UK-China Sustainable Agriculture Innovation Network

# Policy Brief No 3

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# Greenhouse-gas emissions from energy use in the water sector

ADMIT: *Harmonising adaptation and mitigation for agriculture and water in China* is a collaborative research project between China and UK institutions with the objective to estimate the 'carbon cost' of adaptation to climate change with respect to agricultural water use in China. This brief profiles key knowledge gaps and management issues identified through a comprehensive review of energy use and greenhouse gas (GHG) emissions from energy use in the water sector.

The findings show a significant potential for the water sector to better understand and profile its role as a GHG emitter and to harness the co-benefits between adaptation and mitigation.

**The key needs are:**

- a greater understanding of water-energy relationships
- improved data collection and sharing of information on energy use in the sector
- development of standardised tools and mechanisms that facilitate carbon accounting and reduction across the water sector
- greater integration of energy use within water resource management and climate change adaptation planning

## Introduction

Climate change and energy security represent truly cross-cutting challenges to the sustainable management of freshwater resources. Water management is faced with the combined pressures of rising demand, deteriorating water quality, the need to maintain biodiversity and adapt to climate change whilst at the same time reducing emissions of greenhouse gases (GHGs). Increasing demand for water and deterioration of water quality have induced stricter environmental and water quality standards and regulations and water is increasingly being abstracted from more inaccessible sources and transported over longer distances. Increasing water conveyance and intensified treatment of fresh and wastewater requires greater energy use [1].

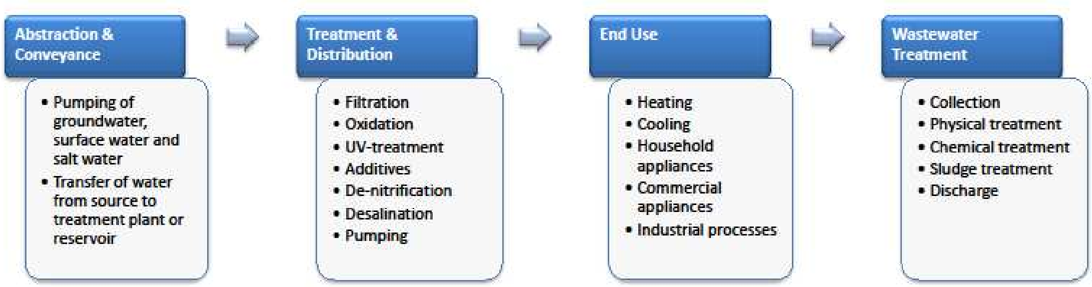
Rising demand for food and international trade in food products continue to drive the expansion of irrigated cropland, cropping intensity and utilisation of water for agriculture. Globally, irrigation accounts for around 20% of the arable land area but uses 70% of total water withdrawals and more than 90% of consumptive water to produce 40% of the global harvest [2, 3, 4]. Irrigation activities generally require high energy inputs for pumping, so that the embedded energy use is considerable in countries with large freshwater withdrawals for irrigation.

Without careful planning, adapting water management to meet increasing domestic and industrial demand, increasingly stringent regulatory water quality standards and increased irrigation demand due to the effects of climate change will require even greater energy use. However, our systematic literature review shows embedded energy use and GHG emissions associated with current and future water management are poorly understood and have been only partially addressed in many aspects of water management and planning [5]. This Policy Brief profiles key knowledge gaps and management issues identified through a comprehensive review of energy use in the water sector.

## How significant is water-related energy use?

On a global scale, commercial energy use for water delivery is an estimated 7% of total world consumption [6]. Figure 1 presents a conceptual model illustrating the energy uses in a water system.

**Figure 1:** A conceptual model of water sector processes involving energy use.



Energy use in the water sector has greatly increased during the last two decades. In the UK, the water sector has doubled its energy use since 1990 and the sector ranks as the third most energy intensive [7]. The UK water industry alone uses 3% of total national electricity consumption with power costs comprising 13% of total production costs and only 10% of power originating from renewable sources [8, 9]. Wastewater collection and treatment have caused the biggest increase in energy use in the water industry as a result of higher standards for water quality and environmental regulation [10]. A study from the US showed that energy use in the water sector accounted for nearly 5% of total national GHG emissions [1].

In South Asia, high water-related energy consumption is strongly linked to irrigation agriculture. This region has experienced rapid development in groundwater abstraction and water transport. In China the electrical intensity (kWh/$m^3$) of water production and supply has increased by nearly 20% from 1997-2005 with agriculture being not only the heaviest water user but also the least water efficient sector [11]. Extensive irrigator countries such as India and China emit up to 100 Mt $CO_2$e yearly (6% and 2% of total national emissions, respectively) for irrigation water use [12]. This underlines irrigation as a significant contributor of GHG emissions – especially in countries with large areas of groundwater-irrigated agriculture. Added to this, irrigation will play a pivotal role in meeting projected trends in global food production and demand.

> Water is heavy and management often requires its transport, sometimes over long distances, with pumping being an energy demanding process; this is what makes groundwater use in irrigation very energy intense. According to a basic theoretical physical relationship, the energy required to lift just 1$m^3$ of water (roughly how much water it takes to produce 1kg wheat, equivalent to a loaf of bread – 1.3$m^3$ water) up 1m at 100% efficiency is 0.0027 kWh.

