

## Embedded Water Derivatives

**Mr. Paras Mahajan,**

BFIA, Shaheed Sukhdev College of Business  
Studies, University of Delhi, India  
Assistant, Business Development and Account  
Management (National Skill Development  
corporation), Ministry of Skill Development  
and Entrepreneurship, India

**Hamendra Kumar Porwal, Phd, MBA(USA), CA**

Associate Professor,  
Shaheed Sukhdev College of Business Studies,  
University of Delhi, India

### ABSTRACT

*There are different approaches to deal with the impending scarcity of water: conservation, recycling, or making water a tradable commodity and letting market forces decide. Water trading is already becoming more common than we realize. Water has become a commodity. This is a slow process, but it is imminent and quite soon we will be observing more and more derivatives built on this commodity and traded through public exchanges and brokers. Since transporting water is impractical for both political and physical reasons, food is the way to invest in water - the water embedded in food. The aim of this research project is thus; to develop a new derivative product that derive its value from the quantum of water embedded in commodities.*

**Keywords:** Embedded water derivatives; water trading market, water footprints.

### INTRODUCTION:

A derivative is “a financial instrument whose value depends on (or derives from) the values of other, more basic underlying variables.” The variables underlying derivatives are the prices of traded assets. It is not a great leap from a water rights trading system to the financial derivatives based on water traded on public exchanges. We already see many water-related products, such as those built on precipitations, the majority of which are traded on the Chicago Mercantile Exchange (CME). The contracts are monthly and seasonal. Another set of water-related financial derivatives comprises monthly and seasonal rainfall options and futures. According to the Weather Risk Management Association, customized weather derivative products grew by 30% over the last year, while the overall market increased by 20% to \$11.8 billion. Demand growth was seen in contracts related to rainfall, snow, hurricanes and wind from industries such as agriculture, construction and transport.

As the water market is gradually maturing and water continues to be a valuable commodity, some new assets existing on other economic markets can be introduced to the water market. One such product can be the embedded value of water in food.

Embedded water refers to the hidden flow of water if food or other commodities are traded from one place to another. This volume of water is used to produce the product. It refers to the total of the water employed in the assorted steps of the assembly chain. The water is said to be virtual because once the commodity is grown, the real water used to grow it is no longer actually contained in the it. The concept of virtual water helps us realize how much water is needed to produce different goods and services. In semi-arid and arid areas, knowing the virtual water value of a good or service can be useful towards determining how best to use the scarce water available.

Freshwater is vital to life, and as the world's population grows, so does our use of it. Globally, the increase is due to more people consuming more water-intensive food, electricity and consumer goods. This puts pressure on water resources, which is a concern in the arid parts of the world where food is grown, goods are manufactured, and water is already in short supply. Water footprints help individuals, businesses and countries

because they reveal water use patterns, from the individual level all the way to the national level. They shine a light on the water used in all the processes involved in manufacturing and producing our goods and services. The water footprint gives everyone – from individuals to business managers to public officials – a solid frame of reference that helps us all be more efficient and sustainable with our water use and appreciate the role of water in our lives.

By the year 2030, experts predict that global demand for water will outstrip supply by 40 percent. Impacts from climate change may increase the likelihood of changes to the water cycle, leading to prolonged periods of drought (and, conversely, more extreme rainfall).

Reduced water supplies could add to water insecurity both in the US and in other countries. History has it, whenever there are forces of demand and supply at work, there is always a possibility of playing with financial aspect of it. The excessive demand and limited supply has eventually made water an economic good rather than a public good. This has indeed dealt with a problem because water is the basic need for every person living on this Earth.

Hence, taking this discussion a step further we can derive the value of water through its embedded value in the commodities and trade these water rights as a non- deliverable contract on the exchange to hedge the physical commodity in hand or to speculate, resulting in huge profits in the hands of farmers and traders alike.

