Tackling Wicked Problems in the Malaysian Water Industry: A Framework for University-Industry Research Partnerships

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ABSTRACT

Despite the relative abundance of rainfall and plentiful surface water resources, recent reports suggest that Malaysia is faced with the prospect of water scarcity. The predicted scarcity is less related to changes in rainfall patterns but in the diminishing availability of water resources and treatment capacity for urban populations, both of which

are linked to the inadequacy of the current water management regime. Further to this, growing concerns over dilapidated infrastructure, urban water pollution, institutional weaknesses, and political interference to the implementation of recent water reforms have sought to characterize Malaysia's modern day water industry. One way of addressing the current unsustainability of the water industry is for greater collaboration and partnership between the industry's key players, including developing robust and relevant university-industry collaborative partnerships. To date, there is no evidence of a strategy to coordinate and integrate broad interests of industry and university stakeholders; instead, research tends to be done in an ad hoc manner, focused on specific technical issues without addressing some of the more fundamental and complex industry challenges. With this in mind, this paper aims to present the findings of a recent research project aimed at developing an interdisciplinary research framework for university-industry collaboration in the Malaysian water industry.

***Keywords**: university-industry collaboration, Malaysia, water industry, interdisciplinary framework*

INTRODUCTION

Harnessing the respective strengths of industry and universities to develop interdisciplinary research outputs has generated much interest amongst researchers over several decades (see Weinberg & Mazey, 1988; Phillips, 1998). University-industry collaborations are regarded as important mechanisms to produce new and commercially useful knowledge, and as means to solve specific industry problems and issues (Polt et al., 2001). Through joint research exercises, universities can gain a deeper understanding of research and development activities within industries that are related to their research interests and develop research agendas with concrete goals for innovation, such as designing a new product or a new manufacturing process (Motohashi, 2005).

With this in mind, this paper develops an interdisciplinary research framework for university-industry collaboration and applies that framework to a range of concerns currently faced by Malaysia's water industry. The water industry in Malaysia is comprised of twenty-four water service providers, including privately owned, state

owned and some joint private-state owned ventures. There is a single wastewater company serving all of Malaysia. Several government departments, at both the state and federal levels, have authority over water resource management and service provision. The industry is beset by a number of localized as well as more complex 'wicked problems', discussed below, and the need for a framework to clarify and prioritize emergent water-related issues has become clear.

In general terms, the concerns faced by Malaysia's water sector stem from the combination of enthusiastic national goals and an increasingly scarce resource. High rainfall throughout most of the year ensures the country is blessed with some of the most plentiful water resources in the Southeast Asian region (River Basin Initiative, 2012). In times of rising concern over a global water crisis (Gleick et al., 2001) and the potential for conflict over this critical natural resource, it appears Malaysia is well positioned for future water security. However, despite the relative abundance of rainfall and plentiful surface water resources, recent reports suggest that the country is faced with the prospect of water scarcity (AWER, 2011; Teng, 2011). The predicted scarcity is less related to changes in rainfall patterns but more explicitly linked to the challenge of meeting increasing water demand from rapid urbanization and concurrent industrial growth. Further to this, growing concerns over dilapidated infrastructure, urban water pollution, institutional weaknesses and political interference to the implementation of recent water reforms have sought to characterize Malaysia's modern day water industry (Elfithri et al., 2011; Tan, 2012).

By developing meaningful, collaborative research initiatives between industry stakeholders and academia, a more integrated, optimal and sustainable policy direction for Malaysia's water industry may be achieved. An organised plan for industry-related research and development is therefore an important issue and the framework developed in this paper may go a long way in elucidating this agenda. The paper is divided into four sections. The first section discusses the main challenges that currently face the Malaysian water industry. It serves as a background to the type of university-industry collaborations which might be established to address these challenges. The second section sketches out the interdisciplinary foundation and approach that is needed to develop a more effective model of university-industry collaborative research within the Malaysian water industry. The third section elaborates upon the integration of this approach

into the research process – in this case, industry stakeholders were brought together in a workshop setting and led through a specific problem solving methodology to develop the interdisciplinary framework for university-industry collaboration. The forth section sets out the interdisciplinary framework with indicative research questions provided. A brief analysis of the next steps are discussed in a concluding section.

