

lessons
for climate
change
adaptation
from better
management
of rivers

Guest Editor
Jamie Pittock



Lessons for climate change adaptation from better management of rivers

First published 2009
by Earthscan

Published 2014 by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN
711 Third Avenue, New York, NY, 10017, USA

*Routledge is an imprint of the Taylor & Francis Group,
an informa business*

© 2009 Earthscan

All rights reserved. No part of this publication may be reproduced, stored in retrieval systems or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without written permission from the publisher.

Cover image: Panos/Philippe Lissac

Responsibility for statements made in the articles printed herein rests solely with the contributors. The views expressed by individual authors are not necessarily those of the editors, the funders or the publisher.

The editors and publishers gratefully acknowledge support from the Swedish International Development Cooperation Agency (Sida) for *Climate and Development*

ISBN 13: 978-1-849-71090-9 (hbk)

ISBN 13: 978-0-415-85247-0 (pbk)

EDITORIAL

191 Why a special issue on adaptation and water management?

JAMIE PITTOCK and STEPHEN DOVERS

PAPERS

194 Lessons for climate change adaptation from better management of rivers

JAMIE PITTOCK

212 Floodplain restoration along the lower Danube: A climate change adaptation case study

SUZANNE EBERT, ORIETA HULEA and DAVID STROBEL

220 Freshwater management and climate change adaptation: Experiences from the Great Ruaha River catchment in Tanzania

JAPHET. J. KASHAIGILI, KOSSA RAJABU and PETRO MASOLWA

229 Adapting to climate change in the Godavari River basin of India by restoring traditional water storage systems

BIKSHAM GUJJA, SRABAN DALAI, HAJARA SHAIK and VINOD GOUD

241 Freshwater management and climate change adaptation: Experiences from the Central Yangtze in China

XIUBO YU, LUGUANG JIANG, LIFENG LI, JINXIN WANG, LIMIN WANG, GANG LEI and JAMIE PITTOCK

249 Integrated river basin management in the Conchos River basin, Mexico: A case study of freshwater climate change adaptation

J. EUGENIO BARRIOS, J. ALFREDO RODRÍGUEZ-PINEDA and MAURICIO DE LA MAZA BENIGNOS

261 Participatory river basin management in the São João River, Brazil: A basis for climate change adaptation?

LUIZ FIRMINO MARTINS PEREIRA, SAMUEL BARRETO and JAMIE PITTOCK

269 Embracing uncertainty in freshwater climate change adaptation: A natural history approach

JOHN H. MATTHEWS and A. J. WICKEL



Aims and Scope

Climate and Development is dedicated to the range of issues that arise when climate variability, climate change and climate policy are considered along with development needs, impacts and priorities. It aims to make complex analysis of climate and development issues accessible to a wide audience of researchers, policymakers and practitioners, and to facilitate debate between the diverse constituencies active in these fields throughout the world.

The journal provides a forum to communicate research, review and discussion on the interfaces between climate, development, policy and practice. Every three months it presents conceptual, policy-analytical and empirical studies of the interactions between climate impacts, mitigation, adaptation and development on scales from the local to global. Contributions from and about developing countries are particularly encouraged; however, research on developed countries is welcome provided that the link between climate and development is the central theme.

Climate and Development is of direct and vital relevance to academics, policy analysts, consultants, negotiators, industrial and non-governmental organisations, and to all those working to ensure a better understanding of the links between climate and development.

The journal is the platform of choice for academic debate on issues that link climate and development, and invites contributions on all such issues. These include, but are not limited to:

- The vulnerability of communities to the combined impacts of climate change and non-climatic stresses
- Links between development and building capacity to respond to climate change
- The integration (mainstreaming) of climate policy adaptation and mitigation into sectoral planning and development policy
- Conflicts and synergies between mitigation, energy development and poverty
- The importance of climate and long-term weather forecasting for development
- Responsibilities of developing countries in a post-2012 climate policy regime
- The effects of climate change on meeting the Millennium Development Goals
- The implications for development of the UN Framework Convention on Climate Change and its Kyoto Protocol, as well as all other existing or proposed policy frameworks
- Financing arrangements for adaptation and mitigation in developing countries
- Economic analysis of the effects of climate adaptation and mitigation on developing countries
- Traditional knowledge and local strategies for managing natural resources and coping with climate change
- Forest management and its relationship to mitigation, adaptation and development
- Adaptation, mitigation and the poor

These and other topics are addressed in a number of ways, including:

- Research articles (theoretical developments, concepts and methods, empirical analysis and policy assessments)
- Review articles
- Case studies
- Viewpoints
- Book reviews
- Meeting reports

Why a special issue on adaptation and water management?