Thus, the discussion can be concluded by discussing the scope of the study mentioned below

### SCOPE OF STUDY:

The scope of this paper confines to

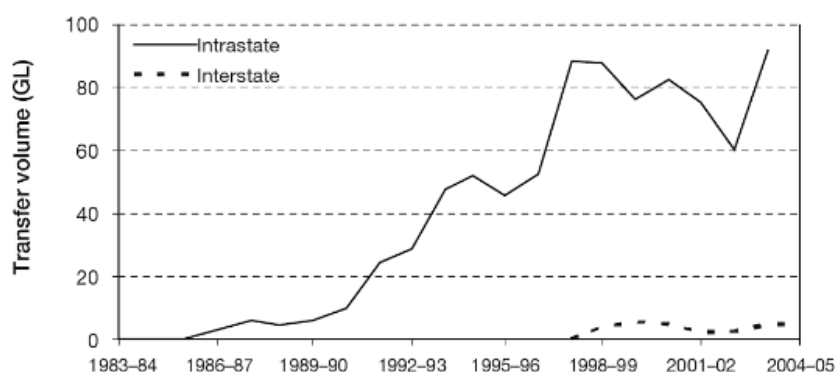
1. finding efficient ways of using water resources.
2. giving a brief overview of the Australian Water Market.
3. developing a new security based on water which can be traded on exchange.
4. making a robust technique for hedging the crop by the farmers and traders.

### REVIEW OF LITERATURE:

In 1994, the Council of Australian Governments (COAG) promoted innovations that included better-specified water rights, market-based approaches to water management, and the need for environmental flows, especially in the Murray-Darling Basin. These reforms, including a cap on withdrawals in the Murray River systems, were designed to ensure water is allocated to its highest-value use while ensuring ecologically sustainable development (Quiggin 2001).

The 2004 National Water Initiative (NWI) expanded the market-based agenda with its endorsement of better-specified water access entitlements that can be recorded in reliable and nationally consistent water registers (COAG 2014).

Water trade in Australia was largely limited to transactions between irrigators. The most active trading region is in the southern Murray-Darling Basin, but markets have expanded considerably since the mid 1990s and should develop further with NWI initiatives. Surface water trading by irrigators, particularly in seasonal allocations, is widespread in many irrigation districts. Markets for derivative products for water, such as leases and forward contracts, are emerging, largely in response to irrigators' preferences for more flexible trading arrangements. Initially, water trading was restricted to trade between irrigators within the same irrigation district. Over time, trade expanded to include intra valley and interstate trade.



**Fig. 1: Water trading in Australia (Interstate VS Intrastate)**

Water markets have been a controversial topic since the early 1990s, with proponents enamoured of their potential to change incentive systems in water management, so that the implementation of rational pricing is not circumvented by those with political power [Rosegrant and Binswanger, 1994]. Water markets are expected to provide gains in economic efficiency as water is becoming increasingly scarce and is reallocated from lower-to-higher-value uses. A large part of the literature concentrates on the potential for water markets [Easter *et al.*, 1998; Horbulyk and Lo, 1998], rather than on actual experience. Thus much of the discussion is focused on how to remove impediments to water markets and to the reduction of transaction costs in making them happen [Leigh Livingstone, 1998]. Global experience with formal markets, similar in scale to the markets in the Murray Darling Basin (MDB), is limited. Evidence of limited trading (especially of permanent water rights) in Chile, Mexico and the United States is viewed differently by various commentators and is also extrapolated more broadly to other countries [Hearne and Easter, 1998].

The water reforms introduced by the Council of Australian Governments (COAG) in 1992 and 1994 have contributed greatly to the present status of water transfers in Australia. The separation of water allocations from land titles was proposed in order to remove barriers to permanent water trading and followed on from a provision in the Victorian Water Act of 1989. Additionally, the COAG agreements required the state governments to implement comprehensive systems of water allocations. Clear specification of entitlements was deemed by water management agencies to involve the definition of entitlement ownership, volume, reliability, transferability and, where appropriate, quality.