WATER INDUSTRY CHALLENGES IN MALAYSIA

To provide the necessary foundation and background to a university-industry research framework, five major challenges to the Malaysia water industry are described and briefly analysed below: 1) uncertain environmental change, 2) river pollution, 3) dilapidated infrastructure, 4) lack of a demand management approach, and 5) water governance and policy paralysis. There are undoubtedly other areas of concern for the industry. However, as reflected in the literature, the challenges identified below are deemed to be five of the most pressing for the development of the industry as a whole.

Uncertain Environmental Change

The uncertainties of environmental change in Malaysia, notably linked to climate change and the prospect of more extreme and unpredictable weather, ensures this will be a priority research topic going forward. Examined from a global perspective Bates et al. (2008) argue that climate change will be most immediately felt through direct impacts on water resources, including changes in precipitation and runoff, more extreme events such as floods and droughts, and declines in water quality, including those resulting from more frequent algal blooms. Recent reports indicate that future environmental change could have a significant impact on Malaysia's weather patterns, watercourses and availability of water resources (Malaysian Meteorological Department/MMD, 2009) which has important implications for the country's water industry as a whole.

The climate of Malaysia is tropical and humid and influenced by the mountainous topography and complex land-sea interactions (MMD, 2009). Malaysia experiences a monsoon season between

November and March and during this period, many parts of Peninsular and East Malaysia are at risk from floods; records have shown severe flooding since the late nineteenth century (Chia, 2004). An increase in tropical storms in the South China Sea has contributed to more extreme events of rainfall and gusting in both East and West Malaysia in recent years (MMD, 2009). According to Chia (2004) flood occurrence is on the increase in Malaysia, especially in the urban centres of Kuala Lumpur, Penang, and Kuching.

In 2009, the Malaysian Meteorological Department (MMD) studied the impact of global warming on the monsoons over the Malaysian region by using twelve coupled Atmosphere-Ocean General Circulation Models (AOGCMs). These models have contributed towards the Intergovernmental Panel of Climate Change's (IPCC) climate change scenario modeling, including the most recent IPPC 5th Assessment Report (IPCC, 2012). In terms of the headline findings with most significance to the water industry, the study projected a consistent increase in temperature for both East and West Malaysia, with rainfall likely to increase by as much as 10% in some areas whilst decreasing in other parts of the country (MMD, 2009).

In a separate study Kavvas et al. (2006) applied simulation models to determine likely hydrological trends for Malaysia. Their results indicate a future increase in inter-annual and intra-seasonal variability with increased hydrologic extremes across Peninsula Malaysia. The authors recommend further studies with a longer simulation time period and/or multiple realizations in order to obtain statistically more reliable results on the impact of possible climate change on Peninsular Malaysian water resources (Kavvas et al., 2006).

Whilst such studies and models are not expected to provide a definite 'answer' to the questions of Malaysia's future environmental change, it gives an indication of the potential environmental change facing the country and the potential impacts to the water industry. Furthermore, even in the absence of any kind of environmental change, freshwater ecosystems and the resources they provide are under increasing pressure because of increasing demand for water and declines in water quality (Pittock, 2011). This is especially the case for Malaysia where water scarcity is expected in certain parts of the country by 2014 (AWER, 2013), particularly in the populated urban centres such as Kuala Lumpur. The likely onset of climate change will exacerbate these impacts, placing even greater pressure

on already stressed resources. Therefore, research that supports the adaptation to and mitigation against likely climate change impacts, specifically in terms of impacts on the water industry and related sectors (i.e. agriculture), are a critical requirement for the country at the present point.

