ethnically diverse, and because it has a history of using SHP for both rural electrification and energy generation for sale to the grid. This question sought to understand how local actors and conditions in Xinping shaped the material manifestation of SHP during the 2000s boom and afterwards.

This chapter found that SHP plants in the last fifteen years have gotten larger and are situated in longer cascades, which can heavily impact streamflow and irrigation water access for farmers. State preferential policies for SHP partly drove this trend towards large-scale SHP systems, but it was not the only factor. For private investors, these large-scale systems are more profitable because they generate greater amounts of electricity for sale to the grid. Local officials approved large-scale SHP because they generated more tax revenue, could attract more CDM funding, and because SHP systems were explicitly tied to cadre promotion. Moreover, the more recent decline of state subsidies for SHP, and the rapid growth in solar and wind, has impelled investors and officials operate SHP plants throughout the year – including during the dry season when streamflow is already reduced. The consequence of these factors is that SHP exacerbates water scarcity in Xinping while providing dwindling returns to investors and local officials. These findings suggest a need to be skeptical about the benefits of privatizing and scaling-up rural renewable energy to try and achieve multiple economic and environmental goals simultaneously – a conclusion shared with studies of green development programs (Bumpus and Liverman, 2008; Kull et al., 2015).

3. What are the impacts of small hydropower on fuelwood use and irrigation water access in Xinping? (Chapter 4)

This question, and Chapter 4, aimed to unearth the benefits and consequences of SHP in rural western China, again using Xinping as a case study. I focused on two aspects of SHP that are known to scholars but still under-studied: its positive contribution to reducing fuelwood collection and use, and its negative impact on streamflow and water access. I randomly selected eight village clusters in Xinping that differed in elevation, size of adjacent SHP plant, geographical relationship to adjacent SHP plant, and average per capita income, among other characteristics. I then trained five graduate students to administer surveys to approximately 15% of households in each location. Through these means, I aimed to parse how SHP impacts are distributed between villages, and the variables that influence this distribution.

The results of the survey demonstrated that fuelwood collection and use are correlated with the price of electricity, not the existence of an SHP plant. Thus, it is only the two villages that receive subsidized electricity through the central government's 'SHP Replace Fuelwood' program that show a significant reduction in fuelwood following the construction of a new plant. These two villages are situated in upland areas with poor soil and transportation links, and were only connected to the power grid in the early 2000s, such that SHP makes a strong positive contribution to farmers' livelihoods. Other villages, in contrast, were connected to the grid in the 1990s or earlier, and pay the same price for electricity regardless of whether it is generated from an SHP plant. Thus, while new SHP plants certainly provide tax revenues for local governments, they offer no direct benefit to villages that do not receive electricity subsidies.

In addition, survey results revealed that irrigation water access is reduced for farmers whose land is located between the intake and powerhouse of an SHP plant. This water scarcity is further exacerbated by larger SHP plants in cascades (such as the 30 MW Dachun #1 plant) that draw water from the headwaters of multiple streams. Villages with the most reduction in access also suffer from poor irrigation infrastructure that had not been upgraded (or had been left to crumble) following the construction of the adjacent SHP plant. Farmers in these villages, in particular, complained that SHP operators would sometimes continue generating electricity in the dry season despite their requests for water, leading some of them to switch to more drought-tolerant crop varieties. However, farmers in villages that draw irrigation water from unaffected sources, or that are located next to smaller SHP plants, voiced few concerns about the impacts of SHP. These results, then, suggest that small hydropower plants and dams are not always beautiful, and that future SHP construction should be designed and managed so that local communities are the main beneficiaries.

4. What SHP technologies and ideas about green development are being transferred to other countries through training courses and investments? (Chapter 5)

While most of the dissertation examined SHP policy, implementation, and impacts within China, this question (and Chapter 5) asked how and why small hydropower is packaged as a green development model for other countries. The main venue for this promotion of SHP is international training programs for government officials, engineers, and NGOs from low-income countries, primarily those in South Asia, Southeast Asia, and Africa. The Chinese government has funded the delivery of these training programs since the early 1980s, first through the Hangzhou Regional Center for Small Hydropower of the Ministry of Water Resources, and then also through the United Nations-sponsored International Center for Small Hydropower. These training programs are a space of encounter where Chinese trainers and international participants learn about and discuss SHP technology, policy, and narratives about how SHP drives green development.

The results of this chapter demonstrate that types of SHP technologies, policies, and ideas about green development that are 'exported' through training programs are largely shaped by the commercial and geopolitical concerns of Chinese actors. I showed the training programs and site visits emphasize the 'success factors' of self-reliance, flexible policy-making, and a strong government and SHP management system, as well as the technological feats of the Chinese state and hydropower companies. I argued that these training programs are 'green' (and transnational) model-making practices, because they situate SHP as an environmentally-friendly outcome of China's modernization that other countries can follow. At the same time, I showed that while there is no one 'China model' of SHP, the actual technologies that are transferred are similar to those that have caused environmental and social impacts in Yunnan, and that they may not be suitable for conditions in other countries. These results, then, urge us to question the politics and practices that shape development models, and the spatialized ideas about green development that they reflect.

6.3 Theoretical contributions

Beyond the empirical findings and answers to the research questions described above, this dissertation also contributed to two key theoretical debates, situated at the intersection of economic geography, political ecology, and development studies.

First, this dissertation highlights that green development to be an inherently geographical process, with dominant interpretations that shift over time, space, and scale. I built on recent work in economic geography that traces how state-led environmental governance has changed over time, moving from a focus on pollution control to climate change mitigation through market mechanisms (Boyd et al., 2011; Ervine, 2013; While et al., 2010). These studies push back against the notion engrained in ecological modernization that environmental governance follows a specific pattern, instead highlighting the power struggles and conflicts that shape how environmental problems are understood and acted upon (Chang et al., 2016; Himley, 2008). Yet, while these studies show how modes of governance are shaped by competing interests, these interests tend to be situated as part of the same political-economic logic, with state intervention understood primarily as a response to capitalism's inherent tendency to destroy the environment (Castree, 2008a). I argued instead that state logics of environmental governance vary between places and scales, which can lead to trade-offs between different 'green' and 'development' priorities. I specifically highlighted how SHP is caught between a logic of conservation-based rural development and a logic of low-carbon national development. In this way, this dissertation infuses studies of environmental governance and low-carbon transition with greater attention to the spatial politics of green development.

Second, this dissertation emphasized that renewable energy – and green development models more generally – are not inherently sustainable or equitable; they are shaped by the local, national, and international contexts in which they are situated. I drew on work by scholars of Asian urbanism who trace how models that arise in specific places are continually re-made as they travel elsewhere, often with adverse or unanticipated results (Chang et al., 2016; Hoffman, 2011). I also built on political ecology scholarship that shows how popular green development programs – such as payment for ecosystem services, or integrated conservation and development – can be hijacked on the ground by powerful actors to serve other political and economic goals (Bumpus and Liverman, 2011; Ghazoul et al., 2010; Kelly, 2011; West, 2007). However, this dissertation went a step further by examining the conditions in which these green development models are *themselves* formulated, and how these models are negotiated and contested through projects like SHP. Moreover, while existing research mainly analyzes development models originating in the Global North, I focused on the growing role of China in shaping global development discourse and practice, and the specific actors and institutions involved. In particular, I showed how Chinese officials and hydropower investors promote SHP as a model of green development through international training programs. These insights enable a better understanding of the competing interests behind different models of development, and their material manifestations.

6.4 Study limitations

This dissertation provides a detailed study of small hydropower in China, from policy, to implementation, to international technology transfer through aid and investment. My more than twelve months of fieldwork in China, using a ‘toolbox’ of methods, aimed to describe these different ‘stages’ of SHP and their spatial underpinnings. Government officials graciously made time to answer my questions, and often elaborated far more than I expected (often over lunch or dinner). SHP investors and operators were often frank and direct about their profit motivations and financial position. And the many farmers that I (and my survey team) spoke with offered nuanced assessments of small hydropower, both its benefits and drawbacks. My partnerships with Yunnan Normal University, the Kunming Institute of Botany, and Tsinghua University provided with project with academic credibility, and I always sought out relevant authorities in each county or prefecture before scheduling interviews or conducting surveys.

Yet hydropower is still a sensitive subject in China, and local governments are often suspicious of foreign researchers. Much of the data about China’s SHP plants – such as their location, electricity output, and curtailment rate – is considered a ‘state secret’ and was unavailable for analysis. I was able to gather some localized SHP data through interviews with CSPG and Ministry of Water Resources employees in Xinping county and Nujiang prefecture, but not in the other study sites. Similarly, I was unable to gain access to local government tax and revenue records in any of the case study locations, so I cannot quantitatively estimate the degree of local economic dependence on SHP (see Hennig and Harlan 2017 for a local economic analysis of SHP in Dehong prefecture). That said, I was able to conduct enough interviews with relevant authorities in each study site to offer a qualitative appraisal of the role of SHP in local economies, which I supplemented with local news articles and government reports.

I also faced difficulty collecting data on Chinese aid and investment projects in other countries. Because overseas SHP projects are mainly financed and constructed by private investors, rather than state-owned enterprises, the Chinese government does not collect detailed information on them. SHP investments and/or equipment sales conducted by HRC or ICSHP are commercial-in-confidence, so I was only able to gather comprehensive information about aid and technology transfer projects, not commercial projects. Nonetheless, by interviewing multiple staff of HRC and ICSHP and participating in four training programs and international conferences, I was able to glean qualitative insights into the type, amount, and locations of SHP investments. Further interviews with commercial SHP enterprises would be required to accurately estimate the degree to which training programs precipitate investments in SHP plants and infrastructure in other countries, and their regional and local impacts.

Beyond issues with data collection, I also recognize the limitations of using one case study technology (SHP) and one case study region (Yunnan) to draw broader conclusions about renewable energy and green development in China. Three limitations stand out, all of which offer opportunities for future research. First, due to the timing of my fieldwork, my interviews with local officials in Yunnan occurred immediately before or after new SHP restrictions were announced. This timing meant that I could find few officials who would offer unequivocal support for SHP, even though many of these same officials rapidly approved plants during the 2000s boom. Likewise, though SHP investment in Yunnan has steadily declined since the early 2010s, leading to lost government revenues, it is difficult to gauge the future economic impact of this decline beyond current conditions. Nujiang prefecture, for example, is being targeted for provincial government investment in eco-tourism, which has the potential to diversify the local economy and provide job opportunities far beyond what SHP offers. Longer-term fieldwork in Yunnan is necessary to determine if and how SHP generation will be replaced with other economic activities, and the role of the state in guiding this transition.

Second, while this dissertation documents the local impacts of SHP on fuelwood use and irrigation water access, it lacks detailed analysis of environmental consequences, particularly those related to stream dewatering and soil erosion due to the use of emergency spillways. Hennig and Harlan (2017) investigate stream dewatering in Dehong prefecture, but I did not collect any hydrological data from Xinping or other case study sites to support their conclusion (streamflow data is also a state secret in China). As I describe in Chapter 4, many of the households in Xinping who experience reduced irrigation water access also complain of streamflow reductions during the dry season; however, I was unable to confirm their experience with flow statistics. Moreover, this issue of environmental impacts points to the broader limitation of case study research, in that findings from one location due not always translate to another. Here, I aimed to contextualize my findings in Xinping by conducting research in Nujiang and Wenshan prefectures, but was unable to gather the same level of detail in these prefectures as I could in Xinping. Thus, while I believe the data presented in this dissertation are representative of SHP in Yunnan, they must be read and interpreted in the specific context in which they were gathered and analyzed.