JAMIE PITTOCK* and STEPHEN DOVERS

Fenner School of Environment & Society, Australian National University, Canberra ACT 0200, Australia

The Copenhagen Climate Change conference in March 2009 reported that 'adaptation measures to lessen the impacts of climate change are urgently needed now. Given the considerable uncertainties around projections of climate impacts on water resources at local and regional scales, building resilience, managing risks, and employing adaptive management are likely to be the most effective adaptation strategies' (Richardson et al., 2009). The conference went on to conclude: 'As part of building effective adaptation, research is urgently required into the implications of existing policies and potential future policies with regard to adaptation: do they support or hinder adaptation, and how do they need to be changed?' (Richardson et al., 2009). This special edition of *Climate and Development* aims to contribute to the ongoing process of learning how our societies may more effectively adapt to a changing climate. We start here by outlining the choice of focus of this volume and summarizing the papers that comprise it. We conclude by highlighting the key lessons drawn from this research.

1. Focus

We chose to focus this edition of *Climate and Development* on water management because it is an important field from which to draw lessons on risk management and adaptation. The Intergovernmental Panel on Climate Change (IPCC) declares that 'adaptation to changing conditions in water availability and demand has always been at the core of water management' (Kundzewicz et al., 2007). The IPCC define such historical actions in the water sector as autonomous adaptation measures 'that do not constitute a conscious response to climate stimuli, but result from changes to meet altered demands, objectives and expectations which, whilst not deliberately designed to

cope with climate change, may lessen the consequences of that change. Such adaptations are widespread in the water sector, although with varying degrees of effectiveness in coping with climate change ...' (Bates et al., 2008). As such autonomous adaptations are widespread and possibly the most common form of adaptation to climate change, there is much that society can learn from the factors that hinder and facilitate the effectiveness of such measures, and from understanding learning processes and the limits of adaptation: this is the focus of this special edition.

2. Case studies

Climate and Development was established (in part) to: 'make complex analysis of climate and development issues accessible to a wide audience of researchers, policymakers and practitioners, and to facilitate debate between the diverse constituencies active in these fields throughout the world', and to 'offer a possibility of publication for many of the practical lessons that are learnt in projects but often not shared with the academic community'. This special edition fills such a role by reporting on the lessons drawn from six empirical, consistently designed freshwater adaptation case studies from developing countries, based on projects of the conservation organization WWF (World Wildlife Fund/World Wide Fund for Nature). These case studies illustrate a number of issues at the forefront of the global debates on sustainable water management and climate change adaptation:

- Gujja et al. report on their work in India that assesses the costs and benefits from restoring traditional village water tanks as an adaption measure. Pittock then

■ *Corresponding author. E-mail: jamie.pittock@anu.edu.au

compares this approach with the proposed construction of a large dam on the Godavari River, encapsulating the debate between proponents of adaptation through large infrastructure vs. decentralized and small-scale appropriate technologies.

- Yu et al. outline the benefits of restoring flood plain lakes in the central Yangtze River basin compared to reliance on flood 'protection' dykes. This paper also highlights the enhanced livelihoods derived from more flood-adapted agri- and aqua-cultural systems, and the importance of concurrent interventions at different geopolitical scales within China.
- Barrios et al. detail their work on enhancing water security in the drought-prone, over-allocated Rio Conchos basin in northern Mexico. Their paper illustrates the need for conjunctive management of surface and ground waters, the need to use multi-stakeholder processes to better manage scarce resources, and the opportunities for international treaties to drive local reforms.
- Pereira et al. outline the development of adaptive management capacities through a multi-stakeholder river basin consortium at Rio São João in Brazil. They highlight the enabling power of sound national water law in facilitating basin-scale institution building, community engagement and adaptive management to progressively address environmental problems.
- Ebert et al. describe reform of river management in the lower Danube basin in Eastern Europe. In outlining the adaptation benefits from large-scale floodplain restoration for flood management, economic diversification and biodiversity conservation, they demonstrate how supranational European institutions have driven reform.
- Kashaigili et al. detail outputs from a programme to restore dry season flows in the Great Ruaha River of Tanzania. They illustrate the benefits of concurrent institutional interventions to reduce poverty and direct interventions to reduce vulnerability to water scarcity.