River Pollution

During the last century, Malaysia's pattern of intense resource extraction and rapid economic development gave rise to various sources of river pollution of water pollution (Badri, 1986; Abdullah, 1995; Hezri & Hasan, 2006), many of these still affecting the quality of rivers today. River water quality is monitored under the Department of Environment (DoE) which currently has a total of 1,064 manual monitoring stations located within 143 river basins throughout the country (DoE, 2010). In 2010, the DoE reported that sixty percent of all monitoring stations were found to be clean, thirty-five percent slightly polluted, and five percent polluted. The trend since 2006 indicates that river water quality is improving; the number of clean river basins was 91 in 2007 compared to 80 in 2006 and the number of slightly polluted rivers basin dropped from 56 in 2006 to 45 in 2007. However, the number of polluted river basin remains at seven which represents five percent of all basins (DoE, 2010).

Untreated or partially treated sewage, discharges from agro-based and manufacturing industries, municipal waste, earthworks and land clearing activities are some of the major sources of water pollution (Abdullah, 1995; Hezri & Hasan, 2006; DoE, 2010). Abdullah (1995) argues that untreated domestic wastewater and sewage had led to the worsening bacteriological contamination in many waterways and coastal waters. Furthermore, effluents from rubber and palm oil mills, both of which have high organic content, also contribute to water quality problems in Malaysia's rivers (Hezri & Hasan, 2006). During the latter half of the last century, these two pollutants accounted for 90% of the total industrial pollution load of local rivers (Abdullah, 1995). Furthermore, the health of river ecosystems, especially in the urban and industrialized areas have been particularly threatened by untreated industrial toxic and hazardous wastes such as heavy metals, polyaromatic hydrocarbons (PAH), and oil and grease (Hezri & Hasan, 2006).

Dilapidated Infrastructure

The origins of Malaysia's water and sanitation infrastructure go as far back as the early twentieth century where the country's first slow sand filters were built for treatment plants in Kuala Lumpur and Penang (Chin, 2008). Since then Malaysia has developed an extensive water and wastewater infrastructure network: in 2010, there were 458 water treatment plants, 8,000 wastewater treatment plants and over 131,286 km of water pipelines and 7,500km of sewer lines (Chin, 2008). Maintaining asset integrity has remained a challenge for both water and wastewater infrastructures. An illustration of this challenge is demonstrated by the high levels of non-revenue water[1] (NRW) reported to be between 30 and 60 per cent across the different regions of the country (NCWS, 2009). This figure represents a loss of approximately 43% of total water revenues from NRW (AWER, 2011). This is in contrast to neighbouring Singapore which reported non-revenue water (NRW) at 4.6% in 2009 (Asian Green Index, 2011). NRW is such a major issue that a Malaysia based research group, Association of Water and Energy Research Malaysia (AWER), have called for a task force and the creation of a national strategy to realise a reduction in NRW (Piarapakaran, 2011).

Lack of A Demand Management Approach

Almost 97% of total water resources utilised for supply purposes in Malaysia are from surface water. There is some extraction of groundwater although research is still required to better understand how much of it can be utilised and how best to monitor the available resources. The demands for residential and industrial water supply has rapidly following the country's economic shift towards industrialization in the 1980s, coupled with an increase in population and urban growth (WWF-Malaysia, n.d.). Between 2010 and 2020 national water demand is expected to more than double from 9,655 to 20,338 mega litres per day (Global Water Intelligence, 2010). According to Abidin (2004), the practicable limit of surface water resources development has been reached in regions of high demand, and it has become necessary to consider inter-basin and inter-state

1 Non-revenue water (NRW) consists of: i) water from illegal connections and; ii) water lost from leakage.

water transfers. High water consumption also contributes towards the growing need for water sources: Malaysia consumes 184 litres / capita / day (lcd) as compared with Singapore (158 lcd), Australia (145 lcd) and Denmark (135 lcd) (Chin, 2008).

