Proceedings of the Global Conference on Global Warming-2009,
July 5-9, 2009, Istanbul, Turkey

A MULTI-SYSTEM CLIMATE CHANGE ADAPTATION APPROACH FOR WATER SUSTAINABILITY IN REGIONAL AUSTRALIA

Antuaned Perdomo, Omar Hussain, Tharam Dillon and Elizabeth Chang

Digital Ecosystems and Business Intelligence Institute
Curtin University of Technology, Perth, Australia
e-mail : { T.Perdomo, O.Hussain, Tharam.Dillon, Elizabeth.Chang}@cbs.curtin.edu.au

ABSTRACT

Climate change represents the possibility of losing the quality and quantity of the existing ecosystems around the world. While dealing with the risks caused by climate change, we need be aware of the various vulnerabilities across the different ecosystems or biodiversities on planet Earth. In order to mitigate these impacts, the process of adaptation across each ecosystem is important. But the process of adaptation and mitigation of the effects of climate change has to be carried out at a regional or local level. The challenge at this level is not only to assess vulnerabilities and risks to each ecosystem, but to develop policies to adapt so as to achieve sustainability. In this paper, we focus on the ecosystem of water and study the different impacts on it from the perspective of regional Australia. We then propose a digital ecosystem-based architecture in a multisystem approach which can be utilized for the process of water sustainability adaptation in Regional Australia.

INTRODUCTION

The world is currently facing a series of issues arising from climate change. The International Panel on Climate Change (IPCC, 2008) defines climate change as the change in the state of climate that can be identified by the changes in the main (and or the variability) which exists for a persistent period of time (IPCC, 2009). It is one of the effects of global warming. Its importance arises from its ability to impact on the existing ecosystems, human activities, health, economy, and all aspects of human life and on Earth's equilibrium. In the recent climate change conference hosted by the University of Copenhagen in March 2009, there were six key messages (Climate Change Global Risk, 2009). They are:

1. The changes in the climatic trends are worse than expected.
2. Some societies are highly vulnerable to even modest levels of temperature increases above 2^{o}C.
3. Effective coordinated global and regional action is required to avoid dangerous climate change.
4. The adaptation to climate change should be according to the level of social exposure and impacts on the people.
5. There is no time to waste. Action needs to be taken immediately.
6. Opportunities that arise should be seized. Educate and encourage the public and government to take action against climate change.

There are two major sets of strategies that need to be adopted in order to deal with climate change and issues arising from it. The first deals with trying to reduce the causes of global warming such as reducing carbon load. The second deals with trying to mitigate the impacts of climate change on different ecosystems and adapt by reducing the weaknesses at the local level. This paper concentrates on the second set of strategies. While dealing with the risks caused by climate change, we need to be aware of the diverse vulnerabilities in specific areas of human societies and ecosystems. Evidently, the effects of climate change are already creating damage in the human settlements and ecosystems; in some cases it will be near impossible to avoid some level of climate change impact. It is possible that in some cases we will not be able to avoid large and costly impacts. But in others, the magnitude of these impacts can be tempered only by our level of adaptation and efforts at international cooperation. But in spite of the different global impacts and consequences of climate change, the approach for adaptation and mitigation has to be done at the regional and local level. In other words, it should be a bottom up approach and not a top down one. Identifying and addressing the impacts of climate change at the regional level will eventually result in managing them at the global level. This is because the vulnerabilities to climate change vary according to the specific region in question and subsequently they must be addressed accordingly. The challenge is not only to identify the vulnerabilities at the local level, but also to develop strategies by which the correct strategies are prepared to face them. This will guarantee the sustainability of the different ecosystems in general and maintain our dependence on them. Sustainability is defined as the preservation of the important ecosystems over time, irrespective of the different challenges and scenarios that may occur.

Climate change represents the possibility of losing quality and quantity of resources, especially when the population is increasing and the resources are limited. In such scenarios, adaptation to climate change cannot be done without generating natural and artificial conditions that allow the ecosystems to strengthen their capacity for resilience to face their vulnerabilities. So for having an effective process of adaptation to climate change specific to a region, all the inter-related dynamics between various factors should be considered. We term such a relationship as the 'Multisystem'. The multisystem varies according to the complexities of the multi scenarios across the specific regions. The dynamic complexity of multi scenarios creates a system in itself which is particularly different according to the regions and local characteristics. So before carrying out the adaptation process in a specific region, it is important to study the multisystem to understand the interconnection and interdependence of the environment, human activities and other different factors in the specific region. In this paper, we aim to study the process of adaptability in one ecosystem, namely water. We aim to study it by taking into consideration the multisystem dynamics associated with it according to the perspective of regional Australia and then identifying the different impacts on it as a result of climate change. We will then study the different factors that need to be considered and studied, and then propose a digital ecosystem-based architecture which can be utilized to achieve water sustainability in Australia in the presence of the challenges posed by climate change. The paper is organized as follows.