These case studies from practitioners do not fully conform to the idealized formulas of academic research. However, given uncertainties associated with climate change impacts and the urgent need to distil and communicate lessons for adaptation in the near term, there is great value in examining programmes that have (in all but one case) been operating for more than five years. These retrospective studies of autonomous adaptation in projects by WWF and its partners lack desirable quantitative data in

places. Yet by drawing on multiple cases and using consistent analytical frameworks they usefully report the trials and errors – and successes – of social learning in multi-stakeholder adaptive management processes (Lee, 1993). The case studies highlight uncertainties in these societies' responses to water management and climate variability and change. Yet it is precisely these sorts of real-life examples of adaptation in uncertain conditions that researchers, policymakers and society at large need to learn from if the global community is to better adapt to the problems of climate change and water management that afflict our globe.

WWF's willingness to expose its work to academic scrutiny is to be welcomed and, consequently, it deserves to be rewarded in terms of constructive engagement to further enhance their programmes. It is to be hoped that this volume inspires other practitioner organizations to publish similar assessments of their programme portfolios.

3. Key lessons

In this volume, Pittock reviews the six case studies to derive common lessons on policy style and sub-programme detail (Dovers, 2005), to inform practitioners, policymakers and our broader societies on measures that may enhance adaptation to climate change. Crucially, he observes that a number of charismatic local programme leaders had not engaged in climate adaptation, concluding that adaptation proponents need to engage better with local institutions (Burgess et al., 1998; Meinke et al., 2006) to seize the opportunities for complementary 'no and low regrets' adaptations in their current activities. The assessment of these freshwater cases in developing countries contributes to debates in the literature, by proposing that climate change adaptation is best enhanced by:

- concurrently acting to reduce poverty and enhance livelihoods, and manage biophysical vulnerability, rather than favouring either response alone (Adger, 2006; Schipper, 2007);
- favouring investment in scalable, decentralized, small-scale appropriate technologies, and enhancing environmental resilience (Tompkins and Adger, 2004), rather than first opting for centralized infrastructure;
- investing in the capacity of local- to basin-scale institutions to apply adaptive management programmes over many years (Connor and Dovers, 2004);
- linking institutions at different geopolitical scales to facilitate better local to global adaptation (Adger

et al., 2005), which in most cases will require more effective and efficient national institutions.

Matthews and Wickel in this volume draw on the lessons derived from this WWF work. They note that climate change impacts on freshwater systems are associated with high uncertainty and criticize model-driven 'impacts thinking'. Identifying the need for multi-generational response, they propose an 'adaptation thinking' approach as a template for sustainable development and climate change adaptation.

Dovers (2009) proposes that 'we can go at least halfway to a believable adaptation policy by implementing known, well-supported policy and management options' and by 'normalizing adaptation, and empowering officials, agencies, local communities'. Pittock's assessment identifies that in many cases national governments have failed to turn policy into effective action, especially in terms of implementing enabling laws and financing measures for sub-national adaptive management institutions, particularly river basin management organizations. These projects also highlight the extensive opportunities in the freshwater and climate adaptation field for 'no and low regrets' interventions: restoration of environmental resilience and other ecological services; scalable, decentralized, small-scale appropriate technologies; and effective, multi-stakeholder adaptive management institutions.

These case studies expose the limits of expert- and modelling-driven adaptation methods by showing that knowledgeable and well-meaning local leaders may postpone action while awaiting better advice and data, when the climate impact uncertainties are unlikely to be reduced to a meaningful extent any time soon. The research also emphasizes the tremendous opportunities available to implement practical adaptation measures now.