The current approach towards water supply in the urban areas of Malaysia is mainly supply driven. When there is a perceived 'shortage', new sources are developed (Abidin, 2004). New sources include the construction of new reservoirs, treatment plants, and inter-state and inter-basin water transfers. The Eighth Malaysia plan (2001-2005) detailed RM52 billion to be spent on development of new water resources by 2050 which includes the construction of 47 new dams. A recent example of inter-state transfer is the Pahang-Selangor Inter-State Raw Water Transfer Project. On completion 2,260 million litres of water will be transferred per day from Pahang into neighbouring Selangor state through a tunnel of 44.6km in length and 5.2 meter wide (Abidin, 2004).

Water Governance and Policy Reform Paralysis

Water governance in Malaysia is complex, multi-layered and embedded within local and national political agendas (Tan, 2012). The root of much of the complexity lies in the ownership and responsibility for water: Malaysia's state authorities have control of water resources (rivers, streams, reservoirs, etc.) whilst the federal government oversees water supply and wastewater service provision (Chin, 2008). The disaggregation of these two components of the water industry allows room for reform stagnation if disagreement exists between State and Federal governments. Furthermore, responsibility for water cuts across as many as eight different government departments and agencies, adding to the multi-tiered governance of the industry (Tan, 2012).

In a move to allow the state run water companies to focus more on efficiency of service operations, the Federal Government has pushed forward a 'debt alleviation' reform. The reform allows state water companies to transfer their debt burden to a government created agency called Perbadanan Aset Air Berhad (PAAB) or Water Asset Corporation Berhad; in return the states must surrender their control and ownership of water assets to the same agency. Until the water companies alleviate this debt, PAAB have been tasked to take

command of all existing assets and related liabilities from the states' water companies, which includes responsibility for future capital and operating expenditure (Borchardt, 2009).

Differences between state and federal governments over asset value, potential tariff hikes, and the political implications of the state's loss of control of water has led to a 'reform impasse' in certain states, which critics argue are holding back the development of the industry as a whole (Tan, 2012). Despite various efforts to develop the industry, including a National Water Resources Policy (Ministry of Science, Technology and Innovations, 2012) to ensure the security and sustainability of water resources, an overarching policy direction for the management of the water industry as a whole is still required.

THEORETICAL FOUNDATION: APPLYING AN INTERDISCIPLINARY RESEARCH FRAMEWORK TO UNIVERSITY-INDUSTRY COLLABORATIVE RESEARCH

This paper represents the application of an interdisciplinary research framework to enhance as well as support university-industry collaborative research. In particular, collaborations that can address complex and policy-related challenges or problems faced by various industry hubs of human work, activity, and common resources in a changing world and emerging knowledge economy and society. As Rycroft & Kash (2004) anticipated, the growing 'complexity challenge of [sustainable] organizational plans, corporate strategies or national policies' indicate how policy research provides a natural focus for both 'internal' multi-disciplinary collaboration within universities and also 'external' opportunities for university-industry collaboration. In this way, interdisciplinary policy research can integrate and harness a wider range of applied research expertise towards the kinds of authentic solutions and outcomes to various challenges increasingly needed by business, government and society.

The emerging field of interdisciplinary research has a particular connection to the central idea of 'wicked problem-solving' (e.g. Kolko, 2012). Wicked problem-solving encompasses the notion that governments, corporations and societies are increasingly dealing with complex challenges and issues which resist simple solutions but require collaboration across areas of knowledge as well as the public-private divide (Klein, 2004; Repko, 2008). The convergent idea

of interdisciplinary problem-solving is also informed by a range of models – such as complexity, fractal and chaos models of science (e.g. Prigogine & Stengers, 1984; Bunge, 2003; Mandlebrot & Hudson 2005) – which in various ways support a convergent 'self-organising systems' view of the relation between nature and human activity in changing and complex environments. This new emerging version of systems theory cuts across the traditional separation between the natural and social sciences on one hand, and on the other mechanical versus information, communications and digital technologies on the other.

