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Screening for Climate Change Adaptation: Managing the Potential Impacts of Climate Change on Water Sector in China

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Abstract: The issue on screening for climate change adaptation is addressed. A screening approach is developed for assessing climate change impacts on water sector and integrating adaptation for water resource projects, and three phases for screening climate change adaptation are introduced that include the semi-quantitative & quantitative analysis, and the evaluation of different adaptation options on the water resources affected by climate change in China. According to different climatic regions facing different problems on water resource, four representative regions in China are chosen in the project; after setting up different objectives, this paper demonstrates the comprehensive research on climate change adaptation, and proposes new ideas, framework and methodologies on screening for climate change impacts and adaptation. This research provides the effective framework and methodology for the planning and risk management of the impacts of future climate change on water resource.

Key words: climate change; water resource; adaptation management

Introduction

In line with global change, China's climate has witnessed significant change in the last 50 years [1−3]. These changes include increased average temperatures, rising sea-levels, glacier retreat, reduced annual precipitation in North China and Northeast China, and significant increases in South and Northwest China. Extreme weather and climatic events are projected to become more frequent in the future and water resource scarcity will continue across the country. Coastal and delta areas will face greater flood and storm risk from sea level rise and typhoon landfalling.

The impacts of climate change have the potential to slow-down economic and human development in China, therefore presenting risks to the efficiency and effectiveness of development investments; at the same time, in some cases climate change might provide opportunities for economic growth and human development. Potentially negative impacts include: direct impacts (e.g. damages from extreme weather and climatic events to infrastructure), indirect impacts (e.g. health impacts that reduce labour productivity in agriculture), underperformance (e.g. agricultural projects that fail when rainfall decreases),"mal-adaptation" (e.g. policies that inadvertently increase vulnerability, such as those encouraging migration into high risk areas).

China is a developing country confronting severe shortage of water resources [4−5]. The impact of climate change on water resources engineering and planning will be the important aspects of climate change assessments, and also be the new challenge on water resources planning, investment and management [5−8]. While there has been limited consideration of future climate change in water sector developments to date, the existing engineering and planning should be improved according to climate change. The key problem in doing so is that adaptation processes may therefore require enhancing existing measures in light of a changing climate, as well as developing new measures. Crucially, adaptation requires a process of ongoing

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monitoring and assessment as scientific understanding of climate change develops.

This project developed a screening approach for assessing climate change impacts and addressing adaptation in development projects in China. It used case studies focusing on the water sector to test a framework for the screening of projects for climate change impacts and adaptation options. This framework can be refined and adapted according to the needs of different users. It is hoped that the results will stimulate debate, and foster further efforts tailored to specific planning, design and implementation procedures in the water sectors and other sectors in China and elsewhere.

1 Overview of the adaptation screening framework on water sector

This project developed a screening framework to assist with the assessment of climate change impacts and the integration of adaptation into development projects. To enable the application of the framework in a wide range of projects and sectors, it does not prescribe a single model, methodology or tool. It is a systematic step-by-step process for assessing climate change impacts and adaptation responses.

The screening framework has 3 phases, relating to framing, analysis and decision making (Fig.1) :

(1) A rapid qualitative analysis of the entire development investment to identify potentially significant problems posed to a development project by climate and/or socio-economic change.

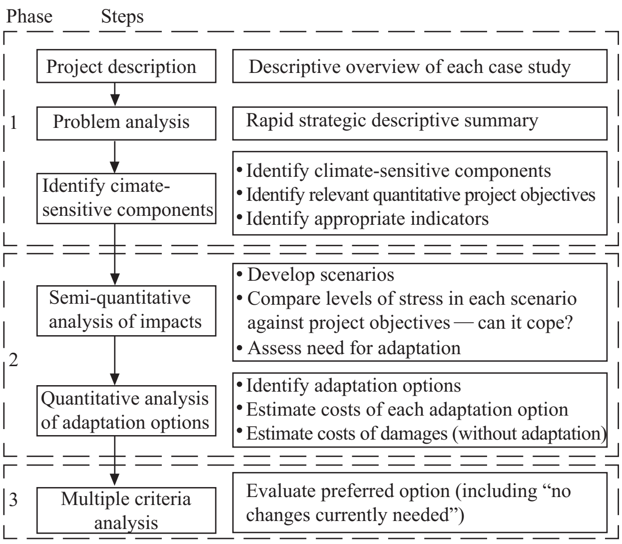

Fig. 1 Overview of the phases and steps of the climate screening framework

(2) A semi-quantitative and quantitative analysis of impacts that climate change may have on the development investment, and the adaptation options that might be required to enable the investment to achieve its intended beneficial outcomes. This includes a cost benefit analysis of the adaptation options to indicate their economic efficiency.

