



POLICY BRIEF

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Improving Irrigation Water Use Efficiency Holds the Key to Tackling Water Scarcity in South Asia: Technical Potential and Financing Options

Key messages

- 📶 Water scarcity is worsening to the point that it has become a limiting factor to the growth of major economies in South Asia, and agriculture is by far the largest water-using sector.
- 📶 Overuse of water for crop production is one of the main causes of water scarcity. This overuse results from low irrigation water use efficiency (WUE) associated with water intensive cropping systems, use of un-optimised irrigation supply systems, uneven water distribution in crop fields, and subsidised electricity for pumping irrigation water.
- 📶 There is huge potential to improve irrigation water efficiency in South Asia by promoting low water consuming crops. For example, jowar and barley need about 73% less water than flooded rice cultivation. Therefore, crop diversification is one of the practical options to reduce water scarcity in water-stressed areas by increasing agricultural WUE in the region.
- 📶 Water-saving technologies such as micro irrigation (including sprinkler and drip irrigation) and laser land levelling can significantly reduce the agricultural sector's water footprint in South Asia. If the full potential of these technologies were to be utilised, Bangladesh, India and Pakistan could save 21%, 31% and 28% of their water respectively, compared with current levels of water use.

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- 📶 Securing funds for additional investment is always a major challenge for South Asian developing countries. Estimates show that a 20% WUE improvement will need USD 0.5 billion, USD 4.7 billion, and USD 1.4 billion of capital investment for Bangladesh, India and Pakistan, respectively. In order to secure capital for WUE improvement, this policy brief recommends to shift existing electricity subsidies from pumping water to improving irrigation WUE.
- 📶 Currently, the agriculture sector receives large subsidies for pumping irrigation water, which is one of the main causes of low irrigation WUE. Direct removal of subsidies from the agriculture sector is also a politically sensitive issue. However, instead of providing subsidies for irrigation electricity supply, this subsidy amount could be shifted to on-farm WUE improvement. This rearrangement of agricultural subsidies would offer farmers low-cost water efficient technologies or services, and generate multiple benefits including economic, social and environmental.
- 📶 A financial compensation mechanism for trading water rights between agriculture and industrial sectors could be established to reduce the financial burden on governments for WUE improvement investment. Under this mechanism, industry would provide financial compensation to farmers to adopt water-saving technologies, and the amount of water saved would be used for industrial production. Financial compensation could be paid to farmers as a subsidy for water-saving technologies.

I Introduction

South Asia is one of the hot spots of economic development in the world, but increasing water shortages pose serious threats to this development (WWAP, 2012; Rosegrant et al., 2013; and Rodriguez et al., 2013). Per capita water availability in the region has already dropped to water stress levels in India and Pakistan. Per capita water availability in India and Pakistan is 1,604 m³ and 1,304 m³, respectively, which is far below the global average of 24,776 m³ (FAO, 2008). Projections show the population of South Asia rising from 1.68 billion in 2010 to 2.22 billion in 2040 (Price, 2014) and greater competition over water is likely. As a result, increasing pressure on the water supply will threaten all development activities in South Asia.

Agriculture is one of the main economic activities in South Asia, and its share of Domestic Gross Product (GDP) is relatively large – 16% in Bangladesh, 19% in India, 32% in Nepal, 12% in Pakistan and 21% in Sri Lanka (Taheripour et al., 2016). Irrigation has played a pivotal role in enabling an expansion of crop production in many parts of the region. Irrigated agriculture accounts for 60–80% of the food production in the region (Yadvinder-Singh, 2014). The irrigated area has expanded rapidly over the last few

decades at an average annual growth rate of 1.7% in South Asia (FAO, 2012). Due to this rapid growth, the agriculture sector has become the largest consumer of water, accounting for almost 95% of the withdrawn water in South Asia region, which is well above the global average of 70% (Babel and Wahid, 2008). Nevertheless, water productivity in this region is 6 times less than that in the world's top food producers in terms of GDP generated per cubic meter of water¹. One of the main reasons for low water productivity is that two thirds of the irrigated area is devoted to low value but high water-using cereal grain production, which is dominated by rice and to a lesser extent wheat.

