CONJUNCTIVE MANAGEMENT OF SURFACE AND GROUNDWATER RESOURCES

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ABSTRACT

Management of the conjunctive use of surface and groundwater resources is essential, as the combination of these two water resources result in huge advantages for the quality of water, irrigation and economic benefit for the farmers and country. The advantages of proper conjunctive management not only secure the availability of water in the whole year but also can be utilised to provide safer potable water for humans. However, it is not an easy thing to manage both resources since they face several challenges and causes conflict because the nature of surface and groundwater resources is very far different. Furthermore, in order can be used as a safe drinking water then the water resources have to be managed free from contaminants and pollutants. In term of economy, better irrigation system could increase the quality and the quantity of crop's harvest, make the soil more fertile and productive, and elevate horticulture and viticulture industries. All these things are very essential not only to increase better lives of farmers but also lead to many economic gains to the nation.

Key Words: conjunctive, management, water resources, irrigation, economic benefit

INTRODUCTION

Surface and groundwater resources need to be managed conjunctively to ensure they can fulfil and meet national objectives of water use in Australia. Basically it is not easy to manage both resources as several challenges are faced. The challenges could be in form of uncertainty of systems and parameters such as reservoirs, precipitation, evaporation and aquifer parameters including hydraulic conductivity and storage coefficients (Abu Rumman, 2005:1). In addition, the interconnection between surface and ground water resources may cause conflict as the hydrological nature of these two resources is different. For example, pumping fresh water from the ground, especially near streams, may decrease the quantity of water available at the surface. This obviously will have big impacts on water users and the environment especially during the low stream flow season. Since there are complex issues and challenges in using surface and groundwater resources conjunctively, water resources need precise and sustainable management.

The Differences Between Surface Water And Groundwater

It is important to determine and clarify the difference between surface water and groundwater resources to make readers understand the different features between these two water resources. Initially, surface water is a liquid that can be found on the surface of the earth such as in rivers, lakes, seas, and in other surface interments. Usually this surface water doesn't contain a high mineral content.

According to Tewoh (2008:1), "surface water is just what the name implies; it is water found in a river, lake or other surface impoundments. This water is usually not very high in mineral content, and many times is called 'soft water' even though it usually is not".

On the other hand, groundwater resources is water that we can find trapped under the ground. Groundwater is usually called "hard water" as it consists of hard mineral compounds such as calcium and magnesium. In addition, groundwater resources also may contain any contaminants that are found in the surface water. This is consistent with the statement of Tewoh (2008:1) who said that groundwater is "that which is trapped beneath the ground. Rain that soaks into the ground, rivers that disappear beneath the earth, melting snow are but a few of the sources that recharge the supply of underground water".

The above definition makes clear that surface and groundwater differ in location they're found and chemical content.

A Barrier To Integrated Management Of Surface And Groundwater

There is a problem integrating or combining surface and groundwater resources. This is that surface and groundwater each have different features. According to the National Australian Water Commission (2007:2) conjunctive management of surface and groundwater resources is difficult because "groundwater unit boundaries sometimes cross traditional surface water catchment[s]". Therefore it is not easy to find areas in which to practise conjunctive management.

OBJECTIVE

The objective of this essay is to analyse and critique the conjunctive use of surface and groundwater resources with regard to drinking water and its quality, irrigation and its economy, surface and groundwater regulations, and the availability of water and its quantity. In addition, surface and groundwater resources obviously can be explored and managed to meet the demands for human for various different uses. However, there is a complexity in conjunctive use of surface and groundwater resources due to the interdependence between these two water resources. For simple instance, pumping groundwater on the one hand will decrease surface water on the other hand. This particular problem should be solved and managed properly to avoid water shortage.

Quality Of Drinking Water For Human Health

The surface and groundwater definitely could be used as sources of drinking water. It is understood that the quality of drinking water is very important as water is essential for human lives. It is a contradiction when we see water is required for people's health whilst on the other hand could be the medium that transmits various severe diseases. One disease that is caused by unsafe water resources is diarrhoea. In this case, the most important thing is how to properly manage and explore surface and groundwater resources to provide safe and clean water so that it can be consumed safely by people.

Comprehensive management of water quality is the answer to the problem. It is very important to control water quality from the catchment to the consumer. According to World Health Organisation (2004:6), there several key issues that should be implemented to make sure that the water has good quality and is safe for consumption. National water authorities should:

1. make a target that water is not only for drinking but also for human health;
2. check whether the system is capable enough to deliver safe and clean water that is free from contamination, microbes, and other hazardous chemicals;
3. build a sanitary inspection and encourage a sustainable water monitoring system;
4. build water safety plans such as communication and management procedures for both normal and abnormal situations; and
5. build independent water monitoring through auditing-type approaches.