Third, and finally, this dissertation recognizes that SHP occupies a somewhat liminal space in the continuum of renewable energy technologies, an acknowledgement mirrored in the Chinese government's own policy reversals. SHP is, at its core, a smaller version of large hydropower, and shares many of its same characteristics and problems. At the same time, like solar and wind, SHP has a lesser environmental footprint than large dams, and it has a history of use for rural electrification. It is this liminality that originally attracted me to SHP, because it illustrates how certain green technologies can become hegemonic, used for different purposes, and ultimately discarded in favor of others. Yet, an analysis of SHP in China can only go so far in describing the changing energy landscape in China and the multiple, shifting economic and environmental priorities of the actors involved. This study must therefore be viewed as a snapshot of renewable energy production in western China, one which must be combined and compared with similar research on large hydropower, solar, wind, and fossil fuel energy sources.

6.5 New low-carbon frontiers

The boom and bust of SHP in western China described in this dissertation underscores the persistence of spatial and class-based inequalities on resource frontiers. It highlights that just because renewable energy systems are low-carbon does not automatically make them equitable. Indeed, they may have perverse local social and environmental impacts. These insights will only become more prescient as Yunnan and western China continue to build large-scale wind and solar installations, which are poised to replace SHP. Unlike SHP, these large systems have no history of rural electrification or local conservation; their only purpose is to generate electricity for sale to the grid. Moreover, they may also experience boom and bust cycles due to fluctuations in demand, over-development by local governments, and technological innovation. And they will not necessarily replace traditional extractive industries, such as rare earths, nonferrous metals, and large hydropower, and may even lead to the rise of new industries. Thus, the decline of SHP in China does not necessarily spell the decline of the low-carbon frontier; it is merely a replacement of one energy technology by others.

And while SHP construction has declined in China, the SHP industry is not yet dead. Turbine and generator manufacturers have begun to 'pivot' to refurbishing older plants; SHP design institutes are focusing on improving plant efficiency; and investors have turned their sights to overseas markets. Opportunities for new SHP plants in Asia and Africa abound, and Chinese companies are well-positioned to finance, construct, and operate them. Indeed, the world is already experiencing a China-led boom in large hydropower construction, and the SHP industry has piggybacked on this trend by manufacturing powerhouse equipment and offering construction services for small- and medium-sized plants. As I described in Chapter 5, these new projects offer potential benefits to rural communities who do not yet have stable electricity access. They also bring potential consequences in the form of local water scarcity and economic volatility. Just as western China is changing, then, we must also train our sights on new 'frontiers' of Chinese energy investment, both low-carbon and traditional extractive landscapes.

In this dissertation, I have offered an overall theoretical rationale for the study of SHP in China: that it is an example of the geography of green development that privileges some spaces and groups over others, both within and outside of China's borders. It offers a window into how the state rationalizes and promulgates certain understandings of how renewable energy should be used, and more broadly, how economic and environmental concerns should be balanced (or not). And SHP highlights how state logics of green development are negotiated, reworked, and packaged as a model in specific places. SHP is thus a microcosm of the regional development and social justice implications of China's green economic transformation, issues that only become more important as China becomes a global superpower.

Yet, this dissertation is also a document about SHP itself, and is an attempt to explain its historical and contemporary importance. Small hydropower was the first electricity source for tens of millions of rural dwellers in China. It is still China's first and most widespread renewable energy technology, and in 2016, SHP generated more power than the booming wind industry. And SHP is still the foundation of hundreds of rural economies in Yunnan and western China. Understanding the function, impacts, and future trajectory of SHP is not just a theoretical exercise; it has real implications for SHP policy and management, and the livelihoods, economies, and environments that are impacted as a result. As China's early experience shows, small hydropower can have multiple environmental and economic benefits, but these are shaped by how and why the technology is used, not the technology itself.

APPENDIX

Survey Instrument (English and Chinese versions)

关于小水电、农业、生计的问卷

QUESTIONNAIRE ON SMALL HYDROPOWER, AGRICULTURE, AND LIVELIHOODS

采访号码 Interview #: __________

采访组 Interview Group: __________

地点编号 Location ID: __________

采访日期 Interview Date: __________

受访者性别 Interviewee Sex: __________

访问者提示 Notice to interviewers

访谈前，访问者须先向被访者念出下述口头知情同意内容。访谈前须获得被访者清楚的口头同意，须使其清楚理解所有内容，自愿接受采访。然后，须给被访者提供研究人员的名片。之后，访谈方可进行。

Before conducting the interview, the interviewer must read the oral informed consent agenda below to the respondent. Wait for the respondent's clear oral confirmation, verifying that the respondent understands the entire contents and voluntarily agrees to undertake the interview. Then provide the respondent with the research team's contact information card. After this, you may begin to conduct the interview.

口头知情同意内容 Oral informed consent

您好！我们是云南师范大学太阳能研究所的学生，为了了解农村绿色能源发展情况，我们将在这里开展一个关于小水电、农业、和民生状况的问卷调查研究。问卷中您对问题的回答没有对错之分，您只要根据自己所了解的实际情况填答就行。对于您的回答，我们将按照《统计法》的规定，严格保密，调查结果只用于统计分析和科学研究，我们将认真对待问卷，以回报您真诚的劳动和帮助。谢谢您的合作！

Hello! We are students from the Yunnan Normal University Solar Energy Research Institute. We are conducting a questionnaire on the relationship between small hydropower, agriculture, and livelihoods, which is part of a bigger research project on rural renewable energy in China. We would like to ask you a few questions about the impacts of your local small hydropower plant on your household, such as electricity and agricultural water use. Feel free to answer questions as best you can and you can end the interview at any time. We will not share this information with anyone else and it will remain completely anonymous. Thank you for your cooperation!

A. 电力与燃料 Electricity and Fuel Wood

1. What is the current electricity price that your household pays per kWh?

______________ 元 / kWh ☐ Don’t know

2. Did your electricity price change after the local grid was connected to the national grid? IF NO, PROCEED TO QUESTION 3.

☐ Yes ☐ No

2-1. Did your electricity price go up or down?

☐ Up ☐ Down

2-2. How much did you pay per kWh the year before the local grid was connected to the national grid?

______________ 元 / kWh ☐ Don’t know

3. How much average electricity does your household currently use per month?

______________ kWh / month ☐ Don’t know

4. Did your electricity usage change after your village was connected to the national grid? IF NO, PROCEED TO QUESTION 5.

☐ Yes ☐ No

4-1. How much electricity did your household use the year before the local grid was connected to the national grid?

______________ kWh / month ☐ Don’t know

5. Does your household receive any government subsidies for electricity?
IF NO, PROCEED TO QUESTION 6.

☐ Yes ☐ No

5-1. What is the amount of the subsidy in 元 per kWh?

______________ 元 / kWh ☐ Don't know

5-2. Please describe how you receive the subsidies.________________________________

____

6. Does your household receive any subsidies from the small hydropower plant for electricity?
IF NO, PROCEED TO QUESTION 7.

☐ Yes ☐ No

6-1. What is the amount of the subsidy in 元 per year?

______________ 元 / year ☐ Don't know

6-2. Please describe how you receive the subsidies.________________________________

____

7. Do you use fuel wood?
IF NO, PROCEED TO QUESTION 8.

☐ Yes ☐ No

7-1. What are your primary uses for fuel wood (choose the most relevant one or two)?

☐ Cooking ☐ Heating ☐ Preparing animal feed

☐ Other (please describe) ____

7-2. Approximately how many m^3 of fuel wood did you use this year?

______________ m^3 ☐ Don’t know

7-3. Approximately how much time this year did you and your family members spend collecting fuel wood?

______________ days (8 hours/day) ☐ Don’t know

8. Did you use fuel wood ten years ago?
IF NO, PROCEED TO QUESTION 9.

☐ Yes ☐ No

8-1. What were your primary uses for fuel wood ten years ago (choose the most relevant one or two)?

☐ Cooking ☐ Heating ☐ Preparing animal feed

☐ Other (please describe) ____

8-2. Approximately how many m^3 of fuel wood did you use ten years ago?

______________ m^3 ☐ Don’t know

8-3. Approximately how much time ten years ago did you and your family members spend collecting fuel wood?

______________ days (8 hours/day) ☐ Don't know

B. 农业用水 Agricultural Water Use

9. How many *mu* of paddy land (田) that belongs to your household is irrigated?

______________ *mu* ☐ Don't know

10. What crops do you irrigate?

☐ Bananas ☐ Oranges ☐ Sugar cane ☐ Rice

☐ Other (please list) ____

11. Do you use an irrigation system?
IF NO, PROCEED TO QUESTION 12.

☐ Yes ☐ No

11-1. What type of irrigation system do you use (choose all that apply)?

☐ Drip ☐ Sprinkler ☐ Other ________________

11-2. Did you construct this system? If no, please describe how it was constructed.
IF NO, PROCEED TO QUESTION 12.

☐ Yes

☐ No (describe how it was constructed) ________________________________

____

11-3. How many *mu* of irrigation system did you construct?

______________ *mu* ☐ Don’t know

11-4. Did you construct this irrigation system with other households? If yes, how many?

☐ Yes ______________ households ☐ No

11-5. How much did it cost your household to construct your irrigation system?

______________ 元 ☐ Don’t know

11-6. Did you receive any government subsidies for constructing an irrigation system? If so, how much per *mu*?

☐ Yes ______________ 元 / *mu* ☐ No

12. Have your irrigation water needs changed in the past five years?
IF NO, PROCEED TO QUESTION 13.

☐ Yes ☐ No

12-1. How much more or less water do you use now compared with five years ago? Please be as specific as possible.

______________ m^3 / year ☐ More ☐ Less ☐ Don’t know

12-2. Why do you use more or less water now compared with five years ago?

____

13. Do you ever need irrigation water for crops, but there is very little water available?
IF NO, PROCEED TO QUESTION 14.

☐ Yes ☐ No

13-1. When has there been very little water? ____________________

13-2. Why has there been very little water? ____________________

____

14. In your opinion, do farming households use more water per *mu*, or do agribusinesses use more water per *mu*? Please explain.

☐ Farming households ☐ Agribusinesses ☐ No difference

☐ Don’t know

____

____

C. 农业与 小水电 Agriculture and Small Hydropower

15. Has your access to water changed since your local small hydropower plant began operating? If yes, please describe.

☐ Yes ____________________

____

☐ No

16. Do you or someone in your village discuss crop water needs with the small hydropower plant?
IF NO, PROCEED TO QUESTION 17

☐ Yes ☐ No

16-1. Describe how this discussion takes place. ______________________________

____

____

17. Do you ever need water for your crops, but there is not enough available because of diversions by the small hydropower plant?
IF NO, PROCEED TO QUESTION 18.

☐ Yes ☐ No

17-1. How many years has this occurred since the small hydropower plant was constructed?

______________ years ☐ Don't know

17-2. Did you complain to the government or the small hydropower plant about your lack of water? If yes, please describe in detail. If no, please describe why not.

☐ Yes ______________________________

____

☐ No ______________________________

____

17-3. Have you changed the crops that you grow due to the lack of water caused by the small hydropower plant? If yes, please describe the crops you changed and when you changed them.

☐ Yes ____

____

☐ No

17-4. Have you made any changes to your irrigation system due to the lack of water caused by the small hydropower plant? If yes, please describe the changes that you made and when you made them.

☐ Yes ____

____

☐ No

17-5. Has this issue of your lack of water due to the small hydropower plant been resolved? If yes, please describe how it was resolved, and how long it took to resolve it.