References

- Adger, W. N., 2006. Vulnerability. *Global Environmental Change*, 16(3). 268–281.
- Adger, W. N., Arnell, N. W. and Tompkins, E., 2005. Successful adaptation to climate change across scales. *Global Environmental Change Part A*, 15(2). 77–86.
- Bates, B. C., Kundzewicz, Z. W., Wu, S. and Palutikof, J. P. (eds). 2008. *Climate Change and Water*. Technical Paper of the Intergovernmental Panel on Climate Change. IPCC Secretariat, Geneva.
- Burgess, J., Harrison, C. M. and Filius, P., 1998. Environmental communication and the cultural politics of environmental citizenship. *Environment and Planning A*, 30. 1445–1460.
- Connor, R. and Dovers, S., 2004. *Institutional Change for Sustainable Development*. Edward Elgar Publishing, Cheltenham, UK and Northampton, USA.
- Dovers, S., 2005. *Environment and Sustainability Policy: Creation, Implementation, Evaluation*. Federation Press, Annandale, VA.
- Dovers, S., 2009. Normalizing adaptation. *Global Environmental Change*, 19(1). 4–6.
- Kundzewicz, Z. W., Mata, L. J., Arnell, N. W., Döll, P., Kabat, P., Jiménez, B., Miller, K. A., Oki, T., Sen, Z. and Shiklomanov, I. A., 2007. Freshwater resources and their management. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson (eds). Cambridge University Press, Cambridge, UK. 196.
- Lee, K. N., 1993. *Compass and gyroscope: integrating science and politics for the environment*. Island Press, Washington, DC and Covelo, CA.
- Meinke, H., Nelson, R., Kokic, P., Stone, R., Selvaraju, R. and Baethgen, W., 2006. Actionable, climate knowledge: from analysis to synthesis. *Climate Research*, 33. 101–110.
- Richardson, K., Steffen, W., Schellnhuber, H. J., Alcamo, J., Barker, T., Kammen, D. M., Leemans, R., Liverman, D., Munasinghe, M., Osman-Elasha, B., Stern, N. and Waeber, O., 2009. *Synthesis Report. Climate Change. Global Risks, Challenges and Decisions*. University of Copenhagen, Copenhagen.
- Schipper, E. L. F., 2007. *Climate Change Adaptation and Development: Exploring the Linkages*. Tyndall Centre Working Paper No. 107. Tyndall Centre for Climate Change Research, Norwich, UK.
- Tompkins, E. L. and Adger, W. N., 2004. Does adaptive management of natural resources enhance resilience to climate change? *Ecology and Society*, 9(2). 10.

Lessons for climate change adaptation from better management of rivers

JAMIE PITTOCK*

Fenner School of Environment & Society, Australian National University, Canberra ACT 0200, Australia

Autonomous adaptation in the water sector is assessed to derive lessons for more successful climate change adaptation from six empirical, consistently designed river management case studies based on projects of WWF. They show that when adaptation measures are considered in the context of common problems in water management, many practical ways of building resilience to climate change through mainstream programs are evident. The cases are mainly from developing countries – India, China, Mexico, Brazil, the lower Danube basin and Tanzania – where efforts to reduce environmental degradation and enhance livelihoods have directly helped to reduce vulnerability to natural hazards and climate change. The key lessons include: the benefits of concurrent measures for improving livelihoods and reducing physical vulnerability; the need to enhance and fund local institutions to mainstream adaptation programmes; and the value in implementing ‘no and low regrets’ measures despite uncertainties.

Keywords: adaptation; climate change; developing countries; institutions; non-governmental organizations; rivers; water

1. Introduction

The world faces grave challenges in sustaining water resources for people and nature, problems that are exacerbated by the impacts of climate change and the need for ongoing, effective and efficient adaptation. The term adaptation can be broadly applied to actions to manage changes in the environment or society, beyond impacts induced by climate change. The Intergovernmental Panel on Climate Change (IPCC) declares (Kundzewicz et al., 2007, p. 196) that: ‘Adaptation to changing conditions in water availability and demand has always been at the core of water management’. The IPCC also defines autonomous adaptation actions as (Bates et al., 2008, p. 48): ‘those that do not constitute a conscious response to climate stimuli, but result from changes to meet altered demands, objectives and expectations which, whilst not deliberately designed to cope with climate change, may lessen the consequences of that change.

Such adaptations are widespread in the water sector, although with varying degrees of effectiveness in coping with climate change’. As autonomous adaptations are widespread and possibly the most common form of adaptation to climate change, there is much that society can learn from the factors hindering and facilitating the effectiveness of such measures, and this is the focus of this paper. Further, as the climate will continue to change, adaptation is considered in this paper to be an ongoing rather than finite process (Matthews and Wickel, 2009).

To contribute to the design of more effective freshwater climate adaptation processes, this paper considers freshwater case studies that meet the IPCC’s definition of autonomous adaptation to derive lessons on what motivated these societies to change, the factors that led to more successful processes, and how interventions may best be sustained. Rather than a theoretical assessment of what measures could or should be

■ *E-mail: jamie.pittock@anu.edu.au

implemented, this paper seeks lessons from ongoing freshwater adaptation processes. The paper also considers the benefits of these autonomous adaptation measures in terms of how they increase resilience¹ (Bates et al., 2008), and reduce vulnerability² (Bates et al., 2008).