MULTISYSTEM DYNAMICS

The human evolution in association with the different existing systems has resulted in different complex factors, interactions, synergies and dependencies within them. Adaptation to climate change requires studying the different factors in great detail in order to understand the complexity which requires a holistic view, and analysis. In reality, the complexity cannot be limited to sectors and, in such scenarios; a multisystem approach is needed to best cope with these requirements. A multisystem is defined as the long term dynamic interaction between the natural, artificial and abstract systems. It is a dynamic self-created system that is a combination of evolution, rules, behaviours, interactions, elements. Natural Systems involve all Earth and universe systems. This exists by itself as a result of centuries of evolution, but this system's equilibrium is in serious danger from anthropogenic actions. Bio-diversity is a dynamic complex of plants, animals, microorganisms and biological diversity (Millennium Ecosystem Assessment, 2005) into the Earth's system. The environment system is defined as living and non-living elements which are a part of the natural system, such as water, air etc. The Artificial System involves the systems created by humans in their interaction and adaptation within them and the natural system across time. This system involves matters such as economy, technology, culture, etc. An Abstract System involves the maximum expression of cumulative socio-political, science and artistic knowledge that impact on human evolution and develop across time. .Fig. 1 shows the classification of natural systems, artificial systems, abstract systems and the dynamic interaction between them, thus creating a multisystem dynamic relation. It does not represent a hierarchy of levels between these systems. The evolution and interaction between each of the systems change for almost every part of the world on the regional or micro level. This is because of factors such as the time, the size of the population, technology, culture and values etc. A dynamic multisystem assessment of a particular region will give the regional and local vulnerabilities specific to an ecosystem and region. This is an important step that is required in the process of climate change adaptation. The vulnerabilities at the regional and local levels have to be determined in dimensions such as physical, environmental and structural forces The impact on an ecosystem from climate changes depends on the process of adaptation, mitigation and action against the factors which harm it. Implementing such adaptation policies will result in the strengthening of ecosystem resilience capacity. The vulnerabilities have to be identified over a considerably long period of time as it is possible that some of them maybe apparent only after a period of time or may involve thresholds which are difficult to measure.