☐ Yes ____

____

☐ No

18. Has there ever been conflict between farmers in your village and the local SHP plant over water use?

IF NO, PROCEED TO QUESTION 19.

☐ Yes ☐ No

18-1. What year did the most recent conflict occur?

______________ 年

18-2. Describe what sparked the conflict and how many households were involved.

____

____

18-3. Was this conflict resolved? If yes, please describe how it was resolved. If no, please describe why not.

☐ Yes ____

____

☐ No ____

____

19. Have there ever been any conflicts over water among farmers in your village, or between farmers in your village and those in another (choose all that apply)?

IF NO, PROCEED TO QUESTION 20.

☐ Yes (within village) ☐ Yes (between villages) ☐ No

19-1. What year did the most recent conflict occur? ______________ 年

19-2. Describe what sparked the conflict and how many households were involved.

____

____

19-3. Was this conflict resolved? If yes, please describe how it was resolved. If no, please describe why not.

☐ Yes ____

____

☐ No ____

____

20. Have you witnessed negative impacts to the river that are the result of the small hydropower plant? If yes, please describe the impacts, and when you first noticed them.

☐ Yes ____

____

☐ No

D. 生计福利 Livelihood Benefits

21. Were you or any others in your village consulted before the small hydropower plant was constructed? If yes, please describe.

☐ Yes ____

____

☐ No

22. Did anyone in your village work in constructing the small hydropower plant? If yes, how many (leave blank if not known)?

☐ Yes ______________ villagers ☐ No

23. Does anyone in your village currently work for the small hydropower plant? If yes, how many (leave blank if not known)?

☐ Yes ______________ villagers ☐ No

24. In your opinion, has your local small hydropower plant led to any changes in your livelihood, either directly or indirectly? If yes, please describe. Examples might be a new job, expansion of agricultural land, electricity and water availability, etc.

☐ Yes ____

____

☐ No

E. 农业生产 Agricultural Production

25. How many *mu* of land (地) belongs to your household?

______________ *mu* ☐ Don’t know

26. How many *mu* of paddy land (田) belongs to your household?

______________ *mu* ☐ Don’t know

27. Please fill out the table below about the current crops that you grow.

	作物 Crop	面积（亩） Land area	地或田 Type	今年价格（元/公斤） 2015 price per kg	去年价格（元/公斤） 2014 price per kg
1					
2					
3					
4					
5					

28. Have you made any changes to the crops that you grow in the last five years? If so, please describe what you changed, and why.

☐ Yes ____

____

☐ No

29. Has community forest in your village been distributed to households?
IF NO, PROCEED TO QUESTION 30.

☐ Yes ☐ No

29-1. How many *mu* of forest land (林) belongs to your household?

______________ *mu* ☐ Don’t know

30. Does your household grow any economic tree crops?
IF NO, PROCEED TO QUESTION 31.

☐ Yes ☐ No

30-1. Please fill out the table below about the current tree crops that you grow.

	林业作物 Tree Crop	面积（亩） Land area	今年价格（元/公斤） 2015 price per kg	去年价格（元/公斤） 2014 price per kg
1				
2				
3				
4				
5				

31. Has any of the land (地) that belongs to your household been reforested through the Sloping Land Conversion Program? If yes, how many *mu*?

☐ Yes ______________ *mu* ☐ No

32. Do you rent out any of your land?

IF NO, PROCEED TO QUESTION 33.

☐ Yes ☐ No

32-1. How many *mu* of land (地) do you rent out?

______________ *mu* ☐ Don’t know

32-2. How many *mu* of paddy land (田) do you rent out?

______________ *mu* ☐ Don’t know

32-3. What year did you start renting out land (地 or 田)?

______________ 年

32-4. Do you rent your land to an agribusiness or a farming household?

☐ Agribusiness ☐ Farming household

☐ Other (please describe) ______________________________

32-5. Where is the agribusiness or farming household from?

☐ Your township ☐ Another part of Xinping county

☐ Another county in Yuxi ☐ Another province ☐ Don’t know

32-6. Please describe your main reason for renting out your land.

____

____

32-7. What was your income from renting out land this year?

__________ 元 ☐ Don’t know

32-8. Do you or any of your family members work for the farmer or company that you rent your land to?

☐ Yes ☐ No

32-9. In your opinion, do you think that you and other villagers will continue to rent out land? Please describe why or why not.

☐ Yes ______________________________

____

☐ No ______________________________

F. 家庭细节 Household Specifics

33. How old are you? ___________

34. What is your ethnicity?

☐ Dai ☐ Han ☐ Yi ☐ Other_______________

35. What is your education level?

☐ No schooling ☐ Primary school ☐ Middle school

☐ High school ☐ University and above

☐ Other (please describe) ____

36. How many people currently live in your household (including you)?

______________ 人

37. Does anyone in your household work outside the village?
IF NO, PROCEED TO QUESTION 38.

☐ Yes ☐ No

37-1. How many household members work outside the village?

______________ 人

37-2. Where do they work (choose all that apply)?

☐ Your township ☐ Another part of Xinping county

☐ Another county in Yuxi ☐ Another province

37-3. What type of job do they have (choose all that apply)?

☐ Salaried worker/professional (有工资) ☐ Businessperson (老板)

☐ Laborer (打工) ☐ Other ______________________________

38. Can you estimate your household's annual household income for this year?

	收入资源 Income source	年收入 Yearly income
1	种地 Cultivation	
2	租地 Renting land	
3	养家畜 Raising livestock	
4	打工 Employment	
5	退耕还林 Sloping Land Conversion Program	
6	别的 Other	
	总结 **TOTAL**	

39. We have reached the end of the interview. Now you have a chance to ask us any questions you would like. Do you have any questions about this interview or this research project?

____

____

____

关于小水电、农业、民生的问卷

采访号码 Interview #: __________ 采访组 Interview Group: __________

地点编号 Location ID: __________ 采访日期 Interview Date: __________

受访者性别 Interviewee Sex: __________

尊敬的受访者：

您好！

我们是云南师范大学太阳能研究所的学生，为了了解农村绿色能源发展情况，我们将在这里开展一个关于小水电、农业、和民生状况的问卷调查研究。问卷中您对问题的回答没有对错之分，您只要根据自己所了解的实际情况填答就行。对于您的回答，我们将按照《统计法》的规定，严格保密，调查结果只用于统计分析和科学研究，我们将认真对待问卷，以回报您真诚的劳动和帮助。谢谢您的合作！

云南师范大学太阳能研究所
联系电话：0871-65940944

A. 电力与燃料 Electricity and Fuel Wood

1. 现在你们家的电价是多少钱一度？

______________ 元 / kWh □ 不知道

2. 加入南方电网（电网改造）后电价改变了吗？

（如果没有变，进入下一个问题）

□ 变了 □ 没有变

2-1. 电价上涨了还是下降了？

□ 上涨 □ 下降

2-2. 在加入南方电网（电网改造）之前的电价是多少？

______________ 元 / kWh □ 不知道

3. 现在你们家平均每月的用电量是多少？

______________ kWh / 月 □ 不知道

4. 在加入南方电网（电网改造）之后你们家的用电量改变了吗？

（如果没有变，进入下一个问题）

□ 变了 □ 没有变

4-1. 在加入南方电网（电网改造）之前你们家每月的用电量是多少？

______________ kWh / 月 □ 不知道

5. 你们有没有收到政府发放的一些用电补贴？

（如果没有变，进入下一个问题）

□ 有　　□ 没有

5-1. 每度电补贴的金额是多少元？

____________ 元 / kWh　　□ 不知道

5-2. 请讲述一下你们是如何收到这些补贴的。____________________

____

____

6. 你们家有没有得到小水电站/公司给你们的一些用电补贴？

（如果没有，进入下一个问题）

□ 有　　□ 没有

6-1. 每年补贴多少元？

____________ 元 / 年　　□ 不知道

6-2. 请讲述一下你们是如何收到这些补贴的。____________________

____

____

7. 你们家里用木柴吗？

（如果没有，进入下一个问题）

□ 用　　□ 不用

7-1. 用木柴主要是为了做什么？(选择最主要的一个或两个)

□ 做饭　□ 取暖　□ 准备家畜/禽食物

□ 其他 (请详述)：____

7-2. 一年大概要用几方（m^3）柴？

______________ m^3　□ 不知道

7-3. 你们家今年花了多少时间捡（收集）木柴？

______________ 天（一天按八小时计）　□ 不知道

8. 十年前你们家用木柴吗？

（如果没有，进入下一个问题）

□ 用　□ 不用

8-1. 十年前你们家用木柴主要是为了做什么？(选择最主要的一个或两个)

□ 做饭　□ 取暖　□ 准备家畜/禽食物

□ 其他 (请详述)：____

8-2. 十年前你们家每年大概要用几方（m^3）木柴？

______________ m^3　□ 不知道

8-3. 十年前你们家需要花多少时间捡（收集）木柴？

______________ 天（一天按八小时计）　□ 不知道

B. 农业用水 Agricultural Water Use

9. 你们家有几亩田需要灌溉？

_____________ 亩 □ 不知道

10. 哪些作物需要灌溉？

□ 香蕉 □ 柑橘 □ 甘蔗 □ 水稻

□ 其他 (请详述)：____________________

11. 你们家有没有在使用一些灌溉系统（设施）？

（如果没有，进入下一个问题）

□ 有 □ 没有

11-1. 你们家用着哪种灌溉系统（设施）？(可多选)

□ 滴灌 □ 喷灌 □ 其他：______________________________

11-2. 是你们家修建了这些灌溉系统（设施）吗？如果不是,请说明一下这些灌溉系统(设施)是如何修建起来的?

（如果是，进入下一个问题）

□ 是的

□ 不是（描述如何修建的）：______________________________________

11-3. 你们家修建了多少亩的灌溉系统（设施）？

_____________ 亩 □ 不知道

11-4. 你们家是和别人一起修建了这些灌溉系统（设施）吗？如果是，和多少家人一起修建的？

□ 是的 ______________ 家 □ 不是

11-5. 你们家修建这些灌溉系统（设施）一共投入了多少钱？

______________ 元 □ 不知道

11-6. 修建这些灌溉系统（设施）你们有没有得到政府的补贴？如果有，每亩多少钱？

□ 有 ______________ 元 / 亩 □ 没有

12. 在过去五年里你们的灌溉需水量改变了吗？

（如果没有变，进入下一个问题）

□ 变了 □ 没有变

12-1. 和五年前相比你的（农灌）用水量增加/减少了多少？请尽量描述清楚。

______________ m^3 / 年 □ 增加 □ 减少 □ 不知道

12-2. 为什么你们的（农灌）用水量比五年前多/少？

____

13. 你曾经是否遇到需要给作物灌溉但是水很少的情况？

（如果没有，进入下一个问题）

□ 有 □ 没有

13-1. 什么时候水很少？ ____

13-2. 水为什么少？ ______________________________

____

14. 在你看来，农户的每亩用水量多还是农产品企业的每亩用水量更多？请解释。

□ 农户　□ 农产品企业　□ 一样多　□ 不知道

解释：______________________________

____

C. 农业与小水电 Agriculture and Small Hydropower

15. 自从小水电运营以来你们的用水情况改变了吗？如果有，请描述。

□ 改变 ______________________________

____

□ 没改变

16. 当你们农灌需要用水时，村民或其他人要去和小电站协商（放水）吗?

