RESEARCH ARTICLE

Toward successful implementation of conservation research: A case study from Vietnam

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Abstract A number of different approaches have been used to explain the successes and failures of biodiversity conservation strategies in developing countries. However, to date, little attention has been paid toward assessing the influence of knowledge transfer between science, policy, and conservation practices in the implementation of these strategies. Vietnam's Pu Luong Cuc Phuong Conservation Area is a globally important ecosystem, situated within a limestone landscape and inhabited by hundreds of local communities. Biodiversity conservation has become an important part of sustainable development in this area. This study analyzes three conservation strategies employed in the Pu Luong Cuc Phuong Conservation Area by applying the Research–Integration–Utilization (RIU) model of scientific knowledge transfer. Our analyses reveal weaknesses in scientific knowledge transfer arising from low-quality research and poor integration strategies. Based on our results, we developed recommendations to improve research and integration in an effort to enhance science-based policy support.

Keywords Biodiversity conservation · ICDP · Poverty alleviation · Pu Luong Cuc Phuong · RIU model · Scientific knowledge transfer

INTRODUCTION

There is increasing recognition of the importance of scientific knowledge and science-based policy advice in the environmental governance of global policy issues (e.g.,

biodiversity conservation and climate change) (Miller 2009; Biermann and Pattberg 2012; Pregernig and Böcher 2012; Pregernig 2014). Given the complex causes of biodiversity loss and the challenges involved in successfully implementing conservation strategies (Wood et al. 2000; Saterson et al. 2004), policymakers increasingly rely on science-based solutions to address them (Perrings et al. 2011; Young et al. 2014; Nesshöver et al. 2016). In 2012, the newly established intergovernmental science–policy platform on biodiversity and ecosystem services (IPBES) emphasized strengthening scientific research and science–policy interfaces for more effective biodiversity conservation (Chapason and van den Hove 2009). However, some of the problems with the conservation science–policy nexus may emanate from unreasonable expectations about how and how much science can contribute to wise decision-making in policy processes (Dietz and Stern 1998; Koetz et al. 2008, 2009). Thus, there is an urgent need to better understand the factors influencing the transfer of scientific knowledge to policy-making in conservation practice.

Studies show that the loss of biodiversity will continue at an alarming rate over the twenty-first century (Pereira et al. 2010). In response, conservationists and policymakers have promoted many conservation strategies to protect the remaining biodiversity (Salafsky and Wollenberg 2000; Saterson et al. 2004; Brooks et al. 2006). However, empirical evidence demonstrates that conservation strategies, especially in developing countries, which ignore livelihood concerns and development goals of local populations, are ineffective (Arnold 2002; McShane 2003; Barrett et al. 2005). Therefore, conservation strategies that attempt to reconcile the benefits of biodiversity conservation and local development (like the Integrated Conservation and Development Projects (ICDPs)) have been widely

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implemented since the 1980s (Wells and McShane 2004). Despite their promises to deliver positive outcomes for both biodiversity conservation and poverty alleviation, ICDPs have shown mixed results (Adams et al. 2004; Garnett et al. 2007; Brooks et al. 2012). The desire for win–win scenarios for conservation and development have rarely been fulfilled in practice (Christensen 2004; Wells and McShane 2004).

Recognizing the multiple perspectives of ICDP outcomes, a number of approaches have been developed to test hypotheses regarding ICDP successes and failures (Salafsky et al. 2001; Agrawal and Chhatre 2006; Brooks et al. 2006). Brooks et al. (2006) used four different groups of criteria to measure project outcomes (ecological, economic, attitudinal, and behavioral), while Winkler (2011) used a bioeconomic model of open-access habitat and wildlife exploitation to show that the breakdown of socially optimal levels of conservation could be the root of failure. From an institutional perspective, Brown (2002) argued that misconceptions about four key elements (community, participation, empowerment, and sustainability) contribute to the failure of ICDPs. Some economists have critiqued ICDP approaches as insufficient for creating real incentives for substantial conservation measures (Ferraro and Kiss 2002). For those engaging in a protection-oriented approach to conservation, ICDPs are too social, meaning that the ICDP contributes more to the public interests of human communities than to substantial biodiversity protection. For those undertaking community-based forest management, ICDPs represent a means to support the established governmental actors and outsiders of local communities (Lovett and Ockwell 2010). Despite these studies, there remains a surprising lack of empirically substantiated research that attempts to explain the failure of ICDPs by investigating potential problems with the underlying science–policy interface. That is our starting point, as we want to investigate the effectiveness of the science–policy interface and its role in biodiversity conservation and poverty alleviation reconciliation as important prerequisites for the success of ICDPs. Thus, our guiding research question is this: Can the successes and failures of biodiversity conservation strategies in ICDPs be explained by the relationship between scientific research and the policy-making process?