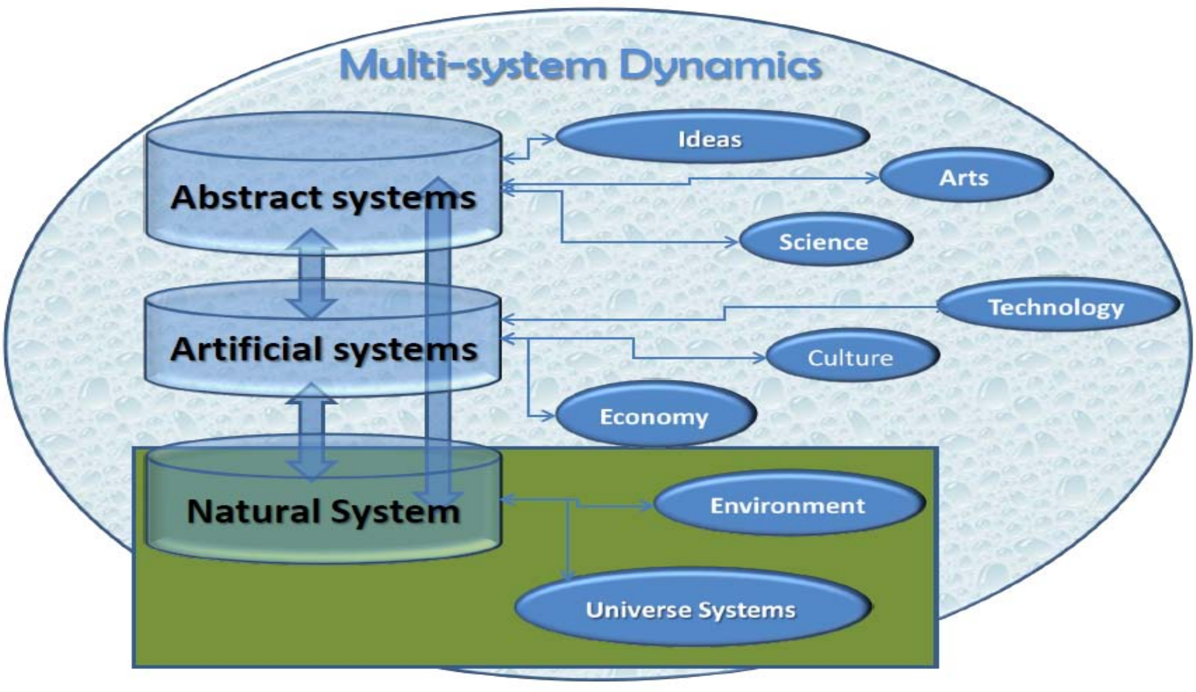

Fig.1. Dynamic Multisystems

Each element of the multisystem plays an important role in affecting the other elements, creating interdependent dynamics across them. The variation in one element of the multisystem impacts on other elements, resulting in a chain of impacts across the different elements of the multisystem. But the continuous stressor in these dynamic reactions and changes are the actions of humans or the consequences of past actions or even the relations between elements, generating a mutable multisystem. The intentional or non-intentional interventions of human beings with the multisystem will result in an ecosystem. According to (Chang et al., 2006), an ecosystem is defined as a loosely coupled, domain-clustered environment where each species conserves the environment and is proactive and responsible for its own benefit. From the climate change perspective, we define an ecosystem as the humans' interaction with the multisystem dynamics and the natural existent systems for their own benefit. A natural, existent system would include biodiversity (living elements) and environment (both living and non-living elements). For climate change adaptation purposes, it is important to represent biodiversity and environment as special elements in the multisystem and Earth system as shown in Fig. 2.

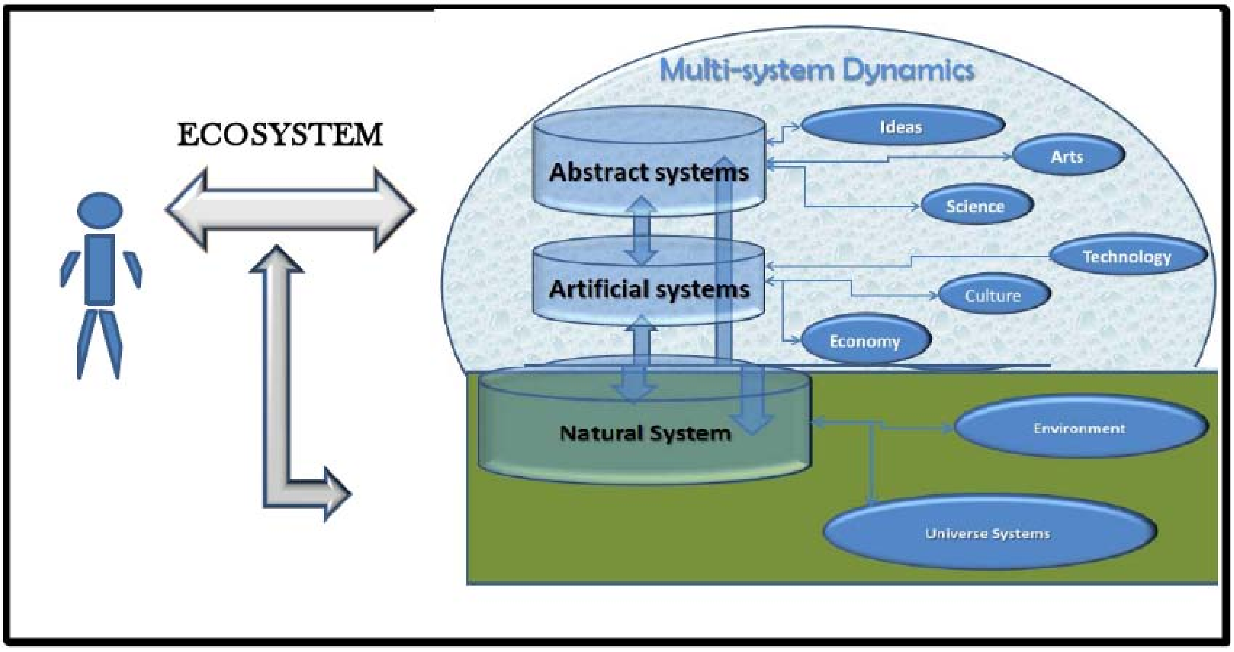

Fig. 2. Ecosystem

An ecosystem is the relation between the species (human and its well–being) and the multi system in their own context and surroundings, like environment (air, water, rocks), bio diversity, its relations with animals, microorganism, etc, and its relation with artificial and abstract systems as well, as part of their development in this approach. All human or natural actions that take place into the ecosystem are cyclic. In other words, each action may result in a future benefit or harm on the same ecosystem or in different multi system dynamics. For this reason, is necessary to approach the multisystem in a dynamic way. Doing so helps to understand the different inter-related factors and help to carry out the process of monitoring and evaluation accordingly. In others words, it helps to understand the different alterations in the ecosystem and the consequences in others elements in the multisystem. For example: An aquaculture farmer may gain material benefits from management practices that increase soil salinity and thereby reduce rice yields and threaten food security for nearby subsistence farmers (Millennium Ecosystem Assessment, 2005). The impact of climate change depends on the level of adaptation, mitigation and action that are adapted in the region. Furthermore, the effect of the adaptation policies associated with any change may be slow to become apparent. So while studying the effects of climate change related to an ecosystem from the dynamic multisystem perspective, it is necessary to study it in great detail and identify the different factors along with their severity. According to the determined analysis, steps for adaptation can be developed and implemented.