(3) An analysis to assess the suitability of different adaptation options against a range of appropriate decision-making criteria to suggest the preferred option. This includes assessing the option of making no major additional changes to the project (“no changes currently needed”). Under this option, ongoing monitoring of climate impacts and maintenance of flexibility to cope with potential change is recommended.

1.1 *Rapid qualitative analysis*

The first phase is a rapid qualitative analysis of the development project under consideration to identify potential impacts of climate change and climate-sensitive components, including:

(1) Project description: this provides a descriptive overview of the geographical area of each case study, its aims and objectives and the associated activities of the project.

(2) Problem analysis: this carries out a rapid descriptive summary of the case study development project, including current climate hazards that might affect the development project and their potential impacts; the current and planned infrastructure, management systems and supporting practices of the development project; the ecosystem vulnerability; climate change trends and their possible consequences for the development project; socio-economic changes.

(3) Identification of climate-sensitive components of the development project. This focuses on the key climate sensitive elements of the project by identifying the components of the development project which are sensitive to climate change; quantifying objectives of these components; and indentifying relevant secondary climate impact indicators, relevant human activity issues and indicators, and the time period of analysis that is appropriate to the development project and to represent the lifespan of proposed new infrastructure, or the time period of a development project or restoration plan.

1.2 *Semi-quantitative and quantitative analysis*

This phase assesses the need for adaptation by determining the extent to which a project’s objectives are threatened by future climate change impacts. This is shown graphically in Fig. 1. Thus, the second phase assesses the impact of projected climate change on the development project, the potential need for adaptation under identified future conditions, and the options for adaptation. Time restrictions did not permit modelling of climate change scenarios and their impacts. Instead, a range of potential scenarios was generated using expert judgement based on existing model outputs.

The phase is divided into a semi-quantitative analysis of impacts and a quantitative analysis of adaptation options to determine their costs and benefits.

(1) Semi-quantitative analysis of impacts

The Semi-quantitative analysis assesses the need for adaptation by determining the extent to which a project's objectives are threatened by future climate change impacts. The analysis works through the case study information: Developing realistic scenarios of secondary climate impact indicators (e.g. surface water availability for irrigation changes from −20 % to 10%) for the chosen time period based on the range of climate change projections; Developing a range of scenarios of human activity indicators (e.g. population changes served by sewage treatment works from −5 % to 20%); Evaluating the contribution of existing and proposed infrastructure/management systems to achieve the case study development project's stated objectives; Comparing levels of stress against infrastructure objectives to assess the ability to cope with changes from scenarios (and the need for adaptation).

(2) Quantitative analysis of adaptation options

The quantitative analysis of these adaptation options estimates the economic efficiency of adaptation. This is then used in Phase 3 to inform the decision-making process. This analysis undertakes the following steps for each case study: 1) For the scenarios in which the development project might fail to achieve its stated objectives, identify adaptation options to reduce potentially unacceptable impacts. 2) Estimate future costs of adaptation at net present value. 3) Estimate benefits of adaptation measures, if implemented, including increased financial/economic output due to adaptation and/or avoided damages (e.g. crop losses, loss of energy generation) at net present value. 4) Calculate benefit-cost (B/C) ratios of adaptation, to determine whether the proposed adaptation is economically efficient, as a contribution to decision making. If individual adaptation options are being considered, their B/C ratios can be compared, but with due consideration of the magnitudes of their benefits. 5) Identify any costs for which estimates, on the basis of current knowledge, could not be produced.