## Knowledge gaps and lack of recognition of the scale of the challenge

Despite the importance of these issues, comprehensive analyses of energy use in the water sector are limited and estimates mostly appear in technical and/or unpublished reports. In the few studies that exist, differences in methodological approaches, units and whether results are expressed as energy use or GHG emissions, limit the potential to quantify, compare and aggregate total energy use across the water sector. Furthermore, studies tend to either focus on specific parts of the water system such as domestic "end use". When focusing on energy use for irrigation, our review of studies ranged from 0.89 to 41.8 GJ/ha depending on the water sources, irrigation system and agricultural practices [5]. Lack of detailed information often leads to assumptions about important factors which make estimates relatively crude and difficult to aggregate or compare.

Secondly, there appears to be a gap between water and energy management at both a policy and practitioner level. Environmental targets and water supply strategies tend to be poorly integrated with energy efficiency and climate change policies. As Cederwall et al. [13: abstract] underline; *"Water* *professionals have often neglected the inter-relationship of water and energy, leading to the inefficient use of one or other resources and adverse environmental and/or economic consequences. Bridges between water and energy professionals can and should be strengthened so that the overall objective of improved integrated management of water and energy resources can be achieved"*. This gap is also exemplified by the low number of peer reviewed papers linking energy use and GHG emissions in the water sector. We identify a clear need for closer integration of water resource management and energy use efficiency.

> Energy considerations have not featured highly in the Intergovernmental Panel on Climate Change's (IPCC) Working Group II chapters on Hydrology and/or Water Resources; from the First to the Fourth Assessment Reports; water-related energy use is only mentioned in passing and mainly in relation to hydro-power generation.

## What are the implications for water resource management and planning?

- **Relative paucity of information and analysis of energy use in the water sector** – underscores the need for policy coherence and innovative responses in water management to secure favourable outcomes for both environmental and economic goals.
- **Inadequate data availability and a lack of standardised methodologies and approaches** – limits the definition of water systems and estimation of GHG emissions and our ability to compare different technologies and regions or countries.

> *"Substantially more water and energy use data is needed before national, regional and local decision-makers can gain a comprehensive understanding of the energy embedded in the nation's water supplies"*. [1: 35]

- **A systematic perspective of the water sector is necessary** – to enable more comprehensive assessment of energy use. To capture all water-related energy use, it is necessary to consider all processes in the water sector (see Figure 1).
- **Greater integration across water, energy and environment** – is required to support the water industry to take advantage, within a regulated regime, of their ability to generate renewable energy and use it to defray energy intensive processes within the sector [8]. Also, the role of water in power generation (for both hydro- and cooling) and water using behaviour, particularly its effects on energy requirements for end use, are critically important.
- **Further research on the 'water-energy nexus'** – should facilitate integration of water resource management and energy use efficiency. Clean technologies for providing water and treating wastewater should be explored and supported in research and development.

**There is significant potential for the water sector to better understand and profile its role as a GHG emitter and a need to integrate energy use further within water resource management and climate change adaptation planning.**

**Through greater understanding of water-energy relationships, improved data collection and sharing and development of systematic tools and mechanisms that facilitate GHG emission accounting and reduction, we can avoid potential conflicts between adaptation and mitigation.**

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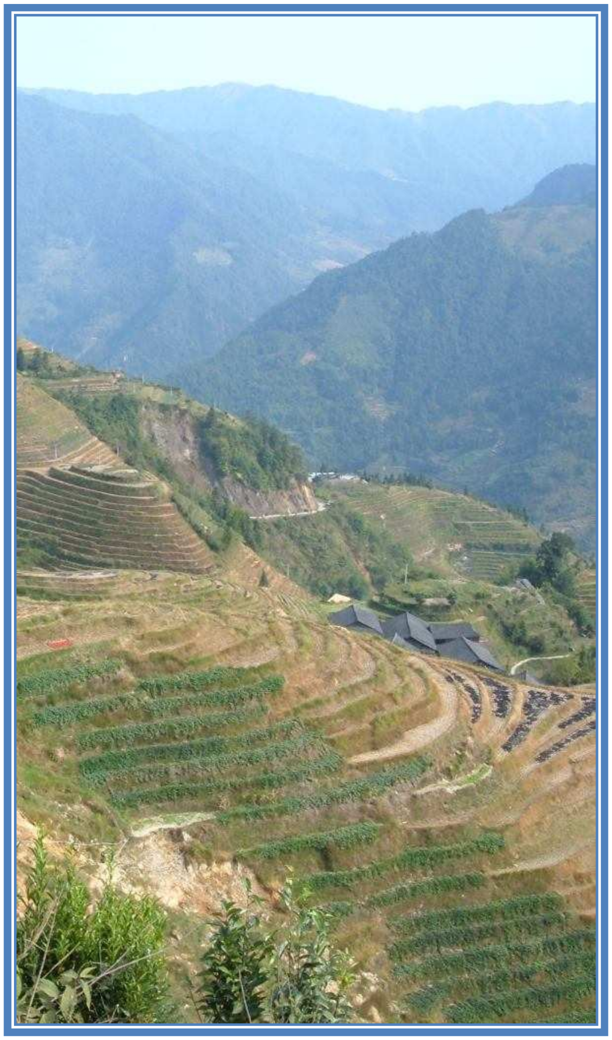

## Project Partners

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