One of the most important ecosystems on the planet Earth is water. The approach to a water system at the regional level based on multi system dynamics is needed due to its importance to all human well-being, economic activities and Earth's equilibrium. In the next section, we will discuss the importance of water on planet Earth and then examine it from the Australian perspective.

EFFECT ON WATER DUE TO CLIMATE CHANGE IN REGIONAL AUSTRALIA

Water is an important substance that is essential for the existence and sustenance of almost all forms of life on planet Earth. It is also an important substance for industrial ecosystems to survive and achieve their objectives. It is utilized by every living being on the planet directly or indirectly in some way or other and hence, is vital for the sustenance of civilization in the world. Apart from that, it is home to some of the world's most popular biodiversity ecosystems and coral systems and to different species of marine life. Its absence will have serious consequences and impacts on the different living ecosystems and dependent ecosystems the world. Water is present on planet Earth in the form of natural springs, lakes, rivers, oceans, and underground water. It is also provided by precipitation from the sky in the form of rain, snow etc. It is also one of the ecosystems whose sustenance is being adversely affected by global warming both globally and regionally. And, as is the same for other ecosystems, the effects of climate change on water vary according to the specific geographic location in question, and subsequently the process of adaptation that needs to be carried out in a region; should be according to the impacts on that particular region.

Australia is a large country that spans across several latitudes and therefore has marked variations in climates. It is the driest inhabited continent on Earth with the world's highest consumption of water (CSIRO, 2009). The patterns of rainfall are highly variable and its climate is strongly influenced by the surrounding oceans. It is particularly exposed to water related risks and hence needs policies which it can adapt to counter them to ensure its sustainability. The different possible scenarios by which the sustainability of water may be affected due to climate change are:

1. Decrease in the quantity of the normal rainfall
2. Increase in the quantity of exceptional rainfall
3. Changes in the average atmospheric temperatures
4. Increase in the sea levels
5. Salinity in ground water reservoirs

Ignoring the effects of climate change on water will have a snowball-like impact on the various other ecosystems that are dependent on it. This includes ecosystems like human, health, agriculture, industry, and environment. In Table 1 we study the different impacts on the different ecosystems due to the various effects of climate change on the ecosystem of water. The impacts that we discuss are not comprehensive and there are many other effects possible from the discussed scenarios and the other types of identified scenarios.

Table1. Impacts on different ecosystems due to climate change

	Volume of water in catchment areas	Quality of water in catchment areas	Establishments	Health Human ecosystems Marine ecosystems	Agriculture	Industry	Ecosystems
Decrease in the quantity of normal rainfall ✓ **Drought**	✓ Reduction in soil moisture Increased demand in supply	✓ Contamination of reservoirs due to fire debris Salinity of water being increased	✓ Increased pressure on sustainability Reduction in the hydro power generation Increase in the economic costs	✓	✓ Land degradation Effect on the yield of the crop yields Soil Erosion	✓ Disruption in their day-to-day activities leading to economic crisis	✓ Increase in the risks of fire
Increase in the precipitation levels ✓ **quantity of exceptional rainfall** ✓ **Cyclones** ✓ **Tropical rains**	✓ Risk of decommissioning a dam if the quality of the water degrades	✓ Risks of contamination	✓ Disruptions in their day-to-day operations which affects the economy Increase in the economic costs	✓ Risks of infectious diseases	✓ Damage to crops Soil erosion	✓ Disruption in their day-to-day operations Increase in the economic costs	✓
Increase in the temperatures ✓ **Warm spells** ✓ **Heat waves**	✓ Increase in evaporation Increase in water demand	✓ Risk of algae blooming Increase in the salinity of water.	✓ Increase in energy demand Increase in the economic costs	✓ Increase risks of heat related illness Increase risks on marine life	✓ Reduction in crop generation	✓ Increase in the economic costs	✓ Increase in solar radiation
Rise in the sea levels	✓	✓ Decrease in fresh water availability	✓ Huge consequences depending upon the spread of population in Australia	✓ Increase in the infectious diseases	✓ Salination of water	✓ Disruption in their day-to-day operations	✓ Disruption in the costal ecosystems