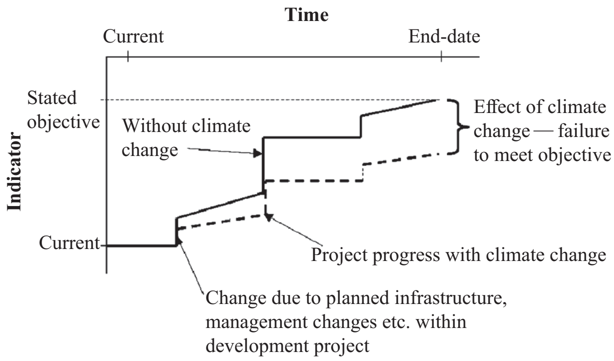

Fig. 2 Schematic diagram showing how climate change may potentially cause a failure to achieve anticipated project objectives

1.3 *Adaptation option assessment*

Usually, the suitability of different adaptation options is assessed against a range of appropriate decision-making criteria to suggest the preferred option. The phase is divided into two steps as the following:

(1) Multi criteria analysis

This phase provides a simple framework to inform decision making on adaptation options. A multi-criteria analysis framework is used to think through and discuss adaptation options in the context of a range of potential decision-making criteria. The process of undertaking the multi-criteria analysis may be considered more important than the results as it opens decision making to a wide range of criteria. The result of the economic analysis outlined in the earlier section is only one of these criteria for choosing adaption options. Decision-making criteria are weighted for their importance as part of the discussion. Ideally, a wide stakeholder group should be involved in the multi-criteria analysis as part of the consultative process. Due to time constraints, the group for each case study was limited, but included technical experts and policy makers working in the field related to the case study topic and region.

(2) Case assessment

The assessment process undertook the following steps for each case study.

Firstly, identify a range of decision-making criteria for evaluating the different options such as cost-effectiveness, unintended consequences (e.g. increased groundwater abstraction to compensate for reduced surface water supply), likelihood of occurrence, and practicality of the option. The selected criteria will vary between development investments as a consequence of differing priorities of decision makers.

Secondly, evaluate the adaptation options, including an option of "no changes currently needed", against the criteria to identify preferred option(s) for implementation into the design process for the case study development project.

Thirdly, where a "no changes currently needed" option is the final outcome, the rationale should be recorded, and the guidance given as to whether flexibility in design to allow for future adaptation is recommended.

2 Adaptation and application

Adaptation can be defined as a process by which strategies to moderate, cope with and take advantage of the consequences of climate change are enhanced, developed and implemented. In an extreme case, identified climate change impacts may lead to a decision not to go ahead with a particular plan or project. In most cases, however, it will simply require adjustments to a plan or project to account for potentially different future climatic conditions. The approach taken to adaptation acknowledges that: 1) Climate impacts may not be the most important constraint on development objectives; climate considerations therefore need to be embedded in a planning process that considers all risks. 2) The basis for adapting to the future climate lies in improving the ability to cope with existing climate variations. Climate change projections inform this process to ensure that current coping strategies are consistent with future climate change. 3) In tackling current hazards, adaptation processes can draw on approaches to disaster risk reduction, as well as tackling gradual changes and new hazards. 4) Because of uncertainty over future climate variability and change, management responses should build in flexibility to cope with a range of potentially different future climate regimes. 5) Managing climate impacts enables an examination of how wider development processes can contribute to reducing vulnerability to climate change.

The framework was tested in four case studies representing contrast water sector development projects. The case studies' geographical location, objectives and partners are shown in Table 1, which demonstrates the use of the screening framework rather than acting as the focus of the study.

(1) Case study 1—Flood Control and Land Drainage Management in the Huaihe River Basin

This World Bank-funded project aims to increase agricultural productivity and farmers' incomes by better protecting properties and lives along lesser tributaries against floods and waterlogging. The project provides improved flood control and drainage works and strengthened institutional capacity. Higher rainfall under future climate change conditions will exacerbate flooding events and waterlogging in a basin with a history of floods and poor drainage.

Three potential adaptation options were identified and evaluated:1) Dredge a network of drainage canals and ponds to increase floodwater storage capacity and use the spoil to raise the average land level to reduce waterlogging.2) Develop improved high level carriers in the floodplain to transfer runoff to the river. 3)Enhance the development of flood and drought monitoring, forecasting, warning and operating systems.