To better understand successes and failures of ICDPs in regard to using science-based information in policy-making, we apply a new model of scientific knowledge transfer, the Research–Integration–Utilization (RIU) model, as our analytic tool. The RIU model states that successful knowledge transfer at the science–policy interface requires a combination of research that is relevant to solving practical problems, and strategic integration between science, policies, and practice to allow long-term implementation of

the suggested solutions. The RIU model was developed based on various research projects that addressed scientific knowledge transfer for environmental and forest policy in Germany (Böcher and Krott 2014, 2016; Böcher 2016; Heim and Böcher 2016) and Eastern Europe (Stevanov et al. 2013). It has also been applied to environmental study and policy interfaces at an international level (Nagasaka et al. 2016; Dharmawan et al. 2016, 2017; Do Thi et al. 2017). In this study, we applied the RIU model as an analytic framework to investigate three conservation strategies including efficient land use; link biodiversity conservation to poverty alleviation; and restricted use of natural resources, which were implemented in the Pu Luong Cuc Phuong Limestone Landscape Conservation Project (ECOLIME project) in Vietnam.

We begin by describing the RIU model that serves as our analytic framework and explaining the research methodology. We then elaborate on the empirical case study of the ECOLIME project to demonstrate the influence of knowledge transfer on the success of science-based policy support for three strategies that combine biodiversity conservation and poverty alleviation. Finally, based on the analytic results, we present conclusions regarding potential improvements for research and integration to enhance science-based policy support for conservation policy in Vietnam.

THEORETICAL FRAMEWORK: THE RIU MODEL OF SCIENTIFIC KNOWLEDGE TRANSFER

The RIU model differs from classical linear models of scientific knowledge transfer, in which “pure science” directly influences the politics by political stakeholders, and the policy-making process is considered to comprise rational problem-solving activities (Guston 2001; Hulme 2009; Beck 2011). However, such linear scientific knowledge transfer is rare because it cannot directly function within the different underlying rationalities of science (the search for truth) and politics (the search for power) (Krott 2012; Böcher and Krott 2014).

The RIU model assumes that policies are the results of co-production between scientific arguments and political reasoning. Thus, it differentiates between activities that are integral to co-production at the microlevel. In this model, scientific knowledge-transfer process is defined as the connection between three central activities: Research (R), Integration (I), and Utilization (U), each of which follows its own logic (Böcher and Krott 2014, 2016; Fig. 1).

Research is understood as the production of specific knowledge by using scientific methods and standards. In the RIU model, research that is used successfully for scientific knowledge transfer must be of high quality, meaning

Fig. 1 The Research–Integration–Utilization (RIU) model of scientific knowledge transfer. Adapted from Böcher and Krott (2016) and Böcher (2016)

it must be based on scientifically accepted principles, methods, and standards, and include assessments of current scientific information, compliance with procedures of good scientific practice, cooperation with other scientific institutions and projects, independent meaningfulness of scientific knowledge) (Böcher and Krott 2014, 2016).

Integration is the interaction between scientific research and political or practical application. In the integration phase, stakeholders select research results appropriate for problem-solving based on their practical demands (Böcher and Krott 2014, 2016). During this selection process, practical and political reasoning drives the selection of scientific findings. Thus, integration is crucial, as it can selectively link the two spheres—science and (political) practice (Böcher and Krott 2014). Successful integration leads to practical utilization of scientific results. Utilization is the active use of science-based products by stakeholders. Weak integration means that little or no utilization of scientific results can be observed. The RIU model sets criteria for assessing integration as an orientation of research toward public goals, the applicability of scientific solutions to practical problems, the relevance to allies, and target group-oriented intermediation by means of the proper media. The RIU model also emphasizes the relationship between the criteria for successful knowledge transfer and the specific actors serving as important allies (“actors that support knowledge transfer from science into political practice by means of their power” (Böcher and Krott 2016)) for knowledge transfer.

This study uses the RIU model as its scientific framework to analyze three of the ECOLIME project’s conservation strategies while considering the model’s criteria for each aspect of scientific knowledge transfer—research, integration, and utilization (Table S1). Accordingly, we developed the following three hypotheses:

Hypothesis 1 Even if high-quality research has been conducted, it might not be applicable in practice because of weaknesses in the integration process.

Hypothesis 2 Low-quality research might fail to lead to practical application, even with integration efforts by powerful stakeholders.

Hypothesis 3 Results from high-quality research may be selected during integration, but if the selection is only oriented toward serving the interests of specific actors, important public goals will not be met.

According to the RIU model, robust research and professional integration are crucial for successful scientific knowledge transfer. The first two hypotheses are formulated to test two possible scientific knowledge-transfer scenarios: strong, but weakly integrated, science and weak, but strongly integrated, science. The RIU model suggests that neither scenario will result in successful scientific support in practice. Both hypotheses are relevant for analyzing our cases because in one case the scientists hoped that their robust research would lead to the implementation of practical solutions, while in another case, strong integration efforts were expected to be sufficient to generate a real impact.