In terms of applied methods of inquiry, data collection, analysis and applied problem-solving, there are a range of related theories and concepts but also specific research methodologies which are either directly supportive of or indirectly useful to an interdisciplinary inquiry or even experimental approaches to authentic complex problems or policy challenges (e.g. Schon & Rein, 1994). This includes such related models as design experiments, grounded theory development, participatory action research, knowledge management, and 'mixed-mode' methodologies of research evaluation (Reigeluth & Frick, 1999; Design-Based Research Collective, 2003). Trewhella (2009) points out how the key to such a framework in practice is to be able to go 'beyond simple collaboration and teaming to integrate data, methodologies, perspectives, and concepts from multiple disciplines in order to assemble and create a common language and framework for discovery and innovation'. In this way Schon & Rein's 'frame reflection' prescription for diverse or conflicting policy stakeholders is also applicable as a basis for achieving an interdisciplinary framework for complex problem-solving.

Although scientific and other academic research is traditionally based upon addressing specific problems or issues, this might be also reconciled with a more relevant, useful and yet accountable framework of university-industry partnerships. This would include collaborative research where the multi-disciplinary implications of complex problems presuppose an outcomes-based interdisciplinary framework of integrated and optimal problem-solving for sustainable solutions (Richards, 2012). Such a framework is able to include conventional rational or descriptive approaches to evidence-based knowledge construction and policy-making in a more meaningful, useful and applied process of planning or strategizing and decision-making (Richards, 2012).

A previous related paper (Richards & Padfield, 2012) outlined a sustainable policy research framework for addressing industry related complex problems in terms of universities (and academic research more widely) as one of the four key macro stakeholders along with government, business and society. This was linked to a related model of how complex problem-solving and related policy solutions might be most effectively approached in terms of four basic stages: first, identify a central problem in the most strategically relevant and useful terms; second, break this down into the key related problems and critical factors; third, not only seek manageable solutions or remedies for these related problems or issues, but do so in terms of their specific interdependent relation and local as well as possible global context; and fourth, develop an overall solution, remedy and/or planning strategy around four generic 'knowledge modes' (see Table 1 below). These knowledge modes are as follows: stakeholder perspectives, knowledge management, science and technology innovations, and environmental adaptation.

Table 1

The Four Knowledge Modes for Outcome Based Problem Solving

	Stakeholder Perspectives	**Knowledge Management**	**Science and Technology Innovations**	**Environmental Adaptation**
Distinct as well as inter-dependent knowledge outcomes	Develop sufficient consensus for a common commitment to an achievable outcome	Encouraging, supporting and harnessing tacit knowledge of industry-focused stakeholders towards improved performance for overall or 'systemic' change and improvement	To design and develop new solutions or adapt existing applied knowledge to new challenges and different contexts	Understand how changes to or crises in society and nature represent an obstacle or challenge to be addressed to maintain or restore sustainability, viability and equitable sharing of resources

As outlined in Table 1, these knowledge modes provide the focus for outcomes-based problem-solving geared towards the 'optimisation' of natural and human resources, a 'green' approach to new science

and technology solutions, and the process of achieving a foundation to sustainable change also through consensus-building with focus on common purposes.

INTEGRATING COMPLEX WATER INDUSTRY-FOCUSED PROBLEM-SOLVING IN THE RESEARCH PROCESS

As noted above, an interdisciplinary framework for university-industry collaborative research is well suited to authentic as well as complex problem-solving. Whilst this approach might also use conventional descriptive methods relevant to related knowledge domains (e.g. social vs. natural sciences), its relevance and application lies in the seeking of design solutions to policy challenges. This capability also applied to our study of possible or projected university-industry collaborative research priorities in the Malaysian water industry. The following sets out the process by which a mix of stakeholders were brought together in a workshop setting and led through a problem solving methodology to develop the interdisciplinary framework for university-industry collaboration.

Thirty-five water industry stakeholders from a range of private, public and non-governmental backgrounds were invited to attend a one-day seminar. The purpose of the workshop was twofold: firstly, to lead the stakeholders through the process of an integrated problem solving methodology to identify potential policy solutions to challenges that currently face Malaysia's water industry; and secondly, to discuss and identify research priorities for university-industry collaboration in the Malaysian water industry. Whilst a survey was also distributed in relation to the second purpose, the seminar was thus framed in terms of an integrated approach which enabled various stakeholders to go beyond their own particular areas of interest or expertise in group discussions before they were asked to formally respond to this.