(2) Case study 2 — Management of Miyun Reservoir in the Capital of Beijing

The inflow to the Miyun Reservoir, that is only one surface water supply source in Beijing city in the Capital of China, has been decreasing due to rainfall change and human activities in recent years. Climate change is projected to increase reservoir inflows in the long term but in the medium term inflows may continue to decline, necessitating adaptation measures to assure water supply to Beijing. Suggested measures included: Converting paddy fields in

Table 1 Case studies for testing the screening framework

Regions	Objectives	Related partners
Huaihe River basin	Reduce flooding and waterlogging	World Bank, Ministry of Water Resources
Chaohe River, Baihe River in Haihe River basin	Sustainable water supply to Beijing	Chinese National Environmental Protection Agency (CEPA), Ministry of Water Resources, World Bank, Global Environment Facility, Municipality of Beijing
Haihe River basin	Improved agricultural water use efficiency	Ministry of Water Resources, World Bank
Shiyang River basin	Sustainable water management	Shiyang River Basin Administration Bureau

the upper reaches to rain-fed agriculture, with compensation paid to farmers; Construction of a 160 km water diversion channel from the Lanhe River to the Chaohe River, which feeds Miyun reservoir; Construct sewage treatment plants to increase effluent re-use.

(3) Case study 3 — Agricultural Water Use Management in the Haihe River Basin

The Haihe River basin is the most water scarce region in China. A drying climate and groundwater over-extraction has led to falling water tables, land subsidence, and deteriorating water quality. The case study project has addressed poor irrigation water use efficiency by making physical improvements to irrigation and drainage systems, improving agriculture support and services for agronomy and management measures, forestry and environmental monitoring, and institutional development. While projections do not show a clear future rainfall trend, projected warmer temperatures are likely to lead to increased irrigation demand, further aggravating the supply-demand imbalance.

Two adaptation options were identified and analysed to redress the water balance: 1) Increase water prices, analysing options for raising price either for industry, for agricultural irrigation, or for both industry and agriculture. 2) Greater investment in physical improvements to irrigation and drainage systems.

(4) Case study 4 — The Shiyang River Basin Integrated Restoration Plan

The restoration plan aims to prevent out-migration from the Minqin oasis due to environmental degradation. Water saving strategies and ecological restoration will be employed to reduce water abstraction and raise groundwater tables in the Minqin basin. Under future climate change scenarios, potential increases in rainfall would be offset by the effects of higher temperatures on glacier retreat and increased water demand for irrigation, industrial and domestic use, further exacerbating the water deficit.

Three main adaptation options were identified and evaluated: 1) Increased investment in planned water saving projects; 2) Increased investment in water transfers from the Yellow River; 3) Financial subsidy to compensate for lost GDP due to water abstraction restrictions.

3 Conclusions and discussion

As climate change impacts become more apparent, adaptation is an increasingly important work around the world. In China, the publication of the National Climate Change Programme by NDRC in 2007 has given impetus to adaptation in the context of sustainable development. A crucial role for this research project has therefore been to strengthen capacity and raise awareness by sensitising experts to the systematic management of climate change impacts through adaptation.

The screening framework established and tested here is not intended as a finished tool. Instead, it provides the iterative base for a cycle of learning involving testing, discussion, refinement and re-testing. Importantly, it serves as a means to promote debate over how development investments in China can integrate the management of climate change impacts in the future. Although the framework has been applied post-hoc rather than as an integral part of the design process, it has been shown to provide a clear framework for prioritization, analysis of impacts, examination of adaptation effectiveness and decision making.

For so many uncertainties in the impacts of climate change on water resources, in the future it should strengthen the base research and practice on water resources: Combining the series of comprehensive river basin planning, and according to different water resources problems, it will emphasis on the research and provide suggestions for decision making needs; Pay attention to climate change on ecosystems of river basin, and study the key factor affecting thresholds; For many different river basins with different characteristics, it will strengthen the key regions and comprehensive research, and explore the law to reduce the uncertainty in the future forecasting.

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