Moreover, as the source of drinking water for public consumption, surface water quality and groundwater quality needs to be managed well.

Managing Surface Water Quality

In order to be used for drinking water, surface and groundwater resources should be free not only from organic contaminants but also from pollution. Managing surface water quality means keeping water free not only from organic contaminants or organic materials such as algae but also from pollution that caused by animal wastes, pesticides, insecticides, industrial wastes, and household wastes. Moreover, surface water runoff is viewed as the biggest barrier to improving water quality.

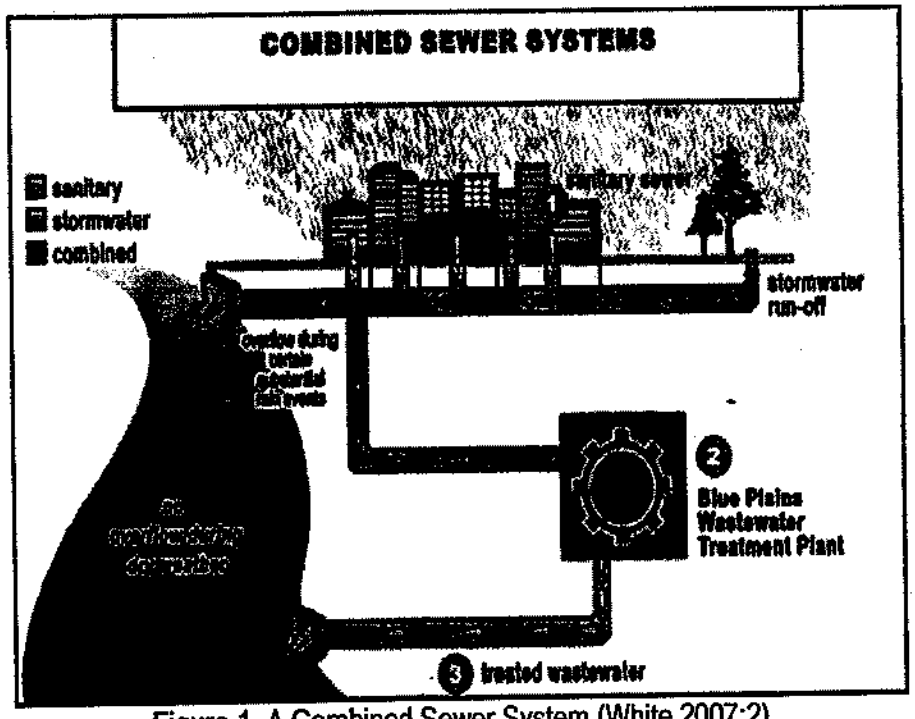

Figure 1. A Combined Sewer System (White 2007:2)

According to White (2007:2), surface water runoff affects watercourse quality and becomes the biggest difficulty to developing and improving surface water quality. To respond to this problem, White (2007:2) stated that instead of using a separate sewer system it is better to use a combined sewer system. A separate sewer system is not sufficiently able to manage problems of diffuse pollution from surface water runoff because this system conveys polluted debris into the storm water system and results in untreated water leaking into the watercourse. On the other hand, a combined sewer system is a better able to manage diffuse pollution, as this system not only washes all diffuse pollution from surface water but is also effective to encounter many environmental problems such as industrial and household waste. Moreover, a combined sewer system diverts diffuse pollution before it is transported to the treatment plant (see Figure 1)

Managing Groundwater Quality

Groundwater contains several hard chemical substances such as mineral calcium, silica, magnesium, and toxic metals as well as containing organic contaminants such as parasites, cryptosporidium,

bacteria, algae, viruses, and fungi (Hamlet 2008:1). In order to make these groundwater resources safe to be consumed then we need a purification and filtration system. Basically purification and filtration are processes to remove hazardous contaminants from raw water sources.

The purification and filtration systems are designed to decrease organic and non-organic dangerous compounds to a certain level to meet the demand of clean and safe potable water for humans. However, the purification and filtration system should meet the standards of drinking water that has been set up by the water authorities. According to Hamlet (2008:1) "These standards will require minimum / maximum set points of contaminants and the inclusion of control elements that produce drinking water. Quality standards in many countries require specific amounts of disinfectant (such as chlorine or ozone) in the water after it leaves the water treatment plant (WTP), to reduce the risk of re-contamination while the water is in the distribution system".
After groundwater has been processed properly through a set of purification and filtration systems, it can be consumed safely.