The stakeholder participants in the seminar were divided into groups to discuss the major challenges facing the Malaysian water industry now and in the future. The discussion was organised around a format of fifteen themes as follows: freshwater pollution, flooding and extreme weather, water supply, wastewater, climate change,

asset management, governance, integrated catchment management, water pricing, investment planning, consumer complaints, managing demand, water distribution, stakeholder management, and water policy. These themes were used as a means to prompt discussion and were selected prior to the workshop following a literature review of the key issues and challenges faced in the Malaysian water industry.

Further to this, stakeholders were asked to consider the different challenges in relation to the four knowledge modes (see Table 1 above). This helped the participants identify various issues from diverse perspectives beyond their own specific knowledge area. These were subsequently broken down into more specific component problems which, in turn, helped inform the discussion on research priorities for university-industry collaboration. The level of discussion ranged from macro-scale, such as national policy constraints and broad-industry enforcement challenges, to the micro-scale, such as specific localized issues only relevant to a particular place.

At the conclusion of this discussion individual groups were asked to consider the most pressing themes from the list of fifteen to be taken forward for further discussion. Dependent on factors that include stakeholder bias, knowledge and interpretation of the themes, the fifteen themes were subsequently reassessed, regrouped and prioritized into seven major themes: 1) environmental change, 2) freshwater pollution, 3) infrastructure, 4) water resource management, 5) governance 6) stakeholder engagement, and 7) cross-cutting themes. These seven thematic priorities were subsequently taken forward as the basis for the framework for research collaboration (see section 5).

It must also be acknowledged that putting into practice a framework of university-industry collaborations, such as proposed in this paper cannot be implemented in isolation of the distinct national, state and local political, social and economic interests and realities that characterise the water industry. As with any industry and sector, tensions exist between different parties and agencies which can influence the success or failure of any kind of collaboration. Despite these challenges, this paper elucidates a way forward which harnesses the relative strengths of different stakeholders towards a common goal, irrespective of the diverse and potential opposing

political perspectives and interests. In the case of the Malaysian water industry, examining how this framework could be implemented in the current political, social and economic context is an area for further research to be taken forward.

A FRAMEWORK FOR FUTURE UNIVERSITY-INDUSTRY COLLABORATIVE RESEARCH IN THE MALAYSIAN WATER INDUSTRY

As set out in the Introduction, developing meaningful research collaborative initiatives between industry stakeholders and academia may be critical to achieve more integrated, optimal and sustainable policy directions in the Malaysian water industry. Such a change might be needed to more effectively address a range of related issues and challenges ranging from the smaller, more localised issues to more complex or 'wicked problems'. Therefore the formulation of an organised plan for industry-related research and development is an important issue. The approach as described above has set out a logical and organised method of identifying research needs and concerns relevant to specific stakeholder groups and knowledge modes which address the wider needs of the industry.

Table 2 outlines how a range of research questions might reflect interdependent yet also distinct relationships to the water industry or sector as a systemic whole. Just as a 'wicked problem' approach might be broken down into interdependent yet distinct challenges and issues, so too these supporting industry-based problems might be most usefully translated into relevant focus questions to depict multi-disciplinary applications for a convergent or interdisciplinary academic framework of collaborative research. Table 2 further links a suggestive as well as comprehensive framework of interdisciplinary research questions corresponding to a complex problem consisting of the thematic priorities identified in the seminar feedback session. It is a sample set of questions and not meant to be definitive. Also whilst the generic framework has universal transferability the particular configuration outlined here remains particular relevant to the local Malaysian context.