Concerning RIU model, implementation of scientific knowledge transfer through strong integration changes the practice in different ways. Some solutions benefit the interests of specific powerful actors, while their effects fail to serve common public interests. We formulated the third hypothesis based on this possibility. These three hypotheses guide our analysis of the scientific knowledge transfer of three conservation strategies developed in the ECOLIME project.

MATERIALS AND METHODS

Study site

The Pu Luong Cuc Phuong (PLCP) limestone range is located in north–central Vietnam (FFI 2002a; Fig. 2). The limestone range covers approximately 170 000 ha and encompasses the shared border areas of Thanh Hoa, Hoa

Fig. 2 Pu Luong Cuc Phuong Conservation Area, northern Vietnam. Map by Dinh Vu Xuan 2016

Binh, and Ninh Binh provinces (FFI 2002a). Owing to its altitude range, orientation, and large size, the PLCP range is recognized as a global karst ecosystem, supporting the largest remaining area of lowland limestone forest in northern Vietnam (FFI 2002a). PLCP forms part of the Annamese Lowlands Endemic Bird Area (Stattersfield et al. 1998) and includes a global center of plant diversity (WWF and IUCN 1994). It supports the last population of the endemic and critically endangered Delacour's langur (*Trachypithecus delacouri*), global population of which is believed to number less than 300 individuals (Nadler et al. 2003). To conserve this important limestone ecosystem, three protected areas were established in 1964, 1999, and 2004. These are the Cuc Phuong National Park (CPNP) at the eastern end of the range, the Pu Luong Nature Reserve (PLNR) at the western end of the range, and the Ngoc Son-Ngo Luong Nature Reserve (NSNLNR) in the center, forming a forest corridor between the CPNP and the PLNR.

A key feature of PLCP is the presence of hundreds of local communities who depend on agricultural cultivation and forest product exploitation (FFI 2002a). Threats endangering biodiversity in this area include hunting,

poaching, fuelwood collection, gold mining, limestone quarrying, and agricultural land encroachment (FFI 2002a). A long tradition of hunting has reduced populations of larger mammals, like the Indochinese tiger, clouded leopard, Asiatic black bear, and serow, to critical levels (FFI 2002a). Although various hunting methods are practiced, the main threat is the use of homemade guns (FFI 2002a).

The ECOLIME project is labeled as an ICDP that aims to maintain the ecological integrity and cultural character of PLCP by addressing current conservation issues and building capacity for ecosystem management (FFI 2002a). The project was divided into two phases. Phase 1 (2002–2006), funded by the Global Environment Facility through the World Bank and the Spanish Agency for International Cooperation, focused on biodiversity research as well as law enforcement and protection. Phase 2 (2007–2009), funded by the Japan Social Development Fund, emphasized community livelihood development initiatives and raising awareness. Both phases were implemented by the Fauna & Flora International (FFI) Vietnam Conservation Support Program in partnership

with the Forest Protection Department of the Vietnamese Ministry of Agriculture and Rural Development. Technical assistance was also provided by the German Development Service (DED).

Data collection and analysis

Data collection

Empirically, this study is based on expert interviews and document analyses. We collected documents from many sources including the FFI library, central Forest Protection Department, and the CPNP, PLNR, and NSNLNR libraries. In total, 30 documents on the ECOLIME project were collected, including project proposals, project completion reports on Phases 1 and 2, technical reports, progress reports, publications, unpublished reports, scientific articles, books, and policy documents. The purpose of the extensive document analysis was to better understand the motivation for the implementation of biodiversity conservation strategies.

We conducted 24 semi-structured interviews between October 2015 and February 2016, and eight interviews between June and July 2017 (Table 1). Interviewees included various stakeholders involved in the ECOLIME project, such as researchers, governmental staff, project staff, forest rangers, and community representatives. The interview questions focused on introduced activities and outcomes of the three conservation strategies in the PLCP area. The interviews, lasting between one and 2 h, were conducted in Vietnamese by a native researcher. The results of the interviews were used to analyze the effects and responses of conservation strategies.

Data analysis

All data from the interviews and document analysis were interpreted following the triangulation method (Hussein 2015) to identify reliable information and data. Then, the data were analyzed according to the main criteria of the RIU model of scientific knowledge transfer. In addition, a qualitative content analysis was conducted (Neuman 2005) to examine the viability of our hypotheses.