（如果不需要，进入下一个问题）

□ 需要　□ 不需要

16-1. 请描述一下当你们灌溉需要用水时是如何跟电站协商的？

____

____

17. 你是否遇到过作物需要灌溉，但因为水被电站引去发电而导致农灌用水不够的情况？

（如果没有，进入下一个问题）

□ 有　　□ 没有

17-1. 小水电建成以来，有多少年出现这样的问题？

______________ 年　　□ 不知道

17-2. 你们向政府部门或小水电站反映过缺水的情况吗？如果有，请详细描述；如果没有，请说明为什么。

□ 有 ____

____

____

□ 没有 ____

____

17-3. 是否因为建设小水电站而导致缺水进而迫使你们改变种植新作物的情况？如果有，请描述一下你们改变种植的作物是什么？什么时候开始改变的？

□ 有 ____

____

□ 没有

17-4. 你们有没有因为小水电导致农灌缺水而调整灌溉系统（设施）？如果有，请描述你们所做的调整以及什么时候开始调整？

□ 有 ____

□ 没有

17-5. 因为小水电站而导致的缺水问题现在解决了吗？如果解决了，请描述这个问题是如何解决的，解决这些问题用了多少时间。

□ 已解决____

____

□ 没解决

18. 你们村的农灌用水与当地小水电用水有冲突吗？

（如果没有，进入下一个问题）

□ 有　　□ 没有

18-1. 最近一次冲突发生在那一年？

______________ 年

18-2. 请描述是什么原因引起了冲突？有多少农户参与了冲突？

____

____

18-3. 冲突解决了吗？如果解决了，请描述是如何解决的；如果没有解决，请描述为什么。

□ 已解决 ____________________

____

□ 没有解决 ____________________

____

19. 你们村的村民之间会因为用水问题而发生冲突吗？你们村与其他村之间会因为用水问题而发生冲突吗？ (可多选)

（如果没有，进入下一个问题）

□ 有冲突 (村子内)　□ 有冲突 (村子间)　□ 没有冲突

19-1. 最近一次发生冲突是哪一年？

__________ 年

19-2. 请描述是什么原因引起了冲突？有多少农户参与了冲突？

____

____

19-3. 冲突解决了吗？如果解决了，请描述是如何解决的；如果没有解决，请描述为什么。

□ 已解决 ____________________

____

□ 没有解决 ____________________

20. 你看到小水电对当地河流产生某些消极影响吗？如果有，请描述；你什么时候开始发现这些问题的？

□ 有 ____

____

□ 没有

D. 生计福利 Livelihood Benefits

21. 修建电站前是否有人来征询过你们的意见？如果有，请描述。

□ 有 ____

□ 没有

22. 你们村有人参加这个小水电的建设吗？如果有，有多少？（不清楚就不用填）

□ 有 ______________ 人　　□ 没有

23. 你们村现在有人在小水电工作吗？如果有，有多少？（不清楚就不用填）

□ 有 ______________ 人　　□ 没有

24. 在你看来，小水电站对你的生活有没有一些直接的或间接的改变？如果有，请描述。例如：提供了新的工作岗位、增加了农田面积、用电情况、水的利用率等。

□ 有 ____

____

□ 没有

E. 农业生产 Agricultural Production

25. 你们家有几亩地？

______________ 亩 □ 不知道

26. 你们家有几亩田？

______________ 亩 □ 不知道

27. 请在表中填写你们家现在种植的作物。

	作物名称	种植面积（亩）	土地类型（地或田）	今年价格（元/公斤）	去年价格（元/公斤）
1					
2					
3					
4					
5					

28. 近五年以来你们家种植的作物（种类）是否有变化？如果变化，请描述如何变化的？为什么？

□ 有 ____

____

□ 没有

29. 你们村的山林已经分（承包）给农户了吗？

□ 是的　　□ 没有

29-1. 你们家有几亩林地？

______________ 亩　　□ 不知道

30. 你们家种植经济林吗？

（如果没有，进入下一个问题）

□ 有　　□ 没有

30-1. 请在表中填写你们家现在种植的经济林。

	林业作物	面积（亩）	今年价格（元/公斤）	去年价格（元/公斤）
1				
2				
3				
4				
5				

31. 你们家有没有退耕还林？如果有，有几亩？

□ 有 ______________ 亩　　□ 没有

32. 你们家出租土地吗？

（如果没有，进入下一个问题）

□ 有　　□ 没有

32-1. 你们家出租了多少亩地？

______________ 亩 □ 不知道

32-2. 你们家出租了多少亩田？

______________ 亩 □ 不知道

32-3. 你们家什么时候开始出租田、地的？

______________ 年

32-4. 你们把田地出租给农业企业还是其他农户？

□ 农业企业 □ 农户

□ 其他 (请描述) ____

32-5. 这些农业企业或者农户是从哪里来的？

□ 本镇的人 □ 新平县其他乡镇的人

□ 玉溪市其他县的人 □ 外省人 □ 不知道

32-6. 请描述一下你出租土地的主要原因是什么？

____

____

32-7. 每年出租土地可以获得多少收入？

______________ 元 □ 不知道

32-8. 你们会去跟你家租种土地的农民或公司那里打工吗？

□ 会　　□ 不会

32-9. 在你看来，你们村或其他村的人会继续出租土地吗？请解释为什么会/不会。

□ 会 ____

____

□ 不会 ____

____

F. 家庭细节 Household Particulars

33. 你的年龄是多少？____________

34. 你是哪个民族？

□ 傣族　□ 汉族　□ 彝族　□ 其他 ______________________

35. 你的学历是什么？

□ 没读过书　□ 小学　□ 初中

□ 高中　□ 大学

□ 其他 (请描述) ____

36. 你们家现在有多少人?

___________ 人，（请描述）

37. 你们家有人在外地（村子以外）工作吗？

（如果没有，进入下一个问题）

□ 有　　□ 没有

37-1. 你们家有几个人在外地工作？

______________ 人

37-2. 他们在哪里工作？**(**可多选**)**

□ 本镇　　□ 新平县其他乡镇

□ 玉溪市其他县　　□ 省外

37-3. 他们的工作是哪类？**(**可多选**)**

□ 机关单位　　□ 自主经营　　□ 打工

□ 其他__________________________________

38. 你能估计一下你们家一年的收入有多少吗？

	收入来源	年收入
1	卖粮食	
2	租地	
3	卖家畜	
4	打工 （元 / 人）	
5	退耕还林	
6	其他	
	总结	

39. 我们的访谈内容结束了，您对此次访谈或者其他方面有没有什么问题？如果有您可以向我们提出。

____

____

非常感谢您抽出宝贵的时间作答，祝您身体健康，全家幸福！

REFERENCES

Abbasi, T., Abbasi, S.A., 2011. Small hydro and the environmental implications of its extensive utilization. *Renewable and Sustainable Energy Reviews* 15, 2134–2143.

Adams, W.M., 2009. *Green Development: Environment and Sustainability in a Developing World*, 3rd ed. Routledge, London.

Alves, A.C., 2013. China's "win-win" cooperation: Unpacking the impact of infrastructure-for-resources deals in Africa. *South African Journal of International Affairs* 20, 207–226.

Amanor, K.S., Chichava, S., 2016. South–South cooperation, agribusiness, and African agricultural development: Brazil and China in Ghana and Mozambique. *World Development* 81, 13–23.

Ansar, A., Flyvbjerg, B., Budzier, A., Lunn, D., 2014. Should we build more large dams? The actual costs of hydropower megaproject development. *Energy Policy* 69, 43–56.

Ashworth, J. H., Neuendorffer, J. W., 1982. Escaping the rural energy dilemma: A process for matching technologies to local needs and resources. *World Development* 10, 305–318.

Baker, D.W., Bledsoe, B.P., Albano, C.M., Poff, N.L., 2011. Downstream effects of diversion dams on sediment and hydraulic conditions of Rocky Mountain streams. *River Research and Applications* 27, 388–401.

Bakis, R., Demirbas, A., 2004. Sustainable development of small hydropower plants (SHPs). *Energy Sources* 26, 1105–1118.

Bakken, T.H., Sundt, H., Ruud, A., Harby, A., 2012. Development of small versus large hydropower in Norway: Comparison of environmental impacts. *Energy Procedia* 20, 185–199.

Bakker, K., 2005. Neoliberalizing nature? Market environmentalism in water supply in England and Wales. *Annals of the Association of American Geographers* 95, 542–565.

Banerjee, S.B., 2003. Who sustains whose development? Sustainable development and the reinvention of nature. *Organization Studies* 24, 143–180.

Barbier, E.B., 2005. Frontier expansion and economic development. *Contemporary Economic Policy* 23, 286–303.

Barbier, E.B., Julian R. Thompson, 1998. The value of water: Floodplain versus large-scale irrigation benefits in northern Nigeria. *Ambio* 27, 434–440.

Barney, K., 2008. Laos and the remaking of a "relational" resource frontier. *The Geographical Journal* 175, 146–159.

Bennett, M.T., 2008. China's sloping land conversion program: Institutional innovation or business as usual? *Ecological Economics* 65, 699–711.

Bergner, M., 2014. Developing Nepal's hydroelectric resources: Policy alternatives. Stimson Center, Frank Batten School of Leadership and Public Policy, University of Virginia, Charlottesville, VA.

Bernstein, S., 2002. Liberal environmentalism and global environmental governance. *Global Environmental Politics* 2, 1–16.

Billington, D.P., Jackson, D.C., 2006. *Big Dams of the New Deal Era: A Confluence of Engineering and Politics.* University of Oklahoma Press, Norman, OK.

Biswas, W.K., Bryce, P., Diesendorf, M., 2001. Model for empowering rural poor through renewable energy technologies in Bangladesh. *Environmental Science & Policy* 4, 333–344.

Blaikie, P.M., Muldavin, J.S.S., 2004. Upstream, downstream, China, India: The politics of environment in the Himalayan region. *Annals of the Association of American Geographers* 94, 520–548.

Blom, B., Sunderland, T., Murdiyarso, D., 2010. Getting REDD to work locally: Lessons learned from integrated conservation and development projects. *Environmental Science & Policy* 13, 164–172.

Boyd, E., Boykoff, M., Newell, P., 2011. The "new" carbon economy: What's new? *Antipode* 43, 601–611.

Bradbury, J., 1988. Living with boom and bust cycles: New towns on the resource frontier in Canada, 1945-1986, in: Brealey, T., Neil, C.C., Newton (Eds.), *Resource Communities: Settlement and Workforce Issues.* CSIRO, East Melbourne, Australia, pp. 3–20.

Bräutigam, D., 2009. *The Dragon's Gift: The Real Story of China in Africa.* Oxford University Press, Oxford.

Bräutigam, D., Tang, X., 2011. African Shenzhen: China's special economic zones in Africa. *The Journal of Modern African Studies* 49, 27–54.

Brenner, N., Peck, J., Theodore, N., 2010. Variegated neoliberalization: Geographies, modalities, pathways. *Global Networks* 10, 182–222.

Breslin, S., 2011. The "China model" and the global crisis: From Friedrich List to a Chinese mode of governance? *International Affairs* 87, 1323–1343.

Bumpus, A.G., Liverman, D.M., 2011. Carbon colonialism? Offsets, greenhouse gas reductions, and sustainable development, in: Peet, R., Robbins, P., Watts, M. (Eds.), *Global Political Ecology*. Routledge, London, pp. 203–224.

Bumpus, A.G., Liverman, D.M., 2008. Accumulation by decarbonization and the governance of carbon offsets. *Economic Geography* 84, 127–155.

Buttel, F.H., 1992. Environmentalization: Origins, processes, and implications for rural social change. *Rural Sociology* 57, 1–27.

Byrne, J., Zhou, A., Shen, B., Hughes, K., 2007. Evaluating the potential of small-scale renewable energy options to meet rural livelihoods needs: A GIS- and lifecycle cost-based assessment of Western China's options. *Energy Policy* 35, 4391–4401.