## THE AUSTRALIAN WATER MARKET:

### Introduction to The Australian Water Market:

Water trading involves the temporary or permanent transfer of a water licence. A temporary or term trade involves the transfer of an allocation of water for a set period and traditionally occurs within the Australian financial year.

Water trading has become a vital business tool for many irrigators, providing flexibility to respond to variable water availability. Water markets allow water to flow to where it can be used most productively. This is particularly valuable as different users have to manage the water demands of annual crops and permanent plantings.

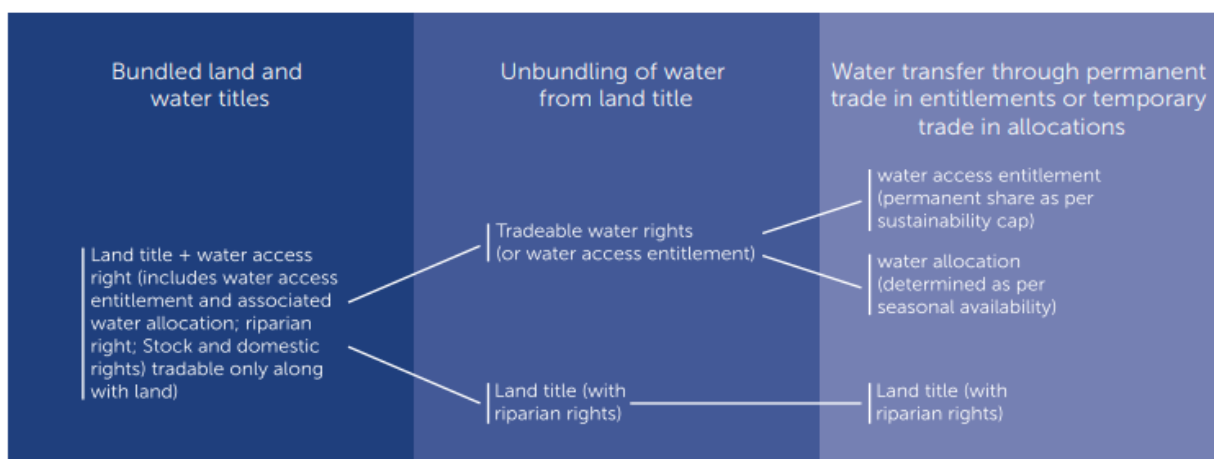
The water markets in the basin are based on a 'cap and trade' system where the cap represents the total pool of water available for consumptive use. Original water rights must be registered with the Australian states, which limit the aggregate drawdown of supply. Available water is distributed to users via water rights administered by the basin states. There are two main types of rights traded in the basin—entitlements and allocations:

1. Water access entitlements are rights to an ongoing share of the total amount of water available in a system.
2. Water allocations are the actual amount of water available under water access entitlements in a given season.

During the year, water is distributed or 'allocated' against entitlements by state governments in response to factors such as changes in rainfall and storages. This provides people with certainty as to the water they will receive, while allowing states to manage water availability through different climatic conditions.

- permanent trade is the trade of water entitlements, known as entitlement trade
- temporary trade is the trade of water allocations, known as allocation trade.

Users determine whether they need to buy or sell their water at a particular time. The price of water is a reflection of these demand and supply factors. The price of water differs across regions, type of water rights and time.



### **How does the water trading works?**

1. A Water License is issued - A water license stipulates how much water can be taken out of a river system which is often aligned with a property.
2. Water Allocations by the Government Authority - Government appointed Water Authorities allocate the amount of water that can be taken from a river system as a percentage.
3. Compliance Issues are met - Government appointed Water Authorities provide specific trading rules that govern license in relation to their licenses.
4. Water users assess needs - Water users identify specific volumes of water that they require for the irrigation season.
5. Water Markets come in action - Water markets facilitate the trading of water between two parties through water brokers.

A 1994 Australian regulation separated land and water rights. This allowed landowners to sell access to water on their land more easily and opened the way for the growth of water markets. These water rights are traded on other water exchanges in Australia.