In this study, we also used Salafsky and Wollenberg's (2000) conceptual framework to analyze the linkage strategy between biodiversity conservation and livelihood development in the study site. In this conceptual framework, Salafsky and Wollenberg (2000) identified three different approaches to reconcile the demands of conservation and livelihood development: (1) no linkage, (2) indirect linkage, and (3) direct linkage. The no linkage approach claims to protect biodiversity by creating parks and protected areas that exclude livelihood activities. The

Table 1 List of interviewees

Interview	Affiliation
1	Manager, FFI Vietnam (by email)
2	Manager of ECOLIME project
3	Coordinator of ECOLIME project
4	Senior researcher, National University of Hanoi
5	Senior researcher, Center for Plant Conservation
6	Researcher, Ethnology Institute
7	Researcher, Ethnology Institute
8	Researcher, Vietnam National University of Forestry
9	Researcher, Vietnam National University of Forestry
10	Researcher, Vietnamese Academic of Forest Sciences
11	Researcher, FFI Vietnam
12	Researcher, FFI Vietnam
13	Director, PLNR
14	Former Director, PLNR
15	Former Director, NSNLNR
16	Director of Nature Conservation Department
17	Forest ranger, PLNR
18	Forest ranger, PLNR
19	Forest ranger, PLNR
20	Forest ranger, NSNLNR
21	Forest ranger, NSNLNR
22	Forest ranger, NSNLNR
23	Villager, PLNR
24	Villager, PLNR
25	Villager, PLNR
26	Villager, PLNR
27	Villager, PLNR
28	Villager, PLNR
29	Villager, PLNR
30	Villager, NSNLNR
31	Villager, NSNLNR
32	Villager, NSNLNR

FFI Fauna and Flora International, ECOLIME Pu Luong Cuc Phuong Limestone Landscape Conservation Project, PLNR Pu Luong Nature Reserve, NSNLNR Ngoc Son Ngo Luong Nature Reserve

indirect linkage approach tries to link livelihoods to conservation activities by providing economic substitutions to local people. The direct linkage approach is based on making livelihood activities dependent on biodiversity, and thus directly linked to conservation goals.

RESULTS

In 2002, input research within the framework of the ECOLIME project was initially commissioned by the World Bank and FFI to provide scientific recommendations for building conservation strategies in the PLCP area. The

research was implemented by a team of international and national researchers, as well as independent consultants. From the perspective of conservation, the research indicated that solutions to conservation problems in the PLCP area would have to involve development programs to reduce poverty, deflect forest use, subsidize the development of alternative economic activities, and find substitutes for forest resources (Apel et al. 2002). On this basis, the ECOLIME project endeavored to implement three main conservation strategies: (1) efficient land use, (2) link biodiversity conservation to poverty alleviation, and (3) restricted use of natural resources (Table 2). We employed the RIU model to analyze the scientific knowledge transfer and relationship between the quality of research and quality of integration in these three strategies. These strategies differed in terms of scientific bases, integration levels, and utilization in practice.

High-quality research and weak integration

We examined Hypothesis 1 (high-quality research might fail in practice owing to weak integration) by analyzing the strategy for conserving biodiversity through the case of efficient land use in the PLCP conservation area. The ECOLIME project believed that conservation

improvements through efficient land use activities would increase agricultural land productivity, address food security concerns, and reduce threats to biodiversity. However, owing to the geological characteristics of the karst ecosystem, land resources for agricultural and forestry production in PLCP is limited (RIGMR 2003), and agricultural productivity is low (Apel et al. 2002; FFI 2002b). Irrigation structures are underdeveloped, resulting in most paddy fields yielding only one crop per year (FFI 2002b, c). Consequently, the livelihoods of communities in and around the two reserves (PLNR and NSNLNR) were at risk, with a considerable segment of the population facing food shortages for three to six months per year (Apel et al. 2002; FFI 2002b). Efficient land use became an important strategy for reducing the dependency of local people on natural resources and contributing to biodiversity conservation. Drawing upon research results, many land use measures were selected for implementation in the communities in and around the PLNR and NSNLNR. Of these, land use efficiency was best addressed through three main activities: (1) agroforestry cultivation, (2) irrigation development, and (3) delivery of improved cooking stoves. These activities were introduced to households in four communes around the PLNR and four communes in the NSNLNR (FFI 2006).

Agroforestry cultivation

Agroforestry can contribute to rural development by making the land more productive (Bene et al. 1977; Schroth et al. 2004; Lu 2006). The availability of useful tree species and other non-timber forest products in the agroforestry system can alleviate resource-use pressure on conservation areas (Bhagwat et al. 2008).

The ECOLIME project introduced numerous agroforestry activities to households (FFI 2006, 2009). Our results show that during the ECOLIME project, agroforestry activities that met the demands of local people were applied effectively by local farmers (interviews 17, 19, and 22). The introduction of new high-yield seeds (e.g., Maize LVN 10) and fast-growing trees (e.g., *Acacia mangium*) contributed to improved yields per hectare or increased numbers of crops per year. Mushroom plantations, beekeeping, and cow/pig husbandry were adopted by some households to develop new alternative sources for subsistence. The planting of fodder (e.g., VA-05 grass) helped reduce exploitation of natural fodder resources for cattle breeding (FFI 2005). An assessment of development activities in the NSNLNR by the ECOLIME project in 2005 showed that project-related agroforestry cultivation activities improved certain aspects of the local peoples' lives (FFI 2005). The project aimed at addressing food security and reducing pressure by local people on the forest