A review of water management practices and policies is needed in order to cope with the multisystem impacts across all the ecosystem synergies and equilibriums. An understanding of the hydrological system and how it relates to the regional and local vulnerabilities is required in order to address these in a comprehensive multisystem adaptation to climate change. Water issues need to be treated in a systematic way in relation to multisystem dynamics and ecosystem interactions. We should stop managing water as a sector with separate uses, and instead develop a comprehensive framework for water resources management. It is critical to have some coordination between different sector users, if this architecture is to be sustainable. Land use and water policies and management need to be linked, and physical and institutional infrastructures must be complementary. In order to have a comprehensive process of adaptation, it is imperative that all the different possible scenarios that will affect the sustainability of water be considered and investigated carefully. The output of this investigation should represent the comprehensive list of impacts that could be experienced across the different ecosystems, from all the possible scenarios. This list should be communicated to the decision-makers who will then develop policies by which the identified impacts can be countered and their effects alleviated or minimized. The major issue that needs to be addressed for sustainability is the quality and quantity of water in such testing times ahead, in order to support the various ecosystems and civilizations that are dependent on it. In the next section, we will study these factors for achieving the sustainability in the ecosystem of water.

FACTORS TO BE ASSESSED FOR ACHIEVING THE SUSTAINABILITY OF WATER IN REGIONAL AUSTRALIA

The three important factors that must be considered in the process of adaptation for water sustainability are:

a) ensuring that sufficient quantity of water is in the reserves;
b) ensuring that the quality of water is maintained beyond a certain level of threshold; and
c) maintaining an equilibrium with other systems.

Quantity of Water

The climate change reports (Garnaut, 2008), (Australia Greenhouse Office, 2003) state that the amount of rainfall will decline abruptly in Australia in the coming years, especially in western and south-western Australia, and in less concentration over the southern part of Victoria. This in turn will have an effect on the various other factors dependent on it, like vegetation, agriculture, food availability, floods, droughts, human settlements, infrastructure, agriculture, hydropower, drainage, irrigation, biodiversity, health, and human well-being. In addition, stressors such us population growth, environmental activities and policies, land use changes, urbanization, pollution, destruction of natural biodiversity, deforestation, increase the regional vulnerabilities and risks. Rainfall is one of the primary sources by which water is obtained and then stored for later use in catchments areas or reservoirs. Subsequently, with the expected decline of the rainfall in the coming years, water management becomes a major issue that demands immediate attention for adaptation in Australia. The main issue that needs to be addressed in this area is the 'sustainability' of water in such testing times ahead, in order to support the various ecosystems and civilizations that are dependent on it. Sustainability of water is achieved by ensuring that a) sufficient volumes of water are present in the catchment areas by which the demand of various sources can be met, and b) the available water is spent in a conservative manner. Approaches have been taken by the water departments across different states of Australia to encourage different users to reduce their daily water consumption. Levels of water restrictions have been developed whose numbers vary in each state. Each level has a comprehensive list of activities that are prohibited according to the quantity of water which they consume. Various other initiatives have been proposed by the local state governments which provide the users with financial incentives for buying water-saving devices. However, the adoption of measures to conserve water helps to achieve only a part of the solution towards ensuring the sustainability of the water. The other considerations are to ensure that the quality of stored water is maintained beyond a certain threshold level.

Quality of Water

Maintaining the quality of water stored in the reservoirs or catchment areas is an important measure to ensure that sustainability of water is achieved. Having desirable levels of quantity, but with low levels of quality defeats the whole purpose of having sufficient volumes of water. Further, due to global warming, the extremes of weather like storms, floods and bush fires are expected to increase all across Australia. Each one of these outcomes has the potential to pollute and contaminate the water stored in the catchment areas. For example, an increase in floods may result in the reservoirs becoming a breeding place for mosquitoes which would lead to infectious diseases within the human ecosystems. On the other hand, ash and debris as a result of bush fires result in contamination that would make the water from the catchment areas unsuitable to drink. This was the scenario experienced in the state of Victoria in February 2009 where, due to bushfires, five of the Melbourne's major nine dams were affected; and Melbourne Water had to transfer 1.3 billon litres of water from the Upper Yarra Dam to Cardinia Reservoir to prevent the water from becoming polluted (Ker, 2009). Also the chances of Maroondah and O'Shannassy dams (which holds 12% of Melbourne's water supplies) being decommissioned were high after they were affected the most due to the bush fires (Ker, 2009). The water catchment areas may also be affected by an increase in the salinity of water and the blooming of the algae which produces serious health hazards to the human species. So steps needs to be taken by which the quality of the volumes of water in the reservoirs or catchment areas are maintained beyond a certain level.