Cabraal, R.A., Barnes, D.F., Agarwal, S.G., 2005. Productive uses of energy for rural development. *Annual Review of Environment and Resources* 30, 117–144.

Callick, R., 2007. The China model: How long can economic freedom and political repression coexist? *The American*, 13 November 2007.

Castree, N., 2008a. Neoliberalising nature: The logics of deregulation and reregulation. *Environment and Planning A* 40, 131–152.

Castree, N., 2008b. Neoliberalising nature: Processes, effects, and evaluations. *Environment and Planning A* 40, 153–173.

Chan, L.-H., Lee, P.K., Chan, G., 2008. Rethinking global governance: A China model in the making? *Contemporary Politics* 14, 3–19.

Chang, I.-C.C., Leitner, H., Sheppard, E., 2016. A green leap forward? Eco-state restructuring and the Tianjin–Binhai Eco-City Model. *Regional Studies* 50, 929–943.

Chang, J., Leung, D.Y.C., Wu, C.Z., Yuan, Z.H., 2003. A review on the energy production, consumption, and prospect of renewable energy in China. *Renewable and Sustainable Energy Reviews* 7, 453–468.

Chen, J., 2013. Sustainable territories: Rural dispossession, land enclosures and the construction of environmental resources in China. *Human Geography* 6, 102–118.

Chen, J.-C., Zinda, J.A., Yeh, E.T., 2017. Recasting the rural: State, society and environment in contemporary China. *Geoforum* 78, 83–88.

Chen, M., Goodman, D.S.G., 2012. The China Model: One country, six authors. *Journal of Contemporary China* 21, 169–185.

Cheng, C., Liu, B., Chau, K.-W., Li, G., Liao, S., 2015. China′s small hydropower and its dispatching management. *Renewable and Sustainable Energy Reviews* 42, 43–55.

Cheng, H., Li, R., 2003. 关于小水电代燃料生态保护工程 规划的一些问题 (Project planning issues for using small hydropower to replace woody fuel in ecological protection). *中国水利 (China Water Resources)* 7, 37–41.

Cheng, X., 2015. A General Survey of SHP Development in China. Presentation at the Hangzhou Regional Center for Small Hydropower, 14 September 2015.

Cherni, J.A., Kentish, J., 2007. Renewable energy policy and electricity market reforms in China. *Energy Policy* 35, 3616–3629.

Cheung, Y.-W., de Haan, J., Qian, X., Yu, S., 2012. China's outward direct investment in Africa. *Review of International Economics* 20, 201–220.

China Daily, 2007. Ecological Civilization. *China Daily*, 24 October 2007. Available at http://www.chinadaily.com.cn/opinion/2007-10/24/content_6201964.htm

China Electricity Council, 2017. 2016 年全国电力工业统计快报数据一览表 (2016 National Electric Power Industry Statistics Express List). Available at http://www.cec.org.cn/guihuayutongji/tongjxinxi/niandushuju/2017-01-20/164007.html

China Electricity Council, 2016. Monthly Statistics of China's Power Industry December 2016. Available at http://www.cec.org.cn/guihuayutongji/tongjxinxi/niandushuju/2017-01-20/164007.html

China Information Office of the State Council, 2014. China's Foreign Aid (No. 2), White Paper on Foreign Aid. Beijing.

China State Council, 2016. State Council adds 240 new national ecological function zones. Beijing.

China State Council, 1994. Agenda 21: *White Paper on China's Population, Environment and Development in the 21st Century*. Beijing.

Christoff, P., 1996. Ecological modernisation, ecological modernities. *Environmental Politics* 5, 476–500.

Clarke-Sather, A., 2012. From the Heavens to the Markets: Development, Nation, and the Mediation of Water in Northwest China. University of Colorado-Boulder, Boulder, CO.

Corkin, L., 2013. *Uncovering African Agency: Angola's Management of China's Credit Lines*. Farnham, Surrey, UK.

Cui, C., Qu, D., 2008. 促进小水电代燃料生态工程建设的探讨 (An inquiry into the promotion of small hydropower for fuel in ecological construction). *东北水利水电 (Water Resources and Hydropower of Northeast China)* 26, 54–55.

Dasgupta, P., 1995. Population, poverty, and the local environment. *Scientific American* 272, 40–45.

Dauvergne, P., Neville, K.J., 2010. Forests, food, and fuel in the tropics: The uneven social and ecological consequences of the emerging political economy of biofuels. *The Journal of Peasant Studies* 37, 631–660.

Davies, M., 2008. China's developmental model comes to Africa. *Review of African Political Economy* 35, 134–137.

de Jong, M., Wang, D., Yu, C., 2013. Exploring the relevance of the eco-city concept in China: The case of Shenzhen Sino-Dutch Low Carbon City. *Journal of Urban Technology* 20, 95–113.

DeHart, M., 2012. Remodelling the global development landscape: The China Model and South–South cooperation in Latin America. *Third World Quarterly* 33, 1359–1375.

Deichmann, U., Meisner, C., Murray, S., Wheeler, D., 2011. The economics of renewable energy expansion in rural Sub-Saharan Africa. *Energy Policy* 39, 215–227.

Dore, J., Yu, X., Li, K.Y., 2007. China's Energy Reforms and Hydropower Expansion in Yunnan. Australian National University, Canberra, Australia.

Duflo, E., Pande, R., 2007. Dams. *The Quarterly Journal of Economics* 122, 601–646.

Dursun, B., Gokcol, C., 2011. The role of hydroelectric power and contribution of small hydropower plants for sustainable development in Turkey. *Renewable Energy* 36, 1227–1235.

Economy, E., 2010. *The River Runs Black: The Environmental Challenge to China's Future*. Cornell University Press, Ithaca, NY.

Economy, E., 2006. Environmental Governance: The Emerging Economic Dimension. *Environmental Politics* 15, 171–189.

Economy, E., 2002. China's "Go West" Campaign: Ecological Construction or Ecological Exploitation? *China Environmental* 5, 1–12.

Engel, S., Pagiola, S., Wunder, S., 2008. Designing payments for environmental services in theory and practice: An overview of the issues. *Ecological Economics* 65, 663–674.

EPS China Data, 2017. China Water Conservancy Statistics. Available at http://www.epschinadata.com/

Erlewein, A., Nüsser, M., 2011. Offsetting greenhouse gas emissions in the Himalaya? Clean Development dams in Himachal Pradesh, India. *Mountain Research and Development* 31, 293–304.

Ervine, K., 2013. Carbon markets, debt and uneven development. *Third World Quarterly* 34, 653–670.

Escobar, A., 1995. *Encountering Development: The Making and Unmaking of the Third World*. Princeton University Press, Princeton.

Fan, J., Li, P., 2009. The scientific foundation of major function oriented zoning in China. *Journal of Geographical Sciences* 19, 515–531.

Ferchen, M., 2013. Whose China Model is it anyway? The contentious search for consensus. *Review of International Political Economy* 20, 390–420.

Ferdinand, P., 2016. Westward ho—the China dream and “one belt, one road”: Chinese foreign policy under Xi Jinping. *International Affairs* 92, 941–957. doi:10.1111/1468-2346.12660

Ferguson, J., 1994. *The Anti-Politics Machine: “Development,” Depoliticization, and Bureaucratic Power in Lesotho*. University of Minnesota Press, Minneapolis.

Ferraro, P.J., 2001. Global habitat protection: Limitations of development interventions and a role for conservation performance payments. *Conservation Biology* 15, 990–1000.

Fletcher, R., 2010. Neoliberal environmentality: Towards a poststructuralist political ecology of the conservation debate. *Conservation and Society* 8, 171–181.

Fligstein, N., Zhang, J., 2015. A new agenda for research on the trajectory of Chinese capitalism. *Management and Organization Review* 7, 39–62.

Forsythe, M., 2017. China aims to spend at least $360 billion on renewable energy by 2020. *The New York Times*, 5 January 2017. Available at https://www.nytimes.com/2017/01/05/world/asia/china-renewable-energy-investment.html

Frey, G.W., Linke, D.M., 2002. Hydropower as a renewable and sustainable energy resource meeting global energy challenges in a reasonable way. *Energy Policy* 30, 1261–1265.

Frost, S., 2004. Chinese outward direct investment in Southeast Asia: How big are the flows and what does it mean for the region? *The Pacific Review* 17, 323–340.

Fu, X., Tang, T., Jiang, W., Li, F., Wu, N., Zhou, S., Cai, Q., 2008. Impacts of small hydropower plants on macroinvertebrate communities. *Acta Ecologica Sinica* 28, 45–52.

Gamser, M.S., 1980. The forest resource and rural energy development. *World Development* 8, 769–780.

Geall, S. (Ed.), 2013. *China and the Environment: The Green Revolution*. Zed Books, London.

Ghazoul, J., Butler, R.A., Mateo-Vega, J., Koh, L.P., 2010. REDD: A reckoning of environment and development implications. *Trends in Ecology & Evolution* 25, 396–402.

Gibbs, D., 2000. Ecological modernisation, regional economic development and regional development agencies. *Geoforum* 31, 9–19.

Gibbs, D., 1996. Integrating sustainable development and economic restructuring: A role for regulation theory? *Geoforum* 27, 1–10.

Giddings, B., Hopwood, B., O’Brien, G., 2002. Environment, economy and society: Fitting them together into sustainable development. *Sustainable Development* 10, 187–196.

Gu, J., Zhang, C., Vaz, A., Mukwereza, L., 2016. Chinese state capitalism? Rethinking the role of the state and business in Chinese development cooperation in Africa. *World Development* 81, 24–34.

Guo, S., 2016. 小水电: 环境问题罪不在“我” (Small hydropower: The environmental problem is not “me”). *中国科学报 (China Journal of Science)*, 18 February 2016..

Gurung, A., Kumar Ghimeray, A., Hassan, S.H.A., 2012. The prospects of renewable energy technologies for rural electrification: A review from Nepal. *Energy Policy* 40, 374–380.

Haines, A., Smith, K.R., Anderson, D., Epstein, P.R., McMichael, A.J., Roberts, I., Wilkinson, P., Woodcock, J., Woods, J., 2007. Policies for accelerating access to clean energy, improving health, advancing development, and mitigating climate change. *The Lancet* 370, 1264–1281.

Harlan, T., 2017. A green development model: Transnational model-making in China’s small hydropower training programmes. *Area Development and Policy* Online First, 1–22.

He, J., 2014. Governing forest restoration: Local case studies of sloping land conversion program in Southwest China. *Forest Policy and Economics* 46, 30–38.

He, Y., Xu, Y., Pang, Y., Tian, H., Wu, R., 2016. A regulatory policy to promote renewable energy consumption in China: Review and future evolutionary path. *Renewable Energy* 89, 695–705.

Hecht, S.B., 1993. The logic of livestock and deforestation in Amazonia. *BioScience* 43, 687–695.

Heltberg, R., Arndt, T.C., Sekhar, N.U., 2000. Fuelwood consumption and forest degradation: A household model for domestic energy substitution in rural India. *Land Economics* 76, 213–232.

Hennig, T., 2016. Damming the transnational Ayeyarwady basin: Hydropower and the water-energy nexus. *Renewable and Sustainable Energy Reviews* 65, 1232–1246.

Hennig, T., Harlan, T., 2017. Shades of green energy: Geographies of small hydropower in Yunnan, China and the challenges of over-development. Forthcoming in *Global Environmental Change*, 1-21.