Table 2 Conservation strategies for Pu Luong Cuc Phuong conservation area

Strategy	Description	Features
Efficient land Use	Agroforestry cultivation	Science-based strategy
	Irrigation development	Lack of sustainable allies for investment
	Improved cooking stoves	Limited influence due to lack of sustainable investment
Linking nature conservation and poverty alleviation	Informal agreements between local people and nature reserve	Innovative, but partly contradicts international scientific literature
		No strong allies for monitoring
		Informal agreements did not work in practice
Restricted use	Gun confiscation by force	Successfully reduced the number of guns, Support of strong allies (government, police, the nature reserve)
		Communication by forced confiscation
		Did not improve livelihoods of local people

resources by implementing efficient land use practices. However, investment in these practices was limited by time and finances; therefore, the contribution toward the improvement of livelihoods was limited (FFI 2005). Moreover, the sustainability of agroforestry activities presented an inextricable problem. After the withdrawal of the project, few households maintained the agroforestry measures in their cropping systems (interviews 18, 19, and 23). The reasons for this were diverse and complex, but most interviewees claimed that the lack of capital and cultivated land, disease, and limited markets were the main causes (interviews 17, 20, 22, and 23).

Small irrigation development

Lack of water for agriculture is a common problem in limestone areas (Liu et al. 2008). There is irregular water distribution in the PLCP area, i.e., there are areas with either too much or too little water for wetland agriculture (RIGMR 2003). An FFI survey in the NSNLNR in 2002, showed that shortage of water is the main reason farmers cultivate only a single crop (FFI 2002b); therefore, although more than 90% of the population in the area is involved in agriculture, they face rice shortages for an average of three months per year (FFI 2002b). A consultant for the ECOLIME project suggested that irrigation could help improve crop productivity and expand productive farmlands. Based on topography analysis, the consultant proposed that small gravity-based irrigation schemes were the most appropriate (FFI 2005). As a result, the project built 13 small irrigation systems that provided water to single-crop areas, allowing them to become double-crop areas (FFI 2009). The interview results revealed that rice production increased from 3.2 ton per ha to approximately 4.5 ton per ha after irrigation construction (interviews 19, 22, 28, 29). To date, 6 of the 13 irrigation systems are still in operation, while the others have been damaged or abandoned.

Improved cooking stoves

There are an estimated 585 million people who depend on traditional biomass as fuel, and by 2030, this number will increase to 632 million (IEA 2002; Kanagawa and Nakata 2007). In Vietnam, biomass is traditionally used in rural areas for cooking and heating (Tu et al., 2010; Schirmer 2014). In 2012, Vietnam's total biomass use accounted for 24% of the total energy consumed nationwide (Schirmer 2014), with fuelwood being the most used type of biomass, accounting for 65% of total biomass consumed (Quang Tuan and Huy Ngoc 2016).

Populations in PLCP have a long history of using fuelwood for cooking, animal husbandry, and homemade

alcohol production. Fuelwood is taken mainly from natural forest areas, generating a substantial pressure on forest resources. Some assert that improved cooking stoves, if well adapted to local circumstances, can contribute to forest conservation and carbon emission reduction (Wallmo and Jacobson 1998; Dresen et al. 2014). As improved cooking stoves can reduce fuelwood demand for cooking by 40–50% (Manibog 1984; Adrianzen 2013; Bensch and Peters 2015), the benefits are promising for developing countries, where alternative commercial fuels are costly or unavailable (Sesan 2012; Urmee and Gyamfi 2014).

The ECOLIME project provided improved cooking stoves to 12 households in two communes (Ngoc Son and Tu do) in the core zone of the NSNLNR (FFI 2009). We observed that only households that have a high demand for cooking, are involved in animal husbandry, and/or are involved in homemade alcohol production continue using improved cooking stoves in their houses (interviews 23, 26, 28, 29). In addition, the use of improved cooking stoves in the area remains limited owing to certain difficulties. Specifically, improved cooking stoves are larger and heavier than traditional stoves, making them inappropriate for the local people's traditional stilt houses (interviews 18 and 22). Thus, the improved cooking stoves were constructed under the stilt houses, which made daily use inconvenient. Moreover, the improved cooking stoves could only be used efficiently with specific-sized pots, which often developed cracks after a short time (interviews 19 and 20).

These initiatives for efficient land use (e.g., agroforestry cultivation, small irrigation development, and improved cooking stoves) were developed based on a 2002 ECOLIME project input study, which acquired both local and international information on ICDP approaches. The research procedures followed proper scientific practices, and the results were clearly documented. However, the results had not been peer-reviewed. The research reports became the foundation upon which the World Bank and FFI developed the biodiversity conservation strategies for PLCP. The research was conducted in cooperation with the Limestone Landscape Improving Negotiation for Conservation project, which used a participatory approach to establish a biodiversity corridor between the PLNR and the CPNP. In addition, two baseline surveys, conducted by FFI in 2002, were consulted for efficient land use strategies in PLCP. Based on such an accumulation of data, implementation of efficient land use activities for biodiversity conservation was clearly based on scientific research.