Rights owners can sell access to their water on a temporary or permanent basis. In both circumstances, the contracts are priced per mega liter, where each mega liter represents a million liter. On a temporary contract, the buyer has the right to consume the designated volume of water in the 12 months following the delivery date. On a permanent contract, where the prices are much higher, the buyer can consume the designated volume every year in perpetuity.

### **TYPES OF WATER TRADE:**

**Temporary Water Trade:** A temporary transfer is a transfer of water specifically for the irrigation season. Although temporary transfers are solely transfers of allocation between New South Wales and Victoria, Queensland and South Australia both have the means of transferring an entitlement on a temporary basis, whereby the water is transferred for the current irrigation season and the purchaser is the beneficiary of any increase in allocation from the date of the transfer.

**Permanent Water Trade:** A transfer of permanent water is the transfer of the water entitlement to the purchaser on a permanent basis, similar to the sale of land. The purchaser will retain the parcel and receive any allocation granted upon it from the date of the transfer indefinitely or until the time at which they sell the entitlement.

**The Forward Market:** The Forward Water Market is a mechanism which enables clients to plan for future irrigation requirements thus removing uncertainty around their requirements. It is a unique and innovative Forward Water Market which is an extension of the current spot market, enabling the contracting of temporary or permanent water parcels at a set price to be delivered at a future date, to be determined by the seller and purchaser.

### **Analysis of the Australian Market:**

The Australian markets have their share of shortcomings which does not allow its adoption in the current scenario in Indian market as it is. These shortcomings are listed below:

1. Water markets are likely to require a significantly greater level of regulatory involvement than most markets because of the importance of water as a resource. Water is critical for human existence. In Australia, the government has traditionally controlled the distribution of water rights. Under these circumstances, a selected few controls a large share of water which is in turn subject to regulatory mechanism.
2. Water markets do not operate equally in all jurisdictions across Australia. For example, Western Australia still has not unbundled rights from land ownership. Because of lack of a regulatory body, markets do not have a standard operating procedure. Such heterogeneity raises questions about the equality of treatment under compromised or absent markets especially when a crucial underlying policy rationale of market trading systems is to avoid the economic distortions and/or inefficiencies of traditional public policy interventions.
3. There is no uniformity across the water markets in Australia. Each region follows own rules and regulations. The trades are not monitored on an Exchange and can be traded over the counter, seemingly reducing the uniformity which is required for a national level acceptance. There have been notable variations in the nature, degree of unbundling, duration and even trade-ability of rights. Hence, compatibility of arrangement is needed for inter-jurisdiction transactions.
4. Development of entitlement structure was done with an outlook towards the primary market in which there are prescribed physical water trades taking place. Secondary market has taken a backseat and policy

intentions also focus on making a robust primary market rather than an exchange traded secondary market which reduces the trade time and increases efficiency.

5. The actual trading of water in the Australian market is a foe as it leads to excessive protectionism and precaution. Restrictions designed to guard accidentally increasing damage of the supply of water prove counterproductive.

Based on these reasons, we would require a new instrument which can be easily merged with our existing regulatory mechanism and lead to acceptance within the ecosystem without much ado. A new financial instrument which can be traded easily on exchange without an actual delivery mechanism as we saw in Australian market would be beneficial for speculators and farmers alike as this would not result in actual loss of the natural resources. Enabling the market forces decide the true price of resource and ensuring equitable distribution should be the prime area where one must work.

## RESEARCH METHODOLOGY:

The variables needed to derive the value of the derivative are:

1. Spot value of the underlying agricultural product.
2. Embedded value of water needed to grow that product.

The spot value of the commodity has been taken from the site of NCDEX and the value of water footprint has been extracted from Food and Agriculture Organization (FAO) of the United Nations.