Hennig, T., Wang, W., Feng, Y., Ou, X., He, D., 2013. Review of Yunnan’s hydropower development: Comparing small and large hydropower projects regarding their environmental implications and socio-economic consequences. *Renewable and Sustainable Energy Reviews* 27, 585–595.

Hepburn, C., 2007. Carbon trading: A review of the Kyoto mechanisms. *Annual Review of Environment and Resources* 32, 375–393.

Hicks, C., 2004. Small hydropower in China: A new record in world hydropower development. *Refocus* 5, 36–40.

Himley, M., 2008. Geographies of environmental governance: The nexus of nature and neoliberalism. *Geography Compass* 2, 433–451.

Hoffman, L., 2011. Urban modeling and contemporary technologies of city-building in China: The production of regimes of green urbanisms, in: Roy, A., Ong, A. (Eds.), *Worlding Cities: Asian Experiments and the Art of Being Global.* Wiley-Blackwell, Malden, MA, pp. 55–76.

Hong, D., Xiao, C., Lockie, S., 2014. China's economic growth and environmental protection: Approaching a win-win situation? A discussion of ecological modernization theory, in: Lockie, S., Sonnenfeld, D.A., Fisher, D.R. (Eds.), *Routledge International Handbook of Social and Environmental Change.* Routledge, Abingdon, UK, pp. 45–57.

HRC, 2017. Intensifying Foreign-aid Training on Small Hydropower and Promoting Capacity-building of Developing Countries. Hangzhou Regional Center for Small Hydro Power, Hangzhou, China.

HRC, 2009. Rural Hydropower and Electrification in China, 2nd ed, Hangzhou Regional Center for Small Hydropower. China Water Press, Hangzhou, China.

Huan, Q., 2007. Ecological modernisation: A realistic green road for China? *Environmental Politics* 16, 683–687.

Huang, L., 2009. Financing rural renewable energy: A comparison between China and India. *Renewable and Sustainable Energy Reviews* 13, 1096–1103.

Huang, Y., Wang, B., 2011. Chinese outward direct investment: Is there a China Model? *China & World Economy* 19, 1–21.

Huber, M., 2016. Resource geographies I: Valuing nature (or not). *Progress in Human Geography* Online First, 1–12.

ICOLD, 2017. International Commission on Large Dams. Available at http://www.icold-cigb.org/

IPCC, 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.). Intergovernmental Panel on Climate Change, Geneva.

Jack, B.K., Kousky, C., Sims, K.R.E., 2008. Designing payments for ecosystem services: Lessons from previous experience with incentive-based mechanisms. *Proceedings of the National Academy of Sciences* 105, 9465–9470.

Jahiel, A.R., 1998. The Organization of Environmental Protection in China. *The China Quarterly* 156, 757–787.

Jessop, B., 2002. Liberalism, neoliberalism, and urban governance: A state–theoretical perspective. *Antipode* 34, 452–472.

Jessop, B., 1995. The regulation approach, governance, and post-Fordism: Alternative perspectives on economic and political change? *Economy and Society* 24, 307–333.

Kadigi, R.M.J., Mdoe, N.S.Y., Ashimogo, G.C., Morardet, S., 2008. Water for irrigation or hydropower generation?—Complex questions regarding water allocation in Tanzania. *Agricultural Water Management* 95, 984–992.

Kaygusuz, K., 2012. Energy for sustainable development: A case of developing countries. *Renewable and Sustainable Energy Reviews* 16, 1116–1126.

Kelly, A.B., 2011. Conservation practice as primitive accumulation. *The Journal of Peasant Studies* 38, 683–701.

Kennedy, S., 2010. The myth of the Beijing Consensus. *Journal of Contemporary China* 19, 461–477.

Kibler, K.M., Tullos, D.D., 2013. Cumulative biophysical impact of small and large hydropower development in Nu River, China. *Water Resources Research* 49, 3104–3118.

King, K., 2013. *China's Aid and Soft Power in Africa: The Case of Education and Training*. James Currey, Rochester, NY.

Kirchherr, J., Pohlner, H., Charles, K.J., 2016. Cleaning up the big muddy: A meta-synthesis of the research on the social impact of dams. *Environmental Impact Assessment Review* 60, 115–125.

Knox-Hayes, J., 2013. The spatial and temporal dynamics of value in financialization: Analysis of the infrastructure of carbon markets. *Geoforum* 50, 117–128.

Kong, Y., Wang, J., Kong, Z., Song, F., Liu, Z., Wei, C., 2015. Small hydropower in China: The survey and sustainable future. *Renewable and Sustainable Energy Reviews* 48, 425–433.

Koninck, R.D., 2000. The theory and practice of frontier development: Vietnam's contribution. *Asia Pacific Viewpoint* 41, 7–21.

Kull, C.A., Arnauld de Sartre, X., Castro-Larrañaga, M., 2015. The political ecology of ecosystem services. *Geoforum* 61, 122–134.

Kuo, L., 2016. China's model of economic development is becoming more popular in Africa than America's. *Quartz*, 28 October 2016. Available at http://qz.com/820841/chinas-model-of-economic-development-is-becoming-more-popular-in-africa-than-americas/

Lacombe, G., Douangsavanh, S., Baker, J., Hoanh, C.T., Bartlett, R., Jeuland, M., Phongpachith, C., 2014. Are hydropower and irrigation development complements or substitutes? The example of the Nam Ngum River in the Mekong Basin. *Water International* 39, 649–670.

Lafarguette, R., 2011. Chongqing: Model for a new economic and social policy? *China Perspectives* 4: 62.

Lagon, M.P., Fried, B.L., 2016. China and Singapore: The models not to follow. Freedom House. Available at https://freedomhouse.org/blog/china-and-singapore-models-not-follow

Lam, W.W.-L., 2015. *Chinese Politics in the Era of Xi Jinping: Renaissance, Reform, or Retrogression?* Routledge, New York.

Lansing, D.M., 2012. Performing carbon's materiality: The production of carbon offsets and the framing of exchange. *Environment and Planning A* 44, 204–220.

Lee, C.K., 2014. The spectre of global China. *New Left Review* 89, 29–65.

Lélé, S.M., 1991. Sustainable development: A critical review. *World Development* 19, 607–621.

Lerer, L.B., Scudder, T., 1999. Health impacts of large dams. *Environmental Impact Assessment Review* 19, 113–123.

Li, G., Liu, B., Li, S., Cheng, C., Li, X., 2013. An overview of large scale small hydropower in Yunnan Power Grid: Situations, challenges and measures. Presented at the World Environmental and Water Resources Congress: Showcasing the Future, American Society of Civil Engineers, Cincinnati, USA, 13-19 May 2013

Li, J., 2016. China's Grand Canyon: no more small hydropower plants for country's last wild river in scenic Yunnan. *South China Morning Post*, 14 March 2016. Available at http://www.scmp.com/news/china/policies-politics/article/1925053/chinas-grand-canyon-no-more-small-hydropower-plants

Li, J., Zhu, L., Hu, R., Zhang, Z., Shi, J., Song, Y., 2002. Policy analysis of the barriers to renewable energy development in the People's Republic of China. *Energy for Sustainable Development* 6, 11–20.

Li, X., Tang, L., Xu, X., Qi, G., Wang, H., 2012. What can Africa learn from China's experience in agricultural development? China Agricultural University, Beijing, China.

Li, Z., Tang, R., Xia, C., Luo, H., Zhong, H., 2005. Towards green rural energy in Yunnan, China. *Renewable Energy* 30, 99–108.

Lin, W., Chen, T.P., 2004. China's widening economic disparities and its "Go West Program." *Journal of Contemporary China* 13, 663–686.

Liu, G., Lucas, M., Shen, L., 2008. Rural household energy consumption and its impacts on eco-environment in Tibet: Taking Taktse county as an example. *Renewable and Sustainable Energy Reviews* 12, 1890–1908.

Liu, H., Liang, D., 2013. A review of clean energy innovation and technology transfer in China. *Renewable and Sustainable Energy Review*s 18, 486–498.

Liu, J., Diamond, J., 2005. China's environment in a globalizing world. *Nature* 435, 1179–1186.

Liu, J., Li, S., Ouyang, Z., Tam, C., Chen, X., 2008. Ecological and socioeconomic effects of China's policies for ecosystem services. *Proceedings of the National Academy of Sciences* 105, 9477–9482.

Liu, L., Zhang, B., Bi, J., 2012. Reforming China's multi-level environmental governance: Lessons from the 11th Five-Year Plan. *Environmental Science & Policy* 21, 106–111.

Liu, Q., 2017. Hydro expansion will fail without energy market reform. *China Dialogue*, 6 January 2017. Available at https://www.chinadialogue.net/article/show/single/en/9506-Hydro-expansion-will-fail-without-energy-market-reform

Liu, X., Zeng, M., Han, X., Peng, L., Deng, J., 2015. Small hydropower financing in China: External environment analyses, financing modes and problems with solutions. *Renewable and Sustainable Energy Reviews* 48, 813–824.

Liverman, D., 2004. Who governs, at what scale and at what price? Geography, environmental governance, and the commodification of nature. *Annals of the Association of American Geographers* 94, 734–738.

Lloyd, B., Subbarao, S., 2009. Development challenges under the Clean Development Mechanism (CDM)—Can renewable energy initiatives be put in place before peak oil? *Energy Policy* 37, 237–245.

Lo, C.W., Tang, S., 2007. Institutional reform, economic changes and local environment management in China: The case of Guangdong province, in: Mol, A.P.J., Carter, N.T. (Eds.), *Environmental Governance in China*. Routledge, New York, pp. 42–62.

Lövbrand, E., Stripple, J., 2011. Making climate change governable: Accounting for carbon as sinks, credits and personal budgets. *Critical Policy Studies* 5, 187–200.

Luo, G., Guo, Y., 2013. Rural electrification in China: A policy and institutional analysis. *Renewable and Sustainable Energy Reviews* 23, 320–329.

Lynch, D., 2015. *China's Futures: PRC Elites Debate Economics, Politics, and Foreign Policy*. Stanford University Press, Palo Alto, CA.

Magee, D., 2006. Powershed politics: Yunnan hydropower under Great Western Development. *The China Quarterly* 185, 23–41.

Magee, D., McDonald, K., 2006. Beyond Three Gorges: Nu River hydropower and energy decision politics in China. *Asian Geographer* 25, 39–60.

Mainali, B., Silveira, S., 2011. Financing off-grid rural electrification: Country case Nepal. *Energy* 36, 2194–2201.

Martinot, E., 2001. World bank energy projects in China: Influences on environmental protection. *Energy Policy* 29, 581–594.

McAfee, K., 1999. Selling nature to save it? Biodiversity and green developmentalism. *Environment and Planning A* 17, 133–154.

Mishra, M.K., Khare, N., Agrawal, A.B., 2015. Small hydro power in India: Current status and future perspectives. *Renewable and Sustainable Energy Reviews* 51, 101–115.

Mishra, V., 2003. Indoor air pollution from biomass combustion and acute respiratory illness in preschool age children in Zimbabwe. *International Journal of Epidemiology* 32, 847–853.

Mol, A.P.J., 2012. Carbon flows, financial markets and climate change mitigation. *Environmental Development* 1, 10–24.

Mol, A.P.J., 2006. Environment and modernity in transitional China: Frontiers of ecological modernization. *Development and Change* 37, 29–56.

Morton, K., 2005. *International Aid and China's Environment: Taming the Yellow Dragon*. Routledge, Abingdon, UK.

Mosse, D., 2011. Social analysis as a corporate product: Non-economists/anthropologists at work at the World Bank in Washington, D.C., in: Mosse, D. (Ed.), *Adventures in Aidland: The Anthropology of Professionals in International Development.* Berghahn Books, New York, pp. 81–102.