Table 2

Research Priorities Framework for the Malaysia Water Industry

Research Theme	**Stakeholder Perspectives**	**Knowledge Management**	**Modes of Knowledge Science and Technology Innovations**	**Environmental Adaptation**
Environmental Change	- How are different stakeholders affected by changes in environmental conditions?	- How to bring together macro and micro level research agendas on environmental change?	- How effective are current water demand forecasting techniques, and what developments are needed to better improve accuracy and address changing drivers of, and controls on, water demand?	- What kind of extreme events are expected as a result of environmental change?
Freshwater Pollution	- How are community stakeholders affected by freshwater pollution?	- How can the useful outcomes of past research activities into pollution control be introduced as standard industry practice?	- Considering extensive past research activities into freshwater pollution control, how can current technologies be improved or adapting? (i.e. is it a question of affordability?)	- How is freshwater pollution likely to be affected by changes in economic and environmental conditions?
Infrastructure	- How can stakeholder consensus be built around the issue of infrastructure i.e. non-revenue water?	- What standards and policies need to be introduced to improve infrastructure?	- What technologies could assist industry reduce non-revenue water (NRW) and how can experiences of other countries inform technological improvement?	- How is water infrastructure likely to be affected by changes in economic and environmental conditions?

(continued)

Research Theme	**Modes of Knowledge**			
	Stakeholder Perspectives	**Knowledge Management**	**Science and Technology Innovations**	**Environmental Adaptation**
Water Resources Management	- How can stakeholder consensus be built around the issue of water resource management?	- What policies need to be introduced to assist with a move towards water demand management?	- What demand management technologies and approaches can be implemented in the Malaysian context?	- How are water resources likely to be affected by changes in environmental conditions?
Governance	- How can community level organizations be better integrated into current water governance regime?	- How can improvements in current water policy be implemented and enforced?	- Are there any products or tools that could be developed to assist in water governance and policy setting?	- Is current water governance and policy adaptable to changes in environmental and economic conditions
Stakeholder Engagement	- How to effectively engage different stakeholders in the catchment to allow different positions to be viewed and consensus reached?	- What policies need to be implemented to allow meaningful stakeholder engagement in water industry decision making?	- Are there any products or tools that could be developed to assist in improved stakeholder engagement?	- How to ensure stakeholder activities in water industry emphasize the changes in environmental and economic conditions in the future?
Cross cutting	- What forms of public awareness campaigns should be explored in the industry as a whole?	- How can policy makers, regulators and practitioners improve the flow of knowledge to scientists to ensure adequate pre- and post-monitoring of new policies?	- What tools and products may be of use across the whole industry?	- What are the financial costs to the water industry if there is no action taken to mitigate and adapt to climate change?

CONCLUSION AND NEXT STEPS

Applying an interdisciplinary framework to the Malaysian water industry, this paper has sought to develop an effective means to address various complex problems around seven priority themes: climate change, pollution, infrastructure, water resources management, governance, stakeholder engagement and cross-cutting. This paper has explored an alternative paradigm which might harness an interdisciplinary framework of both internal university collaboration and engagement with various industry stakeholders. It has done so across a spectrum of challenges and issues – typically extending from management and human resource challenges on one hand and the need for science and technology innovation on the other – which make up the authentic 'wicked problems' which confront government, business and wider society.

Over the course of a workshop exercise, water industry stakeholders were led through a problem solving methodology for university-industry collaboration. The outcome was an agreed interdisciplinary framework and a series of indicative priority research questions. Whilst the research questions reported in the framework are not definitive, it provides a sensible platform to build upon and also an example of what can be achieved through collective discussion. It is recommended that in order to develop the framework further, additional stakeholder engagement exercises be undertaken. Small group sessions with select stakeholder types – e.g. water and wastewater operators, government agencies, civil society groups, consultants and academics – could be undertaken to develop a more comprehensive set of priority research questions. This in turn could be presented to the water industry authorities (e.g. the Malaysian Water Association) to demonstrate the possible future direction of university-industry research collaboration.

Finally, this paper has focused specifically on the context of the Malaysian water industry; however, considering the general nature of the approach employed in the development of the framework, it is argued this approach is useful to water and non-water related industries and sectors, in and beyond Malaysia. In short, the interdisciplinary problem solving framework can be applied to a range of micro and macro scale 'wicked problems' that are increasingly faced by business, government and society in modern times.

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