In the PLCP area, efficient land use was oriented toward two public goals: biodiversity conservation and poverty alleviation—both relevant to the Vietnamese government's poverty reduction policies and programs in rural areas.

Although biodiversity conservation through efficient land use reflects a recent trend in community-based conservation and co-management in biodiversity conservation (Balint 2006; Berkes 2007), we found that its impact was limited and fragmented at the household level owing to the limited funding and duration of the project (FFI 2006, 2009). Moreover, after the project's completion in 2009, few of the implemented efficient land use measures were continued by the local people (interviews 18, 20, and 23). In the RIU model, the ineffective utilization of this strategy was due to a lack of sustainable investment allies arising from weak integration. An analysis of the actors involved in the knowledge-transfer process, presented in Table S2, shows that the strategy did not garner strong support from powerful allies (e.g., provincial people's committees or provincial forest protection departments) such so that the activities could be implemented long-term at the study site. Furthermore, the project itself was not a sustainable ally, as it operated for only a short period (8 years). These results support Hypothesis 1 (high-quality research might fail in practice owing to weak integration), as we conclude that despite its scientific basis, the strategy of efficient land use as a contributor to biodiversity conservation suffered limited implementation owing to the unsuccessful integration of efficient land use in practice.

Low-quality research and successful integration

The linkage strategy of biodiversity conservation and livelihood development was analyzed to test Hypothesis 2 (low-quality research might fail to lead to practical application, even with integration efforts by powerful stakeholders). Since the ECOLIME project is labeled as an ICDP, it attempted to link biodiversity conservation to livelihood development in most of its activities. The project expected to improve conservation efforts and reduce threats to biodiversity by integrating the development needs and aspirations of local communities with biodiversity conservation. Based on Salafsky and Wollenberg's conceptual framework (2000), we claimed that the ECOLIME project employed a mixture of the three approaches (no linkage, indirect linkage, and direct linkage) to mitigate threats to biodiversity (Table 3). The ECOLIME project, in partnership with the Limestone Landscape Improving Negotiation for Conservation project, supported the Hoa Binh provincial government in creating a biodiversity corridor between the PLNR and the CPNP (Do Thi et al. 2017). The creation of a new protected area (the NSNLNR) in 2004, which excluded local people from their land, could be characterized as a no linkage approach.

The ECOLIME project also provided substitute livelihoods to reduce activities that negatively affect biodiversity conservation (e.g., microfinancing, promotion of local

Table 3 Strategies for linkage between biodiversity conservation and livelihood development

Linkage strategy	Activities	Features
No linkage	Creation of Ngoc Son Ngo Luong Nature Reserve	Exclude needs of local people
Indirect linkage	Provided economic substitution (e.g., husbandry, cow bank, small credit scheme, agroforestry)	Informal agreements between local people and Nature Reserve
Direct linkage	Ecotourism	Informal agreements between households and Nature Reserve

products, cow/pig breeding) (interviews 15, 16, and 22). These created indirect linkages between biodiversity conservation and livelihood development; however, the goals of these activities were not easily achieved (Oates 1995; Hughes and Flintan 2001; Sunderland et al. 2007) because these approaches were not directly tied to conservation activities. Accordingly, the project and the PLNR enacted hundreds of informal agreements between the PLNR and local people, providing local people with small grants for livelihood development activities if they took on forest protection efforts (e.g., forest patrolling, watershed forest protection, or reporting violations) (interviews 5, 10, 13, 14, and 15). Unfortunately, the project only supported a small number of locals in targeted groups (FFI 2006, 2009). Moreover, since these informal agreements were not legally binding, the local people were not committed to those efforts after the project ended, as no monitoring systems were created by the agreements. In the PLCP area, violations triggered by neighboring villagers (e.g., poaching and illegal logging) were still observed (interviews 7, 9, and 11). The illegal exploitation and the ineffectiveness of the informal agreements suggest that this indirect linkage strategy did not provide an appropriate local solution for conservation in the study site.

Ecotourism is considered a direct linkage that creates dependent relationships between conservation and development. The idea of ecotourism was initiated within the framework of the ECOLIME project. Interview results have shown that some households could raise income from ecotourism, which is expected to provide a direct incentive to stop external threats to biodiversity. We observed that although ecotourism is prevalent in the area, poor people (the target group of the project) do not reap many benefits from it (interviews 15, 19, and 23). Since poor people lacked the skills and facilities with which to conduct ecotourism (e.g., homestays, transportation, and food services), they could not continue the ecotourism activities

after the withdrawal of the project. Thus, direct linkage through ecotourism did not improve the livelihoods of the poor, who depend greatly on forest resources. The linkage strategies were directed toward two public goals, biodiversity conservation, and poverty alleviation, and were intertwined with the political process in Vietnam. However, although linkage strategies between conservation and development were integrated into the activities of the ECOLIME project, these strategies were not applicable in practice.