Moyo, D., 2014. For poor countries, China Is no model. *The Wall Street Journal*, 19 September 2014. Available at http://www.wsj.com/articles/for-poor-countries-china-is-no-model-1411141900

Mulvad, A., 2015. Competing hegemonic projects within China's variegated capitalism: "Liberal" Guangdong vs. "Statist" Chongqing. *New Political Economy* 20, 199–227.

Murphy, J., 2000. Ecological modernisation. *Geoforum* 31, 1–8.

Naughton, B., 2010. China's distinctive system: Can it be a model for others? *Journal of Contemporary China* 19, 437–460.

Nautiyal, H., Singal, S.K., Varun, Sharma, A., 2011. Small hydropower for sustainable energy development in India. *Renewable and Sustainable Energy Reviews* 15, 2021–2027.

NDRC, 2016a. The 13th Five Year Plan for Economic and Social Development of the People's Republic of China 2016-2020. National Development and Reform Commission (NDRC), Beijing.

NDRC, 2016b. 可再生能源发展"十三五"规划 (The 13th Five Year Renewable Energy Development Plan 2016-2020. National Development and Reform Commission (NDRC), Beijing.

NDRC, 2012. The 12th Five-Year Plan Energy Efficiency and Environmental Protection Industrial Development Plan 2012-2020. National Development and Reform Commission (NDRC), Beijing.

NDRC, 2011. The 12th Five Year Plan for Economic and Social Development of the People's Republic of China 2016-2020. National Development and Reform Commission (NDRC), Beijing.

NDRC, 2006. 中华人民共和国国民经济和社会发展第十一个五年 (The 11th Five-Year Plan for Economic and Social Development of the People's Republic of China 2006-2010. National Development and Reform Commission (NDRC), Beijing.

NDRC, 2001. 中华人民共和国国民经济和社会发展第十个五年计划 (The 10th Five Year Plan for Economic and Social Development of the People's Republic of China 2001-2005). National Development and Reform Commission (NDRC), Beijing.

NDRC, 1996. 中华人民共和国国民经济和社会发展第九个五年计划 (The 9th Five Year Plan for Economic and Social Development of the People's Republic of China 1996-2000). National Development and Reform Commission (NDRC), Beijing.

Nielsen, S.L., 2003. Chinese interpretations of sustainable development. Presented at the Nordic Conference of China Studies, University of Oslo, 17-19 June 2003.

Oakes, T., 2004. Building a southern dynamo: Guizhou and state power. *The China Quarterly* 178, 467–487.

O'Connor, J., 1998. *Natural Causes: Essays in Ecological Marxism*. Guilford Press, New York.

Oi, J., 1999. *Rural China Takes Off: Institutional Foundations of Economic Reform*. University of California Press, Berkeley, CA.

Okot, D.K., 2013. Review of small hydropower technology. *Renewable and Sustainable Energy Reviews* 26, 515–520.

Olsen, K. H., 2007. The Clean Development Mechanism's contribution to sustainable development: A review of the literature. *Climatic Change* 84, 59–73.

Ottinger, R.L., Williams, R., 2002. Renewable energy sources for development. *Environmental Law* 32, 331–368.

Paish, O., 2002. Small hydro power: Technology and current status. *Renewable and Sustainable Energy Reviews* 6, 537–556.

Palit, D., 2013. Solar energy programs for rural electrification: Experiences and lessons from South Asia. *Energy for Sustainable Development* 17, 270–279.

Pang, M., Zhang, L., Ulgiati, S., Wang, C., 2015. Ecological impacts of small hydropower in China: Insights from an emergy analysis of a case plant. *Energy Policy* 76, 112–122.

Parris, K., 1993. Local initiative and national reform: The Wenzhou Model of development. *The China Quarterly* 242–263.

Peck, J., 2010. *Constructions of Neoliberal Reason*. Oxford University Press, Oxford.

Peck, J., Theodore, N., 2012. Follow the policy: A distended case approach. *Environment and Planning A* 44, 21–30.

Peck, J., Zhang, J., 2013. A variety of capitalism … with Chinese characteristics? *Journal of Economic Geography* 13, 1–40.

Peck, J.A., Tickell, A., 1992. Local modes of social regulation? Regulation theory, Thatcherism and uneven development. *Geoforum* 23, 347–363.

Peng, W., Pan, J., 2006. Rural electrification in China: History and institution. *China & World Economy* 14, 71–84.

People's Government of Yunnan Province, 2016. 云南省人民政府关于加强中小水电开发利用管理的意见 (Suggestions of the People's Government of Yunnan on Strengthening the Management of Development and Utilization of Small and Medium-Sized Hydropower).

People's Government of Yunnan Province, 2003. 云南省人民政府关于加快中小水电发展的决定 (Decision of the People's Government of Yunnan Province on Accelerating the Development of Small- and Medium-Sized Hydropower).

Qi, Y., 2003. 云南省中型水电开发与矿电结合的探讨 (Exploration of joint small hydropower and mineral resource development in Yunnan province). 云南水电技术 (Yunnan Hydropower Technology) 4: 2–3.

Ramo, J.C., 2004. The Beijing Consensus. The Foreign Policy Centre, London.

REN21, 2006. Renewables Global Status Report: 2006 Update. Renewable Energy Policy Network for the 21st Century, Paris.

Richter, B.D., Postel, S., Revenga, C., Scudder, T., Lehner, B., Churchill, A., Chow, M., 2010. Lost in development's shadow: The downstream human consequences of dams. *Water Alternatives* 3, 14–42.

Robbins, A.S.T., Harrell, S., 2014. Paradoxes and challenges for China's forests in the reform era. *The China Quarterly* 218, 381–403.

Robinson, J., 2004. Squaring the circle? Some thoughts on the idea of sustainable development. *Ecological Economics* 48, 369–384.

Rodrigues, A.S.L., Ewers, R.M., Parry, L., Souza, C., Veríssimo, A., Balmford, A., 2009. Boom-and-bust development patterns across the Amazon deforestation frontier. *Science* 324, 1435.

Rousseau, J.-F., 2014. Green Energies the Socialist Way: Hydropower, Energy Crops and Handai Livelihoods Along the Red River, Yunnan Province, China (PhD Thesis). McGill University, Montreal.

Ru, P., Zhi, Q., Zhang, F., Zhong, X., Li, J., Su, J., 2012. Behind the development of technology: The transition of innovation modes in China's wind turbine manufacturing industry. *Energy Policy* 43, 58–69.

Sautman, B., Yan, H., 2007. Friends and interests: China's distinctive links with Africa. *African Studies Review* 50, 75–114.

Schroeder, M., 2009. Utilizing the Clean Development Mechanism for the deployment of renewable energies in China. *Applied Energy* 86, 237–242.

Scoones, I., Amanor, K., Favareto, A., Qi, G., 2016. A new politics of development cooperation? Chinese and Brazilian engagements in African agriculture. *World Development* 81, 1–12.

Scudder, T., 2011. Development-induced community resettlement, in: Vanclay, F., Esteves, A.M. (Eds.), *New Directions in Social Impact Assessment: Conceptual and Methodological Advances*. Edward Elgar, Cheltenham, UK, pp. 186–201.

Shao, X., Wang, H., Wang, Z., 2003. Interbasin transfer projects and their implications: A China case study. *International Journal of River Basin Management* 1, 5–14.

Sharma, A., Gupta, A. (Eds.), 2006. *The Anthropology of the State*. Blackwell, Malden, MA.

Shen, Y., Diplas, P., 2010. Modeling unsteady flow characteristics of hydropeaking operations and their implications on fish habitat. *Journal of Hydraulic Engineering* 136, 1053–1066.

Sheppard, E., 2011. Geographical political economy. *Journal of Economic Geography* 11, 319–331.

Shih, V., 2004. Development, the second time around: The political logic of developing Western China. *Journal of East Asian Studies* 4, 427–451.

Siciliano, G., Urban, F., Kim, S., Dara Lonn, P., 2015. Hydropower, social priorities and the rural–urban development divide: The case of large dams in Cambodia. *Energy Policy* 86, 273–285.

Simon, G.L., 2010. Mobilizing cookstoves for development: A dual adoption framework analysis of collaborative technology innovations in western India. *Environment and Planning A* 42, 2011–2030.

Smith, N., 1984. *Uneven Development: Nature, Capital, and the Production of Space*, 3rd ed. University of Georgia Press, Athens, GA.

Sneddon, C., Howarth, R.B., Norgaard, R.B., 2006. Sustainable development in a post-Brundtland world. *Ecological Economics* 57, 253–268.

Su, X., 2014. Multi-scalar regionalization, network connections and the development of Yunnan province, China. *Regional Studies* 48, 91–104.

Sun, D.-F., Li, H., Dawsom, R., Tang, C.-J., Li, X.-W., 2006. Characteristics of steep cultivated land and the impact of the Grain-for-Green policy in China. *Pedosphere* 16, 215–223.

Sun, H., Zhi, Q., Wang, Y., Yao, Q., Su, J., 2014. China's solar photovoltaic industry development: The status quo, problems and approaches. *Applied Energy* 118, 221–230.

Sutter, C., Parreño, J., 2007. Does the current Clean Development Mechanism (CDM) deliver its sustainable development claim? An analysis of officially registered CDM projects. *Climatic Change* 84, 75–90.

Tang, X., Li, Q., Wu, M., Tang, W., Jin, F., Haynes, J., Scholz, M., 2012. Ecological environment protection in Chinese rural hydropower development practices: A review. *Water, Air, & Soil Pollution* 223, 3033–3048.

Tan-Mullins, M., Mohan, G., Power, M., 2010. Redefining “aid” in the China–Africa context. *Development and Change* 41, 857–881.

Teng, F., Zhang, X., 2010. Clean Development Mechanism practice in China: Current status and possibilities for future regime. *Energy* 35, 4328–4335.

The Climate Group, 2015. The Business Case for Off-Grid Energy in India. London.

Tian, Q., 2004. China develops its west: Motivation, strategy and prospect. *Journal of Contemporary China* 13, 611–636.

Tilt, B., 2010. *The Struggle for Sustainability in Rural China: Environmental Values and Civil Society*. Columbia University Press, New York.

Tilt, B., Braun, Y., He, D., 2009. Social impacts of large dam projects: A comparison of international case studies and implications for best practice. *Journal of Environmental Management* 90, S249–S257.

Tilt, B., Gerkey, D., 2016. Dams and population displacement on China’s Upper Mekong River: Implications for social capital and social–ecological resilience. *Global Environmental Change* 36, 153–162.

Tugendhat, H., Alemu, D., 2016. Chinese agricultural training courses for African officials: Between power and partnerships. *World Development* 81, 71–81.

UNEP, 2011. Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. United Nations Environment Program, Nairobi, Kenya.

UNEP, DTU, 2016. UNEP DTU Clean Development Mechanism / Joint Implementation Pipeline Analysis and Database. United Nations Environment Program (UNEP) and Danish Technical University (DTU). Available at http://www.cdmpipeline.org/

UNIDO, 2010. A Greener Footprint for Industry: Opportunities and Challenges of Sustainable Industrial Development. Green Industry for a Low-Carbon Future. United Nations Industrial Development Organization, Vienna.

UNIDO, ICSHP, 2016. World Small Hydropower Development Report 2016. United Nations Industrial Development Organization and International Center on Small Hydro Power (ICSHP), Hangzhou, China.