An important factor to be considered is that the process of adaptation is not a one-off process but is iterative. Subsequently, the process of adaptation too should be iterative and vary according to the severity of specific factors on hand. For example, according to the third assessment report of IPCC on climate change, the sea levels were expected to rise by 18-59 cm (IPCC, 2001) by the year 2100 due to the increase in temperatures. But in the recent climate change conference in Copenhagen, the estimated figure by which the sea levels will rise by 2100 has increased to at least 1m (Climate Change Global Risk, 2009). With such an increase, the policies of adaptation that were developed keeping in mind the first figure will not be of significant use to reduce or alleviate the rise in sea levels at the current rate. So policies need to be re-developed and re-adapted so that they address this specific factor according to its current state. The process of adaptation is carried out for alleviating or minimizing the risks to the sustainability of water due to the climate change. So in other words, the process of adaptation can be termed as the process of risk management to ensure the sustainability of water. In order to have an efficient process of risk management, it is imperative that the prerequisite steps which are, vulnerabilities assessment, risk identification and risk assessment be completed first. This is done by carrying out a comprehensive risk analysis whose steps are:

1. determining the probability of occurrence of the identified risk events, and
2. determining the impact of occurrence.

The probability and impact of occurrence of the identified risk events determine the severity of the adaptation process. For example, there might be some factors whose severity of impact on the sustainability of water is high, whereas there might be some factors whose severity is low. The process of adaptation should be carried out accordingly. Such an analysis of the various risk events is achieved by carrying out simulations in the real world.

So, in order to have a detailed and comprehensive process of adaptation, all the risk factors along with their possible impacts have to be investigated in detail by using simulations. Furthermore, the determined analysis and results should be demonstrated by using a portal as it will educate people and increase their awareness. What we need is to develop a digital ecosystem which can be utilized to capture all the relevant micro factors of climate change and study their level of occurrence. Based on that analysis, the digital ecosystem should be able to determine their effects on the ecosystems of water by considering the different multisystems by using simulations, and then develop risk mitigation policies according to the specific region in question. In the next section, we will give a brief overview of our proposed digital information infrastructure ecosystem which can be utilized for capturing, assimilating and representing the relevant information related to the ecosystem of water.

A DIGITAL ECOSYSTEM ARCHITECTURE TO SUPPORT AND UNDERSTAND MULTISYSTEM DYNAMICS FOR ADAPTATION TO CLIMATE CHANGE IN WATER

One of the main factors to be considered when developing an information ecosystem infrastructure for multi-system adaptation is that it should track and visualize the different risk factors on water arising from global warming. This will require effective data capture, gathering, storage, analysis and processing of this information in a way that preserves its semantics. To achieve this, we propose to develop a digital ecosystem-based architecture as shown in Fig. 3. The proposed architecture will take as inputs the different types of information from different sources and will utilize it to simulate and determine the effects on the ecosystem of water.

1. Collecting information from different sources,
2. Annotating and storing the information while ensuring their integrity is maintained,
3. Functionalities to simulate and process the information according to the desired outputs,
4. Effective visualization and representation of information taking into consideration different levels of geographic locations' granularity and the specific factors to be represented depending upon the specific location,
5. Development of risk mitigation and adaptation techniques for addressing micro effects of climate change, specific to the ecosystem of water,
6. Aggregation of the different micro effects to compute and simulate the various macro effects of climate change,
7. Development of risk mitigation and adaptation policies for risk management in the ecosystem of water due to the effects of global warming.

The main features of the proposed digital ecosystem architecture are:

- **Real time data gathering.** This is an essential step for the process of risk assessment, adaptation and mitigation. Having real time data will help to develop policies to react in time and to self learn the flexibility to reassess strategies in the multisystem dynamics detected at the local level. Sensors, direct observation, net communication, and social networks can be some of the areas from which inputs are obtained.

- **Data quality and integrity**. The collected information forms the source from which different computations and simulations will be performed. So care has to be taken that its correctness is checked and its integrity and semantics is maintained and preserved. This is done by annotating and structuring the information in an ordered way or according to a pre-defined standard format by which it can be classified easily at a later stage.

- **Social and human aspects.** The assessment of human well-being and needs in vulnerability in each region, can affect the availability of human resource for the installation, sustainability and self learning process.

- **Simulations and modeling.** Simulations help to determine and model the different impacts that could be experienced over a given period of time. But while doing so, it may be necessary to aggregate, composite and transform the information. The integration of the different type of information should be dynamic in order to obtain the required relevant information from different repositories. The visualization of the dynamics, process and results are necessary for community understanding of the changes and possible scenarios of adaptation and mitigation, as well as the impact of climate change integrated within the dynamic system synergy relations. Modeling a digital ecosystem infrastructure requires high level models with comprehensive data, more sophisticated analyses, improvements in understanding of the process and dynamics within the multisystem, and extensive exploration in real time data of observation in uncertainty factors or interaction that is difficult to measure or which is not yet very clear in some regions.