Since the colonial era, irrigation development has been dominated by a supply-driven approach. In recent years, also a number of river diversion mega projects have been planned to supply water to water-stressed areas. From the supply side, inter-basin water transfer is one of the main solutions being considered to deal with water scarcity, but this usually comes with high investment costs, as well as significant social and environmental costs (WWF, 2009). In contrast, demand side management measures through WUE improvement offer environmentally-friendly, low-cost

¹ According to country level water productivity data at <http://data.worldbank.org/indicator/ER.GDP.FWTL.M3.KD>

solutions for reducing water scarcity.

Many studies argue that WUE improvement in agriculture could significantly contribute to meeting future water demand because the agriculture sector is the largest water user (World Bank, 2014; McKinsey, 2009; Molden, 1997). The importance of WUE improvement is also clearly acknowledged in Sustainable Development Goal 6 on water and sanitation.

However, in reality, the average irrigation WUE in South Asia is 40% (Ali et al., 2012), which is relatively low compared to some other Asian countries such as Japan and Taiwan (60%), China (49%) and Malaysia (45%) (Postel and Vickers, 2004). There is therefore

great potential to improve irrigation water efficiency in South Asia and any positive change in irrigation WUE would greatly help to reduce water scarcity, which is essential to support sustainable economic prosperity.

This policy brief aims to provide decision-makers and policy managers with suggestions and actionable measures to mitigate water scarcity in South Asia. To this aim, this policy brief will: i) examine key factors causing the relatively high water footprint of agricultural crop production in South Asia; ii) recommend some practical ways to reduce the irrigation water footprint through improvement of WUE, which will also help to mitigate water scarcity in the region; and iii) suggest ways to finance WUE improvement for agriculture in South Asia.

2 Trends in irrigation development in South Asia

South Asia is the most intensively irrigated region, accounting for nearly 40% of the world’s irrigated cropland. Since the region faced major famines in 1960s, national governments and international agencies promoted irrigated crop production to ensure food security. In the last few decades, irrigation development rapidly increased to double the average annual growth rate to 3.4% (Barker and Molle, 2004). The amount of irrigated cropland increased dramatically

between 1968 and 1998: 712% in Bangladesh, 132% in India and nearly 65% in Pakistan. Since late 1990s the rate of expansion of irrigation has slowed (Figure 1). In 2008, India accounted for the bulk of an irrigation area of 88 million hectares, which is more than 78% of the total irrigated cropland in South Asia. Bangladesh and Pakistan accounted for 6 million hectares and 19 million hectares of irrigated cropland in the region, respectively.

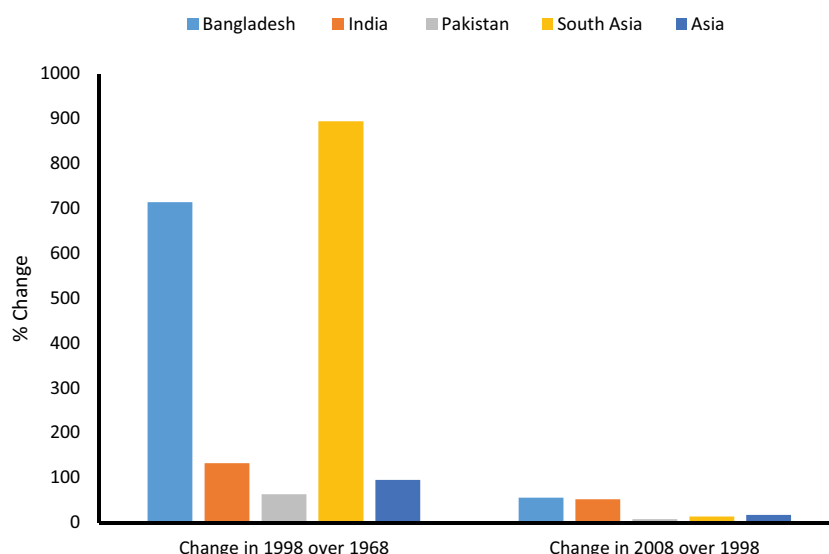


Figure 1 Percent change of irrigation cropland in South Asia between 1968 and 2008
 (Source: Prepared by authors based on FAO-AQUASTAT database)