United States Department of Energy, 2017. Planning a micro-hydropower system. Available at https://energy.gov/energysaver/planning-microhydropower-system

Urmee, T., Harries, D., Schlapfer, A., 2009. Issues related to rural electrification using renewable energy in developing countries of Asia and Pacific. *Renewable Energy* 34, 354–357.

Van der Kroon, B., Brouwer, R., van Beukering, P.J.H., 2013. The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis. *Renewable and Sustainable Energy Reviews* 20, 504–513.

Wang, F.-L., Elliot, E.A., 2014. China in Africa: Presence, perceptions and prospects. *Journal of Contemporary China* 23, 1012–1032.

Wang, G., Innes, J.L., Lei, J., Dai, S., Wu, S.W., 2007. China's forestry reforms. *Science* 318, 1556–1557.

Wang, J., Huang, J., 2006. 浅议新平县小水电的可持续发展 (Sustainable development of small hydropower in Xinping county). *云南电力技术 (Yunnan Electric Power Technology)* 34, 71–72.

Wang, J., Xu, K., Chi, Y., Wang, J., Zhang, X., Lu, J., Wang, X., 2014. 我国环境功能评价与区划方案 (The environmental function assessment and zoning scheme in China). *生态学报 (Acta Ecologica Sinica)* 34, 129–135.

Wang, J.-H., Tseng, S.-W., Zheng, H., 2015. The paradox of small hydropower: Local government and environmental governance in China. *The Journal of Development Studies* 51, 1475–1487.

Wang, Y., Sun, M., Wang, R., Lou, F., 2015. Promoting regional sustainability by eco-province construction in China: A critical assessment. *Ecological Indicators* 51, 127–138.

WCD (World Commission on Dams), 2000. Dams and development: A new framework for decision-making, Report of the World Commission on Dams. Earthscan, London.

Wen, D., 2016. Development model must stem from country's reality. *Global Times*, 6 December 2016. Available at http://www.globaltimes.cn/content/1022277.shtml

Wen, T., Lau, K., Cheng, C., He, H., Qiu, J., 2012. Ecological civilization, indigenous culture, and rural reconstruction in China. *Monthly Review* 63, 29–35.

West, P., 2007. *Conservation is Our Government Now: The Politics of Ecology in Papua New Guinea*. Duke University Press, Durham.

While, A., Jonas, A.E.G., Gibbs, D., 2010. From sustainable development to carbon control: eco-state restructuring and the politics of urban and regional development. *Transactions of the Institute of British Geographers* 35, 76–93.

Wilczak, J., 2017. Making the countryside more like the countryside? Rural planning and metropolitan visions in post-quake Chengdu. *Geoforum* 78, 110–118.

Williams, C.C., Millington, A.C., 2004. The diverse and contested meanings of sustainable development. *Geographical Journal* 170, 99–104.

Wilmsen, B., 2016. After the Deluge: A longitudinal study of resettlement at the Three Gorges Dam, China. *World Development* 84, 41–54.

Winkler, H., Simões, A.F., Rovere, E.L. la, Alam, M., Rahman, A., Mwakasonda, S., 2011. Access and affordability of electricity in developing countries. *World Development* 39, 1037–1050.

Woods, N., 2008. Whose aid? Whose influence? China, emerging donors and the silent revolution in development assistance. *International Affairs* 84, 1205–1221.

Woodworth, M.D., 2017. Disposable Ordos: The making of an energy resource frontier in western China. *Geoforum* 78, 133–140.

World Bank, 2007. Poverty and Environment: Understanding Linkages at the Household Level. World Bank Environment Department, Washington, D.C.

World Bank, 2012. Financing Renewable Energy: Options for Developing Financing Instruments Using Public Funds. World Bank, Washington, D.C.

World Commission on Environment and Development, 1987. Our Common Future. Oxford University Press, Oxford.

Xinhua, 2016a. 习近平对生态文明建设作出重要指示 李克强作出批示 (Xi Jinping gives important instructions on the construction of ecological civilization), 2 December 2016. Available at http://news.xinhuanet.com/politics/2016-12/02/c_1120042543.htm

Xinhua, 2016b. 中非合作为非洲经济转型带来新动力 (China-Africa cooperation brings a new driving force to Africa’s economic transition), 19 July 2016. Available at http://news.xinhuanet.com/2016-07/19/c_1119245472_2.htm

Xinhua, 2015. 非洲专家呼吁学习中国农业发展模式 (African experts practically studying China’s agricultural development model), 10 April 2015. Available at http://news.xinhuanet.com/world/2015-04/10/c_1114926687.htm

Xinhua, 2011. 德报: 中国援助模式惠及非洲百姓 (China’s model of aid benefits African people), 25 July 2011. Available at http://news.xinhuanet.com/world/2011-07/25/c_121715899.htm

Xu, J., 2006. The political, social, and ecological transformation of a landscape. *Mountain Research and Development* 26, 254–262.

Xu, W., 2017. Belt and Road Initiative to drive up renewable energy. *China Daily*, 17 May 2017. Available at http://www.chinadaily.com.cn/beltandroadinitiative/2017-05/17/content_29389333.htm

Xu, X., Li, X., Qi, G., Tang, L., Mukwereza, L., 2016. Science, technology, and the politics of knowledge: The case of China's Agricultural Technology Demonstration Centers in Africa. *World Development* 81, 82–91.

Xue, L., Zhou, L., 2011. Technology commercialization in Chinese universities: An innovation system approach, in: Butler, J.S., Gibson, D.V. (Eds.), *Global Perspectives on Technology Transfer and Commercialization: Building Innovative Ecosystems*. Edward Elgar, Cheltenham, UK, pp. 1–39.

Yan, C., Zhu, Y., 2011. Analysis on the environmental effect of renewable energy consumption by rural residents in daily life in China: From the perspectives of carbon emissions. *Energy Procedia* 5, 1642–1646.

Yang, G., 2005. Environmental NGOs and institutional dynamics in China. *The China Quarterly* 181, 46–66.

Yang, M., 2003. China's rural electrification and poverty reduction. *Energy Policy* 31, 283–295.

Yang, Q., 2011. 浅谈边远地区小水电的开发 (On the development of small hydropower in remote areas). *湖南农机 (Hunan Agricultural Machinery)* 38, 35–36.

Yang, Y., 2006. China's integration into the world economy: Implications for developing countries. *Asian-Pacific Economic Literature* 20, 40–56.

Yeh, E.T., 2013. The politics of conservation in contemporary rural China. *The Journal of Peasant Studies* 40, 1165–1188.

Yeh, E.T., 2005. Green governmentality and pastoralism in western China: "Converting pastures to grasslands." *Nomadic Peoples* 9, 9–30.

Yeh, E.T., O'Brien, K.J., Ye, J., 2013. Rural politics in contemporary China. *The Journal of Peasant Studies* 40, 915–928.

Yeh, E.T., Wharton, E., 2016. Going West and Going Out: Discourses, migrants, and models in Chinese development. *Eurasian Geography and Economics* 57, 286–315.

Yeung, Y., Lee, J., Kee, G., 2009. China's Special Economic Zones at 30. *Eurasian Geography and Economics* 50, 222–240.

Yu, W., 2015. 我国小水电开发过度了吗?--专家详解小水电开发热点问题 (Is small hydropower over-developed? Experts explain the main problems with small hydropower development). *Xinhua*, 20 September 2015. Available at http://news.xinhuanet.com/fortune/2015-09/20/c_1116618901.htm

Yuan, Z., Bi, J., Moriguichi, Y., 2006. The circular economy: A new development strategy in China. *Journal of Industrial Ecology* 10, 4–8.

Yuen, S., 2014. China's new rural land reform? Assessment and prospects. *China Perspectives* 1: 61.

Yunnan Statistical Yearbook, 2015. Beijing: China Statistics Press.

Zarfl, C., Lumsdon, A.E., Berlekamp, J., Tydecks, L., Tockner, K., 2015. A global boom in hydropower dam construction. *Aquatic Sciences* 77, 161–170.

Zhang, K., Wen, Z., 2008. Review and challenges of policies of environmental protection and sustainable development in China. *Journal of Environmental Management* 88, 1249–1261.

Zhang, L., Yang, Z., Chen, B., Chen, G., 2009. Rural energy in China: Pattern and policy. *Renewable Energy* 34, 2813–2823.

Zhang, S., Andrews-Speed, P., Ji, M., 2014. The erratic path of the low-carbon transition in China: Evolution of solar PV policy. *Energy Policy* 67, 903–912.

Zhang, X., Kumar, A., 2011. Evaluating renewable energy-based rural electrification program in western China: Emerging problems and possible scenarios. *Renewable and Sustainable Energy Reviews* 15, 773–779.

Zhao, S., 2014. A neo-colonialist predator or development partner? China’s engagement and rebalance in Africa. *Journal of Contemporary China* 23, 1033–1052.

Zhao, S., 2010. The China model: Can it replace the Western model of modernization? *Journal of Contemporary China* 19, 419–436.

Zhao, X., Liu, L., Liu, X., Wang, J., Liu, P., 2012. A critical-analysis on the development of China hydropower. *Renewable Energy* 44, 1–6.

Zhao, Y., 2016. 我国小水电发展现状调查: 多了还是少了？会不会破坏生态？ (Current status of China’s small hydropower development: More or less? Will it harm the environment?). *People’s Daily*, 6 January 2016. Available at http://fj.people.com.cn/n2/2016/0106/c181466-27480251.html

Zheng, S., Kahn, M.E., 2013. Understanding China’s urban pollution dynamics. *Journal of Economic Literature* 51, 731–772.

Zheng, S., Sun, C., Qi, Y., Kahn, M.E., 2014. The evolving geography of China’s industrial production: Implications for pollution dynamics and urban quality of life. *Journal of Economic Surveys* 28, 709–724.

Zhou, S., Zhang, X., Liu, J., 2009. The trend of small hydropower development in China. *Renewable Energy* 34, 1078–1083.

Zhou, Y., Laconic, W., Sun (Eds.), 2016. *China as an Innovation Nation*. Oxford University Press, Oxford.

Zhou, Y., Zhu, S., He, C., 2017. How do environmental regulations affect industrial dynamics? Evidence from China’s pollution-intensive industries. *Habitat International* 60, 10–18.

Zhu, J., 2005. Agricultural Renewable Energy and Its Management in China, in: Bradbrook, A.J., Lyster, Ottinger, R.L., Wang, X. (Eds.), *The Law of Energy for Sustainable Development*. Cambridge University Press, Cambridge, pp. 156–180.

Zhu, S., He, C., Liu, Y., 2014. Going green or going away: Environmental regulation, economic geography and firms' strategies in China's pollution-intensive industries. *Geoforum* 55, 53–65.

Zinda, J.A., 2014. Making National Parks in Yunnan: Shifts and Struggles within the Ecological State, in: Yeh, E., Coggins, C. (Eds.), *Mapping Shangrila: Nature, Personhood, and Sovereignty in the Sino-Tibetan Borderlands*. University of Washington Press, Seattle, pp. 105–128.

Zinda, J.A., 2013. Organizing Conservation and Development in China: Politics, Institutions, Biodiversity, and Livelihoods. University of Wisconsin-Madison, Madison, WI.

Zinda, J.A., Trac, C.J., Zhai, D., Harrell, S., 2017. Dual-function forests in the returning farmland to forest program and the flexibility of environmental policy in China. *Geoforum* 78, 119–132.

Ziv, G., Baran, E., Nam, S., Rodríguez-Iturbe, I., Levin, S.A., 2012. Trading-off fish biodiversity, food security, and hydropower in the Mekong River Basin. *Proceedings of the National Academy of Sciences* 109, 5609–5614.