### Various Assumptions are as follows:

1. The value of the commodity, which is held physically by the farmer, is same as that of the value held by him in the form of water rights. Therefore, the contract size of the embedded water derivatives should be same as that of the commodity. The implication is that water derivative can act as a perfect hedge against price movement of the underlying commodity.
2. The farmer should use the water for one and only one commodity. This assumption essentially separates the water used for irrigating two different commodities. The focus is primarily on the end use of the water which is used to irrigate. This assumption commoditizes water into different products. Hence, water used to irrigate wheat ( $W_{\text{Wheat}}$ ) is different from water used to irrigate rice ( $W_{\text{Rice}}$ ).
3. There is no significant cost other than that of procuring water. Hence, the focus is only on procurement of water for growing agri-commodities, no other significant cost like procurement of seeds, fertilizers etc is taken into consideration.
4. The minimum trading value of the embedded water derivative is same as that of the underlying asset to act as a perfect hedge against the price movements in the commodity markets. This assumption states that the commodity held physically and the value of water derivative held in the portfolio are perfect substitutes of each other. Hence, the farmer has no gain or loss if it being replaced by one another.
5. The country's average is taken to calculate the water footprint to standardise the contract and to show a better picture. This assumption acts as a neutralizing agent for water rich and water deficit areas.
6. The risk-free rate is taken as Minimum Support price as decided by the government. This acts as a benchmark price for all the agri-commodity, hence, the same stands true for embedded water derivatives as well.

### Derivation of embedded water derivative:

The value of the new product is derived with the help of an example:

Asset under study is *Wheat*

Spot value (as on 6 <sup>th</sup> April, 2018)	Rs.1789.4 /Quintal (extracted from NCDEX)
Country's average water footprint of Wheat	634 metric tonne (extracted from FAO)

Since the value of the numerator is in Quintal and that of denominator is in Tonne, one must make the fraction of the same value.

Mathematically, one quintal of wheat costs Rs. 1789.4 and one Quintal is equal to 0.1 tonne.

Hence, re-writing the above statement, 0.1 tonne of wheat costs Rs. 1789.40.

Therefore, one tonne of wheat must cost Rs. 17894.00 (1789.4/0.1).

Now, the value of  $W_{\text{wheat}}$  can be calculated through the following formula:

The value of Water footprint per ton of crop is;

$$W_{\text{Wheat}} = \frac{\text{Spot Value}}{\text{Average water footprint}}$$

Thus,  $W_{\text{wheat}} = 28.22$

which means for growing one tonne of wheat, we would require 28.22 m<sup>3</sup> of water.

The information about the 'unit of trading' of Wheat from contract specifications is given as on NCDEX, unit of trading of Wheat is 10 tonnes and assuming the farmer is holding the minimum value.

Thus, the contract value becomes = units held x  $W_{\text{Wheat}}$

Now, we know that the maximum contract on the exchange for Wheat is 500 tonnes.

Therefore, a range of the price movements is established which will help in understanding the valuation of the derivative.

Contract Size	Value
Minimum Trade	282.2 (10x28.22)
Maximum Trade	14,110 (500x28.2)

If the price is ranging towards the downside, it is undervalued, and a buy signal is sought. If the price is ranging towards the upside, it is overvalued, and a sell signal is sought. Hence the price range is established and market forces decide the price of the water right.

Similarly, we can establish price range of every commodity traded on the exchange, which is shown in the following table.

Commodity	Minimum Trade	Maximum Trade
Barley	112.79	5,639.65
Maize Kharif	55.38	2,769.09
Maize Rabi	58.06	2,903.08
Wheat	282.24	14,111.99
Castor seeds	53.59	2,679.30
Soy Bean	88.99	4,449.55
Sugar M	1,161.39	58,069.66
Pepper	1,631.91	81,595.67
Turmeric	214.50	10,725.10
Coriander	43.57	435.72

## ANALYSIS – Embedded Water Derivatives:

### Impact of embedded water derivatives for farmers:

Introducing embedded water derivatives is likely to provide farmers with additional income, more choices on trading their water allocation and water price certainty. Thus, farmers can benefit from this 'leverage effect' in the following way: increase their exposure to the water market with limited capital so that they can make additional profit from favourable water price movements while minimising their potential losses.