- **Representation of Information according to different levels of abstraction**: The computed information may need to be accessed by a variety of people from different domains such as environmental scientists, regional managers, decision makers and policy formulators at both regional and national levels. Each of them may require the processed information to be displayed at various granularities of detail and hence, presentation of the information is a vital issue. For easy understanding and better education, it is important that the digital ecosystem have the functionality to represent the computed information at different levels of abstraction. This will help the computed information to be represented according to the end users' requirements, depending upon their level of expertise. To account for the composition of the processed information and services combined with information visualization and animation at distributed sites, it is necessary to have a digital ecosystem that employs service oriented architecture through semantics, ontologies and targeted markup languages.

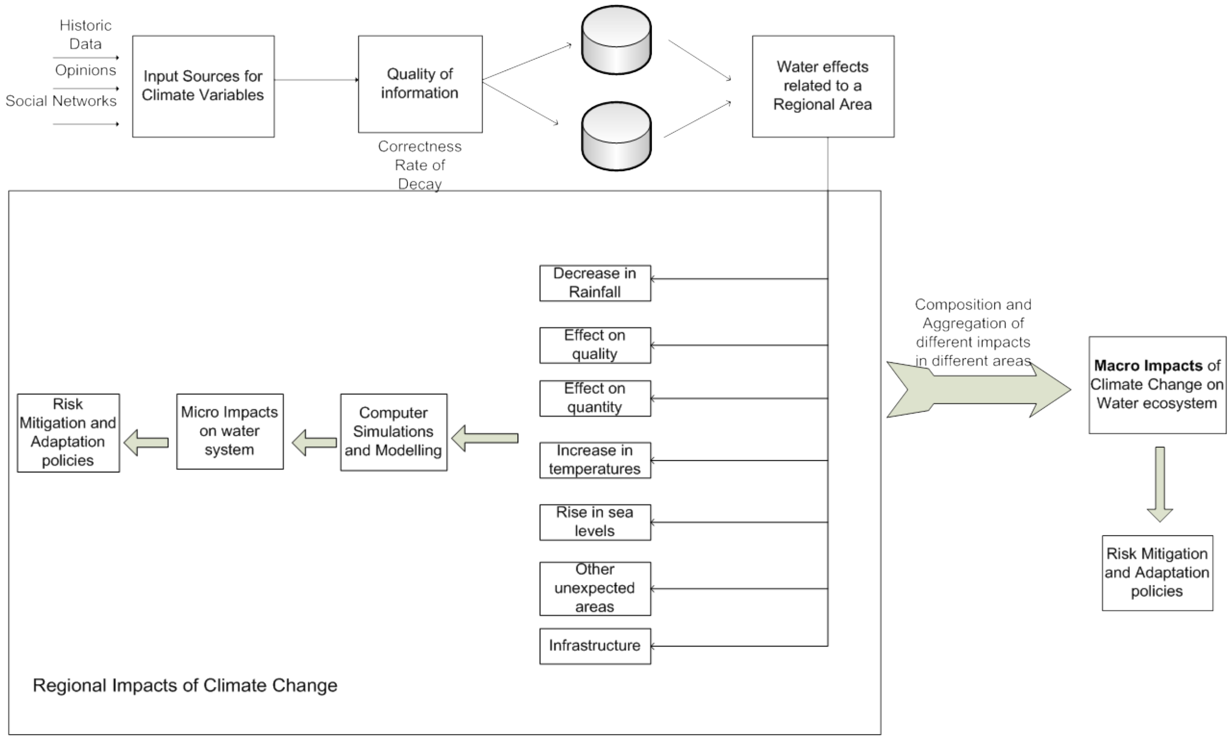

Fig.3. Digital ecosystem architecture for adaptability of climate change in Water

- **Open access for users.** Digital Ecosystem architecture should be installed with open access to users and specifications, free use of standards and not dependent on one single actor. (Digital Ecosystem Vision, 2005)