In many cases climate change is expected to be felt first, and most severely, by changes in hydrology. In response, development of effective policies requires in part 'practical implementation knowledge' as one key evidence base (Head, 2008), as well as scientific and political knowledge. While these case studies have elements of all three types of knowledge, it is lessons from ongoing implementation that are sought in this paper. Rather than a search for a complete package of programme elements (Dovers, 2005), the comparative policy analysis undertaken in this research is focused on sub-programme detail, derivation of lessons from specific elements of the processes, and also the policy style.

In 2008, in presenting the preliminary findings for UN Water's 3rd World Water Development Report, the report's content coordinator, Dr William J. Cosgrove, regretted the lack of published case studies that linked freshwater management and its potential to contribute to climate change adaptation. He called on implementing agencies to publish assessments of their activities. In response, this paper is intended to identify such knowledge from the work of a large non-governmental organization.

This paper reports on the global lessons drawn from six empirical, consistently designed case studies of autonomous freshwater adaptation processes based on projects of a conservation organization, the World Wide Fund for Nature (also known as the World Wildlife Fund or WWF). The cases are from India (Gujja et al., 2009), China (Yu et al., 2009), Mexico (Barrios et al., 2009), Brazil (Pereira et al., 2009), the lower Danube basin (Ebert et al., 2009) and Tanzania (Kashaigili et al., 2009). Project sites were selected by the largely independent local WWF offices at different times, although three of the six projects were substantially funded in

the period reported on here through a globally coordinated programme called Investing in Nature, supported by the Hong Kong Shanghai Banking Corporation (HSBC) and WWF UK. The six river basins concerned were all considered by WWF to be significant for biodiversity conservation, and their conservation work commenced more than six years ago at all sites, except with the Godavari project. Otherwise, the only common thread in their selection was a need perceived by WWF and sectors of the local community to respond to severe environmental degradation, often indicated by disasters, which threatened biodiversity and peoples' livelihoods (Table 1).

In response to this environmental degradation, WWF and the local institutions instigated actions that reduce vulnerability to climate variability and related natural resource management problems, including the types of climate impacts expected to be exacerbated by climate change. WWF is a proponent of the sustainable development environmental discourse (Dryzek, 1997), and its actions in these field projects reflect their beliefs in nested social and ecological systems, that environmental protection and socio-economic benefits are mutually reinforcing, and in decentralized, exploratory and variable approaches in pursuit of sustainability (Lee, 1993).

A key dilemma facing policymakers is whether adaptation is better facilitated by focusing on biophysical risk reduction, or whether it would be more effective to invest in reducing poverty and improving livelihoods more generally so as to build the resilience and adaptability of local communities to climate change impacts (Brooks, 2003; Adger, 2006; Schipper, 2007). The research considers how such measures are best integrated into society (Ross and Dovers, 2008). A further choice is between more technical infrastructure on the one hand, and on the other, favouring small-scale and decentralized interventions with a greater emphasis on increasing societal capacities (Moench and Stapleton, 2007; Ribot et al., 2009). These questions are further assessed in this paper.

TABLE 1 Environmental degradation and disasters that instigated WWF and societal responses