Prior to the establishment of the ECOLIME project (2002), scientific research revealed that linkage between biodiversity conservation and livelihood development is a necessary but insufficient condition for conservation to take place, and high linkage by itself does not guarantee successful conservation (Salafsky and Wollenberg 2000). However, despite the scientific claim that success through such linkages is elusive (Adams et al. 2004; Christensen 2004), the ECOLIME project made many attempts to link livelihood development to biodiversity conservation through indirect and direct linkage approaches with the aim of achieving successful conservation in the PLCP area.

However, these linkages were not efficiently maintained owing to weak monitoring of the nature reserve and a lack of strong allies investing in economic substitution for the long term. According to the RIU model, weak utilization of these linkage strategies could be explained by low-quality research that partially contradicted the international scientific literature. Thus, Hypothesis 2 is supported.

Lack of orientation toward public goals in integration

We analyzed the natural resource restriction strategy of gun confiscation in the PLCP conservation area to examine Hypothesis 3 (although high-quality research results may be selected during integration, if the selection orients toward serving specific actors' interests, important public goals will not be met). Restricting the use of natural resources is a traditional regulatory policy instrument used to solve nature-based social or economic conflicts (Krott 2005). Regulatory political interventions are based on legally binding regulations that can be implemented by force and the imposition of sanctions by the government (Krott 2005; Böcher 2012). The ECOLIME project claimed that the PLCP area needed a strategy to restrict the use of natural resources, related specifically to the one of the main threats to biodiversity conservation—hunting (both commercial hunting by outsiders and subsistence hunting by local people) (Apel et al. 2002). The ECOLIME project's research revealed that illegal hunting led to the decline of macaque, white-checked gibbon, and Delacour's langur populations (FFI 2003a). Moreover, hunting survey

indicated that wildlife hunting and trade are ineffectively monitored and relatively uncontrollable (FFI 2003a).

Given the seriousness of the hunting threat to biodiversity in PLCP, a hunting survey was carried out in 2002, to provide science-based advice for establishing a gun confiscation program in the PLNR. The survey revealed that many people continued to hunt to fulfill food and market demands (FFI 2003a). Furthermore, a report by FFI in 2003 was consulted to provide alternatives for a gun control program in PLCP (FFI 2003b). These research efforts followed proper scientific practices, and the results were clearly documented. Accordingly, the research reports became the basis for establishing a gun confiscation program in the area.

This gun confiscation program was implemented in nine communes in and around the PLNR from 2006 to 2009, with the support of the Vietnamese police department, forest protection department, district government, and management board of the PLNR. The gun confiscation conformed to decision 08 of the Vietnamese government, which stated that hunting within special-use forests is illegal, and to the gun confiscation policy of the Vietnamese police department. In total, 1197 guns were confiscated and destroyed (PLNR 2010) (Table 4). Traps and crossbows were also confiscated. The interviews revealed that the numbers of guns kept locally declined significantly (interviews 19, 21, 28, 29). There was also a decrease in gunshots in the forest recorded by the nature reserve forest rangers and in the number of people bringing guns to the forest (interviews 17, 19, 21, 22).

The hunting confiscation program was based on scientific recommendations by researchers and experts from the ECOLIME project. In addition, evidence from Africa has shown that the efficacy of law enforcement remains a crucial determinant in the conservation of large mammals (Milner-Gulland and Leader-Williams 1992; Arcese et al. 1995). However, since hunting was a commercial activity that contributed to local livelihoods (FFI 2003a), gun confiscation restricted subsistence efforts by local people, making their lives more difficult. Moreover, there remained a strong cultural interest in hunting as well as the bearing of arms by men in Thai and Muong communities in PLCP (interviews 15, 18, and 21). In addition, because guns, traps, and crossbows could all be bought on the black market or made locally (interviews 14 and 19), it was difficult to completely eliminate them from the PLCP area.

Table 4 Guns confiscated in 2006–2009. Source: PLNR 2010

Year	2006	2007	2008	2009	Total
No. guns	450	426	223	98	1197

PLNR Pu Luong Nature Reserve

A similar gun confiscation program in the Ba Be National Park, Vietnam (part of another internationally funded ICDP), created conflict between forest rangers and local people (Zingerli 2005). In PLCP, the effectiveness of this gun confiscation program and whether guns would return to the PLCP area in a short time remain questionable.

Our results indicate that Hypothesis 3 is supported. The strategy of confiscating guns led to the exclusion of poor people with regard to their former practice of biodiversity management. Although enforcing the regulatory gun policy successfully reduced the number of guns and contributed to biodiversity conservation, it did not improve the livelihoods of the local people, which was an important goal of the ECOLIME project.