The proposed digital ecosystem architecture is based on a social network approach for identifying, assessing and modeling the impacts on the ecosystem of water as the result of climate change. Real time monitoring by using satellites and sensors is an effective approach for having a reliable process of risk assessment, but high temporal resolution via satellite to regional areas is often technically expensive. As a result, it is very difficult to have an analysis and apply it to all different locations, especially in developing and remote areas. Although the benefits and advantages of utilizing real time analysis is the best solution for facing the threats of climate change, alternatives too have to be considered due to financial and infrastructure concerns. This is achieved by the proposed digital ecosystem architecture for climate adaptation that uses different possibilities for inputs like real time data analysis, historical data, blogs, wikis, personal opinions etc. The simulation and projection of the future data could provide a very good understanding of the future system scenarios. This will help to develop policies according to these dynamics and can be utilized for different locations under the same or similar conditions. Multisystem information across the portfolio has to be taken into consideration for the adaptation scenario in sectors including infrastructure, resource management, social and politics behavior, institution, communication and financial. These sectors are not mutually exclusive and usually overlap in the occurrence of an event. The importance of an early reaction to an event can not only mitigate the impact in one region, but can also create opportunities for other regions, for example maps of coincident floods and droughts in a relative closer locations. The adaptation to climate change has to involve new flexible and smart technology based on multisystem dynamics, with the capacity to regenerate itself and integrate with the physical and social systems. The digital ecosystem approach can explore in detail the measurable variables in the multisystem dynamic and their real time behavior in relation to the forces of anthropogenic and climate change at the local and regional level. It can then integrate this multi analysis in whole regions for achieving a better global understanding of the water ecosystem sustainability, self learning process and an understanding of the various weaknesses in the resilience capacity for adaptation to climate change. The proposed digital system architecture can be utilized to develop an “Early Warning System” which can be utilized to mitigate the impacts of climate change on the ecosystem of water and on human settlements. The proposed ecosystem can be utilized to create an easy understanding of the possible future scenarios by using simulations. These can be utilized to develop policies by which current or future similar events in different locations can be managed and averted beforehand, under the same or approximate conditions. The importance of early reaction to, and avoidance of an event, can not only mitigate the impact on one region, but can also be beneficial across regions in other ecosystems. However, in order for the developed policies to be successful and easily adapted, it is necessary for the ecosystem to represent in an easily comprehensible manner the impacts and the necessary adaptations to be made.

CONCLUSION

As mentioned in the IPCC report scenarios, there are recent observations which confirm that the worst-case scenarios have becoming real. There is a significant risk that many trends will accelerate during the period of time for which the impacts have been predicted - abrupt risks, irreversible climate shifts, affecting long-term social and economic costs will occur much sooner. We have no excuse for not acting immediately to implement adaptation. The existing technology, knowledge and research is sufficient for us to utilize and implement ecosystem rehabilitation and decarbonise economies. In this paper, we highlighted the importance of climate change adaptability and then studied its effects on the ecosystem of water. We defined what a multisystem is and then studied its relationship with an ecosystem. We highlighted the micro impacts of climate change on the ecosystem of water and identified the different factors that need to be studied. We then proposed a digital ecosystem architecture which can be utilized to study the different risk factors and develop policies to adapt them by which sustainability in the ecosystem of water is achieved. In our future work, we will concentrate on utilizing the proposed digital information ecosystem for developing adaptation strategies in order to ensure water sustainability in regional Australia.

REFERENCES

Peter Ker, "Dash to save Melbourne's drinking water," The Age, Ed., 2009.

Grafton, R. and D. Paterson., 2007. *Water trading and Pricing. In Managing Water for Australia*, CSIRO, 78.

Johnson, M. and S. Rix., 1993. *Water in Australia. Managing Economic, Environmental and Community Reform*, PlutoPress. 166-184.

Copenhagen, 2009. Climate *Change Global Risks Challenges & Decisions, "Rising sea levels set to have major impacts around the world"*.

D, Bachelet. The Proceedings of the 8th Annual International Digital Government Research Conference, 2007 *Global Climate Change Implications for Digital Government Research*, Keynote Panel.

E, Chang and M, West, 2006. *Digital Ecosystem a next generation of the Collaborative Environment*. Proceedings of iiWA2006.

Hogan, Daniel and Marandola E, 2005.*Towards an Interdisciplinary conceptualization of vulnerability*. Population, Space and Place. Wiley InterScience.

The Digital Ecosystem Research Vision: 2010 and beyond. 2005. Creative Commons Attributions-ShareAlike Licence.

Australian Greenhouse Office, 2003.*"Climate Change: An Australian Guide to the Science and Potential Impacts," Climate Change Global Risks Challenges & Decisions,* 2009. "http://climatecongress.ku.dk/,"

Garnaut Climate Change Review. Draft Report. 2008. *The Impacts of Climate Change in Australia.*

Gleick, P. and J. Morrison, 2006-2007. Water Risks that Face Business and Industry. In *The World´s Water, The Biennial Report on Freshwater Resources* eds. ISLANDPress.

Intergovernmental Panel on Climate Change, 2009."*Climate Change and Water IPCC Technical Paper VI"*

Intergovernmental Panel on Climate Change, 2008. *"Climate Change and Water"* .

Intergovernmental Panel on Climate Change, 2001.*"IPCC Third Assessment Report: Climate Change 2001"*

Land and Water report. 2007. *Stakeholders´ perspectives on Australia´s land and water resources research needs. CSIRO.*

Millennium Ecosystem Assessment, 2005. *Ecosystem and Human Well-being: Biodiversity Synthesis*, World Resource Institute, Washington, DC.

Ross Garnaut, 2008."*The Garnaut Climate Change Review",*. Technical Paper IV of IPCC 2007. *Climate Changes and Water.*

Water Reform Implementation Committee. December 2006. *A blueprint for water reform in Western Australia*. Government of Western Australia.