Conjunctive Use Of Surface And Groundwater For Irrigation Systems In Terms Of Economy And Law

The use of groundwater and surface water for agriculture irrigation obviously will have significant contribution to the increase of agriculture harvest that will lead to the higher income for farmers in particular and for people in general. However, methods of irrigation management and water allocation system as well as taxation, pricing, and regulation are definitely needed to support the sustainable system of agricultural irrigation based on the exploration of surface and groundwater resources.

There are lots of benefits and advantages that can be derived from efficient use of surface and ground water resources for better irrigation system in terms of economy. The use of irrigation for crops such as rice and corn in arid and semi-arid areas definitely helps increase the production and harvest of these crops as well as making the soil surrounding the crops more fertile and more productive. Yet, there is a problem with water allocation for irrigation due to the physical interdependence between surface and groundwater resources. As O'Mara said, "research in irrigation has focused attention on the potentially large benefits to be gained from efficient join use of surface water and groundwater in those large alluvial basins where the physical interdependence of the two water resources complicates allocation" (O'Mara, 1988:17).

Moreover, conjunctive water use means that there is simultaneous use of surface and groundwater to meet the crops' demand. There are many farmers in canal areas who use groundwater and surface water for irrigation without any control from water law authorities. Actually there is a difference between conjunctive use and conjunctive management of surface and groundwater. Conjunctive use tends to explore and utilise surface and ground water by individuals and is not controlled by any scheme or basin level entity. In contrast, conjunctive management is a responsible effort to use surface and groundwater resources limited by any scheme of basin level entity to ensure the sustainability of water sources for the crop water productivity.

The World Bank said that "Conjunctive management...refers to effort planned at the scheme and basin levels to optimize productivity, equity, and environmental sustainability by simultaneously managing surface and groundwater resources. In many systems and basins, such planning is needed to raise crop water productivity" (World Bank, 2006:1).

Economic Benefits Of Using Water Sources For Irrigation Systems

The smarter and the more efficient use of surface water and groundwater resources for irrigation will lead to many economic gains not only for farmers but also to the nation. There is no doubt that precise irrigation system will increase the production of crops and generate horticulture and viticulture industries, from which crops will potentially be exported overseas. Additionally, the export of the crops will increase national income as well as the wealth of farmers. Efficient irrigation systems improve not only the quantity of harvest crops but also the quality of them. It is believed that the higher quality crops will generate higher prices in the market.

However, economically it also depends on supply and demand in the agriculture markets. In Australia, the potential use of surface and groundwater for irrigation is a dominant issue because agriculture is an important economic activity. Development of more efficient irrigation is an obvious strategy to increase agricultural production instead of the development of small or medium sized reservoirs. Furthermore, irrigation water can also be pumped from underlying aquifers, and pumping costs depend on the distance between underlying aquifer to water table.

One piece of technology which aids development of efficient use of surface and ground water resources is an irrigation system evaluation called Irrimate™ that can evaluate the efficiency of water use on farm sites. There is one example of this system in New South Wales, Australia.
In 2001 there was an experiment of using Irrimate™ for determining irrigation efficiency and to find out whether management change and or field redesign could save more water. It was found that halving the field length would optimise the efficiency of water use. Based on this result, in the following year the researcher undertook the necessary earthworks to divide the 66 hectare field into two 33 hectare fields. In 2003, he continued his experiment by doing Irrimate™ evaluation to estimate the success of the field redesign and fine tune his water management.

Table 1 indicates the success of redesigned of land field development and the water saving achieved by using the Irrimate™ water management evaluation system:

Table 1: Measurements of Water Savings through Irrimate™ Optimization in Field 1

	Before Change (Measured)	After Change (Optimised)
Field Length (m)	885	408
Flow Rate (L/s)	2.7	3.8
Time Water Applied (h)	20	6
Deficit (mm)	60	60
Inflow (mm)	110	83
Tail water (mm)	27	21
Water Infiltrated (mm)	83	62
Application Efficiency (85% Tail Water Recycling)	69%	92%
Distribution Uniformity (DU)	92%	92%
Potential Water Saving (ML/Ha)		0.22

Source: Economic Benefits of Performance Evaluation (Reynolds & Jackson, 2007:2)

From the table above it can be seen that by redesign of field length from 885 metres to 408 metres and increasing head ditch as well as tail drain capacities, water could be saved, up to 0.22 megalitres per hectare per irrigation.

Furthermore, underneath Table 2 indicates the benefits and costs that are related with redesign of field lengths and water savings in field 1.