DISCUSSION

Previous studies have evaluated ICDPs by assessing social, economic, or political factors (Brown 2002; Ferraro and Kiss 2002; Brooks et al. 2006; Winkler 2011). Our contribution to the enhanced theoretical understanding of ICDPs is to analyze the underlying processes of scientific knowledge transfer to reveal why biodiversity conservation strategies succeed or fail in an internationally funded ICDP. The ICDP, developed by experts and implemented by the Vietnamese government, can be viewed as the result of a scientific knowledge transfer that we analyzed by empirically investigating the research, integration, and utilization elements of three conservation strategies based on the main criteria of the RIU model.

Our analysis shows that successful knowledge transfer that leads to implementation requires a combination of high-quality research and a good integration strategy. Because of the absence of this required combination, neither the biodiversity conservation strategy through efficient land use nor the linkage strategy between conservation and development were successfully implemented in practice. The restricted use strategy through the regulatory policy instrument of gun confiscation achieved certain successes with regard to the biodiversity conservation goal but ignored the livelihood development goal, which is an important factor in conservation strategies in developing countries. This emphasizes the importance of selecting appropriate research materials during scientific knowledge transfer, to orient the resulting policy toward common interests to meet public goals.

Previous studies also pointed out the need to improve the interfaces between science and policy to manage the continuing biodiversity loss (Watson 2005; Nesshöver et al. 2008, 2013; Young et al. 2014). Such studies have shown that scientists can contribute significantly to the application of science in policy development by providing

high-quality policy-relevant data and by actively sharing the results of their work to policymakers (Scott et al. 2008). In this study, we take additional analytical steps to clarify that high-quality research can only forge successful knowledge transfer from science to practice when combined with a good integration strategy. The analysis of actors involved with developing the three biodiversity conservation strategies shows that the support of powerful allies is important in achieving successful integration. For the biodiversity conservation strategy through efficient land use, it is crucial to garner the support of provincial and district governments by integrating efficient land use activities into socioeconomic development plans to help to make these measures permanent. Concerning linkage strategies between biodiversity conservation and livelihood development, efforts should be made to establish legally binding agreements between conservation activities and livelihood support in order to improve the ability to monitor the strategies. Although the strategy on restricted use through gun confiscation was successful in regard to conservation, it should be combined with development activities to help achieve the public-interest goal in the ICDP (e.g., gun owners should be encouraged to hand in their guns and be supported in livelihood development activities as compensation). In addition, legally binding agreements to prevent local people from reusing the guns should be issued.

Much of the previous research has focused on either theoretical and practical issues of conservation and development or the science–policy interface. Our study uses a novel model of scientific knowledge transfer (the RIU model) to reveal the effectiveness of the science–policy interface and its role in biodiversity conservation and poverty alleviation reconciliation. Based on our results, we emphasize that excellent scientific results would not have practical impacts unless research was accompanied by professional integration and vice versa. Therefore, a focus on improving the quality of research and the quality of integration could help internationally funded projects such as the ECOLIME project to be more successful in practice.

CONCLUSIONS

In this study, we examined scientific knowledge-transfer processes involved in developing three conservation strategies in Vietnam by applying the RIU model of scientific knowledge transfer. Based on our analysis, we provide recommendations for improving the impact of conservation strategies in practice. Although Strategy 1 (undertaking efficient land use activities to contribute to biodiversity conservation) worked in practice, it lacked sustainable allies to fully integrate the strategy into a long-

lasting practice. Thus, improvement of integration between science and practice is necessary to improve this strategy. Strategy 2 (emphasize linkage between biodiversity conservation and livelihood development) was found to be insufficient scientifically and inapplicable in practice because of low-quality research that contradicted scientific evidence. Thus, in the future, researchers should clarify the nature of the linkage and seek more sufficient solutions for linking biodiversity conservation and livelihood development goals. Strategy 3 (restricted use of natural resources through gun confiscation) was successful in terms of biodiversity conservation (i.e., the number of guns available to local people decreased). However, this strategy only served the interests of specific state actors (e.g., government agencies, police department, and actors from the nature reserve) and did not contribute to poverty alleviation, an important factor in conservation strategies in developing countries. Improvement of this strategy would require a greater focus on both biodiversity conservation and poverty alleviation goals.

Overall, the results demonstrated that conservation research can provide support for successful implementation of conservation strategies only when the data meet high scientific standards and achieve successful integration. Low-quality research and/or unsuccessful integration can result in failures of science-based policy support. Our study recommends improvements to both the research and integration processes of scientific knowledge transfer in order to successfully implement conservation research. Future research should examine the applicability of the RIU model for analyzing scientific knowledge-transfer cases and identify potential improvements in processes involving scientific knowledge transfer.

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