This 'leverage effect' can generate additional income for farmers who do not want to trade in the physical commodity market due to limited capital resources or other constraints. For instance, a farmer may not be able to buy his water due to limited capital or some other economic reasons, but he can still buy his water allocation in the market with limited funds to make a profit should water price move in his favour. Thus, the leverage effect is especially useful for annual crop growers who can either buy or sell their water allocation depending on the profitability of their agriculture businesses. In addition, they can defer their buy or sell decision in the physical market by holding only futures. In this case, they can trade their futures to profit without entering into the physical market. Therefore, the leverage effect of options trading is likely to encourage more farmers to participate in both physical and water future markets.

### Factors affecting the price of the embedded water derivatives:

#### 1. Spot Price and Embedded Water Derivative:

According to our derivation, there is a positive correlation between the spot price and embedded water derivative. Thus, if the spot changes to higher price the value of the water derivative tends to increase. While the spot price of commodity is important in terms of immediate buy-and-sell transactions, it perhaps has more importance with reference to the derivatives markets. This is illustrated as follows:

Consider the previous price of Wheat = Rs 17894.0

Let the price increase to Rs 18,500 due to increase in demand of wheat, keeping other things constant, the new price of embedded water derivative changes to 29.17 [18,500/634] from 28.22.

## **2. MSP and Embedded water derivative:**

Minimum Support Price or MSP is the price at which government purchases crops from the farmers, whatever may be the price for the crops. The MSP helps to incentivize the farmers and thus ensures adequate food grains production in the country. It gives sufficient remuneration to the farmers, provides food grains supply to buffer stocks and supports the food security programme. For our study, thus, it makes the perfect proxy for the risk-free rate. Thus, if the MSP of the commodity is reduced it will lead to decrease in production of the commodity and hence there will be excess water available for the same commodity to grow, thereby essentially reducing the price of water embedded derivative. The strategy to earn profit in this scenario can be by buying the embedded water derivatives if the farmer holds the commodity of the reduced MSP.

Else if MSP increases then there will be increase in supply of the commodity and hence more water is required to grow the commodity thereby increasing the value of embedded water derivative. The strategy to earn riskless profit in this case, can be to sell the water derivative if the farmer is holding the commodity of the increased MSP.

## **3. Rainfall and Embedded water derivative:**

When there is abundant rainfall in the area, the cost of procuring water will be reduced hence, there is an inverse relation between rainfall and embedded water derivative. More rainfall means abundant water is available naturally to the farmer, which significantly reduces the irrigation cost and the value of the water derivatives.

## **4. Underlying commodity and embedded water derivative:**

The value of the embedded water derivative is directly dependent upon the value of the underlying commodity much like any other derivative product. Thus, if there is any change which affects positively, the same affect will be seen in the value of water derivative too.

## **5. Time to expiry and embedded water derivative:**

Time to expiry is linked with the seasonal nature of the agricultural commodities. The Indian cropping season is classified into two seasons – Rabi and Kharif. Rabi season begins from October to march and kharif is from July to October.

The kharif crops include rice, maize, sorghum, pearl millet/bajra, finger millet/ragi (cereals), arhar (pulses), soyabean, groundnut (oilseeds), cotton etc. The rabi crops include wheat, barley, oats (cereals), chickpea/gram (pulses), linseed, mustard (oilseeds) etc.

Kharif crops are sown usually with the beginning of the first rains towards the end of May in the southern state of Kerala during the advent of south-west monsoon season. As the monsoon rains advance towards the north India, the sowing dates vary accordingly and reach July in north Indian states. Hence, the demand for water will be more in the sowing stage as compared to other stage during the life of a crop, thereby; the value of the derivative will be more in the sowing season of kharif crop. The rabi crops are sown around mid-November, after the monsoon rains are over, and harvesting begins in April/May. Therefore, the demand for irrigation will be high in winters and the value of the derivative instrument will also be high.