Table 2: Benefits of Monitoring and Change

Activity	Description	Total Cost	$/Ha
Yield Improvement	Average increase of 1.2 bales/ha/year @ $450/bale (Variable costs unchanged)	$35,424	$540
Water Savings	0.22 ML/Ha/per irrigation savings @ $ 18.39/ML	$1,592	$24
Total		$37,016	$564

Source: Economic Benefits of Performance Evaluation (Reynolds & Jackson, 2007:2)

It can be seen from the table above that the changes that were made through Irrimate™ water use evaluation system has successfully increased yield improvement and produced water savings of $540/Ha and $24/Ha respectively. It is a good example of how better management of using surface and groundwater can benefit people economically.

Surface And Groundwater Regulations

The use of surface and groundwater should be regulated strictly as these two water resources are very important to the environmental sustainability. The regulation of surface and groundwater resources is expected can protect the quality of water as well as to encourage the sustainable and efficient use of surface and groundwater resources.

The following are several possible impacts of irresponsible use of water sources due to the weaknesses of the water authorities in applying strict water regulations:

a) reduction in surface water availability that affects the low flow water regime;
b) reduction of groundwater flow for the environment, such as forests, grassland, wetlands, and fisheries habitats;
c) triggering of conflicts of those who have rights to use water;
d) generating of conflicts over domestic wells while the extraction of groundwater in certain area may decrease the capacity of the wells;
e) impacts on land stability and subsidence;
f) floods and property damage due to uncontrolled flowing artesian wells.

Due to many negative impacts on the environment, surface and groundwater laws are definitely needed. Basically water law should be emphasise the following key specific areas:

a) use water based on necessity or make sure there is equilibrium between water resources and water requirements;
b) set regulation to develop better water quality;
c) protect water resources from any damages such as from floods and pollution;
d) clear regulation about water recycling and saving;
e) improve surface and groundwater management systems;
f) establish clear regulation for use of water resources for those who have water licences and for those who have not water licences.

The regulation of water use as one important aspects of conjunctive use of surface and groundwater resources should be a main concern of legal water authorities.

Conjunctive Use Of Water For The Improvement Of Water Quantity

The Australian National Water Commission (2008:1) states that "In some localities base flows in streams are maintained by drainage into them from underground sources while in other places streams is a source of replenishment for underground supply. Consequently, exploitation of the one can affect the availability of supply from the other. It is desirable, therefore, and likely to become increasingly important, that the conservation and utilization of both resources should be planned jointly."

From the above statement it can be seen that the conjunctive use of surface and groundwater can be managed simultaneously and will lead to the availability of water for a longer term. In addition, the conjunctive management use of surface and groundwater resources is definitely important to improve the long term reliability of water supplies.

There are two different ways of using surface water and groundwater conjunctively. Firstly is by direct conjunctive use. It is basically done by importing water into the aquifer and after that water pumping it out as required. This direct conjunctive use is different to indirect conjunctive use, also called the replacement way. Replacement conjunctive use basically uses imported water rather than pumping groundwater resources and leaves the groundwater available in the aquifer for the next term use.

Moreover, the other management of conjunctive use to ensure there is enough water for different various seasons is by establishing seasonal storage operation management. Seasonal storage operation management fills an aquifer with imported water during rainy seasons when there is a lot of surface water available. On the other hand, the seasonal storage operation management will pump the water out from the aquifer during high demands of water and during drought season where the availability of water at the surface is lower than in the wet season.

Furthermore, the availability of water throughout the year and to fulfil the water demand during high demand seasons is obviously determined by the ability of legal water authorities to apply smart management systems, using surface and groundwater conjunctively.

SUGGESTIONS AND RECOMMENDATIONS

This paper only analyses and describes the conjunctive use of surface and groundwater resources in some limited aspects. These aspects are explored in terms of quality of drinking water, economy of irrigation, law and regulation, and quantity of water available. These aspects are very limited as there are many others that can be explored. Therefore the writer strongly recommends the readers to examine this paper with other relevant articles and find out other aspects of conjunctive use of surface and groundwater in Australia to enrich our knowledge about water resources.

CONCLUSION

The use of surface and groundwater conjunctively for irrigation will benefit farmers and the public. For farmers, the availability of water throughout the whole year will enable them to cultivate more and better quality crops. For people, the crops that are exported overseas will increase the income of the country, indirectly generating more wealth for its people. However, the conjunctive use of surface and

groundwater resources should be explored carefully as surface and groundwater are raw water sources that still contain hazardous chemical substances.

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