Basin and location	Major environmental degradation and disasters	WWF project period	WWF project objective/s (as summarized by the author)
Maner River tributary of the Godavari River, India	Water scarcity – an increasing problem in the region as populations increase and water resources are extensively exploited. Access to water is a focus of many government and community organizations' programmes.	March 2005–February 2007	Assess the socio-economic and environmental costs and benefits of restoring traditional village water tanks as an alternative to major infrastructure schemes to increase water supplies.
Lakes in the central Yangtze River basin, China	Floods, drought, pollution, fishery decline – all increasing problems. Major floods in 1995, 1996, 1998 and 1999 sparked responses from governments.	2002 to present	Demonstrate that re-linking floodplain lakes to the Yangtze River, and promoting more diverse and flood-adapted livelihood activities would improve water quality, biodiversity conservation and the livelihoods of local people.
Rio Conchos, Mexico	Water scarcity – drought from 1994 to 2006 instigated responses from stakeholders.	2002 to present	Improve the condition of freshwater ecosystems in the Rio Grande/Bravo basin by promoting the application of integrated river basin management.
Rio São João (Rio de Janeiro State), Brazil	Pollution, fishery decline, water scarcity. By 1999 eutrophication of water bodies had largely eliminated the inland fisheries, and reduced water access and sparked community demands for rectification.	1999 to present	Restore the water quality and biodiversity of water bodies in the São João region by promoting the application of integrated river basin management.
Lower Danube River, Romania, Bulgaria, Moldova and the Ukraine	Floods, pollution both increasing problems. Major floods in 1998–2002, 2005 and 2006 resulted in demands for more effective management by governments and communities.	1992 to present	Establishment of the Danube River basin as a model of nature conservation and community prosperity, including restoration of freshwater and forestry resources along the lower Danube.
Great Ruaha River, Tanzania	Water scarcity – river ceased flowing in the dry season from 1993 resulting in a 2001 Prime Ministerial commitment to restore river flows.	2003 to present	To enable the people of the Great Ruaha River catchment to plan, manage and utilize their water and related natural resources sustainably, and by doing this, alleviate poverty and improve livelihoods.

2. Methods

Six existing WWF projects (see [Table 1](#)) were selected for research by the author in consultation with staff of WWF UK. The projects were selected on the basis that they had the following characteristics: a significant focus on people's management of hydrological variability; were from countries with developing or emerging

economies and from a broad continental distribution; and had been under way for sufficient time to have produced substantial outputs.

This assessment was undertaken between February and December 2008. Each WWF project was funded to employ a local consultant reporting to the local WWF office to prepare a case study report responding to an analytical framework. The reports covered the background to

the work and the outputs and lessons in three areas: adaptation, livelihoods and conservation. They were prepared iteratively in consultation with the author in order to clarify data and increase consistency between the reports. The questions that were applied to each of the projects are detailed in the Annex. The case studies were then analysed by the author.

The work of these projects involved social and institutional changes as much as or more than biophysical and technological interventions. The measures deployed in these autonomous adaptation processes can be categorized as:

- Decommissioning or changing the operations of underperforming infrastructure, like flood 'protection' dykes and sluice gates.
- Restoring the ability of the natural environment to provide ecosystem services, such as floodwater retention, storing water in aquifers, water purification and fisheries.
- Adopting locally available and small-scale technologies, such as village water tanks.
- Changing agricultural and aquacultural practices to more sustainable methods that: produce fewer pollutants; reuse water, such as for fish production then irrigation; are more water efficient; require less inputs; and secure higher returns for more valued produce.
- Providing better waste management systems, especially for sewerage.
- Diversifying local livelihoods into more profitable and less water-dependent enterprises.
- Increasing the incomes derived from natural commodities, such as fish, to reward producers adopting more sustainable practices and increase the resilience of these households.
- Establishing and strengthening local institutions to facilitate adaptive management and self-determination, including establishing and enforcing more sustainable behavioural norms for uses of natural resources such as water.
- Facilitating basin-scale multi-stakeholder institutions to: establish partnerships; develop common visions; lead adaptive management;

and connect the local to global measures needed for more effective adaptation and sustainability.

- Advocating laws and government programmes that facilitate subsidiarity by providing basin and local institutions with the mandate and access to resources for adaptive management.
- Improving connectivity in freshwater ecosystems by applying environmental flows, ensuring wildlife passage through or over water infrastructure, and restoring riparian habitats.
- Restoring habitats to increase the resilience of these ecosystems to climate impacts, and their capacities to support greater populations of flora and fauna species, especially those that are threatened or of economic value.

3. Results

Table 2 summarizes the main adaptation, livelihood and conservation benefits to date from the six projects.

Successful outcomes to date from these autonomous adaptation cases can be categorized under the following:

- *Flood retention*: increased capacity to safely retain higher peak flood flows.
- *Water security*: more reliable access to water in areas prone to scarcity.
- *Pollution reduction*: cuts to pollution levels and the risk that pollution impacts like eutrophication will be exacerbated by higher temperatures resulting from climate change.
- *Livelihoods*: diversified income generation strategies and increased incomes of many participants that may increase resilience of communities to climatic events.
- *Institutional capacity*: established and strengthened local institutions, increasing their adaptive management capacities.
- *Connectivity*: re-linked habitats and populations of species, enabling greater mobility and capacity to colonize new habitats that may be required to survive in a warmer world.