## **6. Level of ground water and embedded water derivative:**

Ground water is the water present beneath Earth's surface in soil pore spaces and in the fractures of rock formations. The level of ground water is inversely proportional to the value of embedded water derivative, as more resources are required to extract water from the ground where there is a dearth of ground water. Thus, more cost is associated with irrigation and more the value of derivative instrument.

## **INTERNATIONAL TRADE AND EMBEDDED WATER DERIVATIVE:**

We know that water is not equally distributed across countries and geographies. There are some countries, which are surplus in water and some are scarce. Hence, it is easy to classify the countries into 'water surplus' countries and 'water deficit' countries.

Rudimentary trade theory suggests that a country should be exporting things that it has in abundance and importing those that are scarce. By this logic, an efficient trade in water can be said when 'water surplus' country exports water to 'water deficit' country. Since, physical movement of water is next to impossible or even if possible, it would be a costly affair for the parties involved, the way out is very simple indeed. Food is the best way to invest in water. That is, grow food in water-rich areas and transport it for sale in water-poor areas. This method is for redistributing water that is least contentious, and ultimately it can be profitable, which will ensure that this redistribution is sustainable. This makes the water - the water embedded in food – a tradable commodity.

Thus, water embedded derivative can be traded internationally.



### The Indian scenario and water embedded derivatives:

India virtually exported 10 trillion litres of water. At least one-fifth of this would have been surface/groundwater. According to the Water Footprint Network (WFN) database, India had the lowest virtual imports of water in the world. India is a large virtual net export of water because of agricultural products. Despite of this, India faces water shortage for a major part of the year according to WFN.

Below is the figure showing number of months by water scarcity in a given river basin.

#### MOST OF INDIA HAS SEVERE WATER SCARCITY

Bars show the number of months in a year by water scarcity situation in a given river basin.

Figures in parentheses with river basin indicate the population in million. Data refers to 1996-2005

Low Moderate Significant Severe



Note: Concept of different water scarcity levels are explained in the story. \*Indus river basin includes areas in Pakistan.

Source: Hoekstra, A.Y. and Mekonnen, M.M. (2011) Global water scarcity: monthly blue water footprint compared to blue water availability for the world's major river basins, Value of Water Research Report Series No. 53, UNESCO-IHE, Delft, the Netherlands.

Therefore, while exporting water-rich commodities, the price of embedded water should also be factored in. This would lead to increase in revenue for India.

### CONCLUSIONS AND RECOMMENDATIONS:

The paper proposes introduction of water options to the market. This innovation can impact economy in both positive and negative ways. The benefits of the introduction of water options to the market can be summarized as follows:

- **Water price insurance for farmers:**

By paying a relatively small up-front fee (option price), farmers are protected against adverse water price movements in the future and still allow themselves to benefit from potential favorable water price advances. For water option holders, no matter how adverse the water price movement might be, his loss is limited to the amount he paid for his options.

- **More choices for farmers**

Farmers have the choice to participate in either or both of the physical and stock markets to achieve their purposes. As derivative instruments are cheap ; compared to the price of their underlying assets, it is ideal to hold them rather than the underlying assets. By holding them, farmers could retain future water price certainty without actually trading their water allocation.

- **Advantages for perennial crops growers**

The options market gives them the opportunity to hedge from any adverse changes in water prices in advance and at the same time taking advantage of favorable water price movements. This will effectively reduce the cost of their business.

The negative impacts can be outlined as follows:

- **Information gap**

As farmers generally do not fully understand the risks involved in trading options, there is an information gap which would need to be filled by the government or financial intermediates.

- **Potential water price distortion**

As the water trading market in Australia is not very large, and water price is determined by supply and demand, supply and demand could decrease significantly if a large proportion of farmers use the options market instead of the water trading market.

- **Potentially speculative activities**

Although options can be used for hedging purposes, they can also be used for speculation and arbitrage. It is



likely that speculative activities will occur given the nature of option trading. Therefore, there is a need for both government and financial institutions to set up controls to ensure that trading activities are closely monitored. This potential problem can also be minimized by restricting the access to the options market.

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