3 What are the key factors causing the high water footprint of agricultural crop production in South Asia?

3.1. Dominance of water intensive cropping systems

The first driver of the high water footprint of agricultural crop production is water intensive cereal crops, which predominate in the irrigated area of South Asia. Relatively high water-intensive rice cultivation covered about 40% of irrigated land. Wheat is the second staple food in the region after rice, particularly in India and Pakistan, covering about 35% of total irrigated land. The country level data shows that rice production alone dominates irrigated agricultural production in Bangladesh, where over 90% of irrigated land is used for rice production (Figure 2). In Pakistan, wheat cultivation accounted about 65% of the total irrigated land of 16 million hectares. In the case of India, both rice and wheat dominate the irrigation agricultural production and account for 25 and 27 million hectares of irrigated land, respectively. Other major irrigated crops are sugarcane, cotton and maize.

Figure 2 shows that various types of crops are grown with irrigation water supply, but the two major cereal crops (rice and wheat) cover about 80% of the irrigated land in South Asia. The water footprint of major irrigated crop production varies significantly. With

conventional irrigation practices, the water footprint of rice, wheat and sugarcane cultivation is 15,000 m³/ha, 4,500m³/ha and 16,000 m³/ha, respectively in South Asia (Authors' estimation based on Fishman et al., 2015). Based on the water footprint of these crops as reported in Fishman et al. (2015), we estimated the annual water footprint for irrigated crop production in South Asia as shown in Figure 3.

Although growing wheat requires a relatively small amount of water, the annual water footprint of total wheat production in the region is relatively large. In South Asia, it is equivalent to 170 billion cubic meters (BCM)/year, the second largest user of irrigation water. As discussed earlier, wheat is the second staple food in South Asia and its production covers more than 40% of the irrigated area in the region. The largest annual water footprint is accounted for by rice, which is equivalent to 384 BCM/year. Sugarcane production has the third largest annual water footprint in South Asia. Country level analysis shows that each country has different characteristics of annual water footprint for irrigated agricultural crop production. For example, in Bangladesh, more than 96% of irrigation

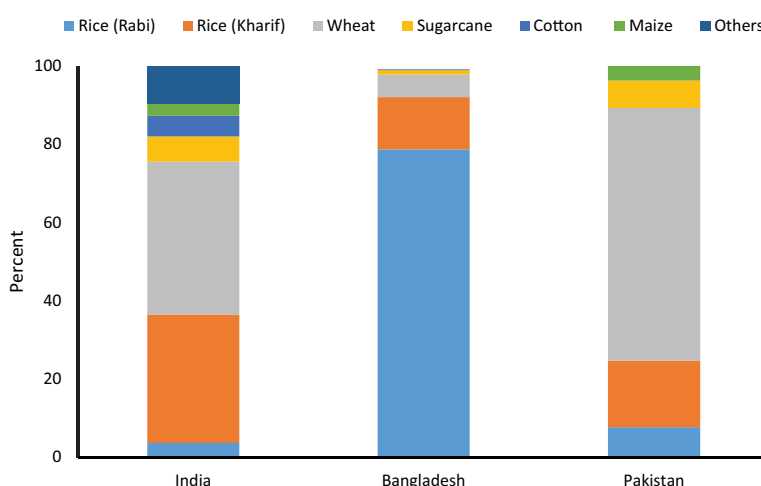


Figure 2 Irrigated area covered by major crops in South Asia^{2,3}
(Source: National statistics of respective countries)

² Rice grown during the winter season is called Rabi Rice.

³ Rice grown during the wet season is called Kharif Rice.

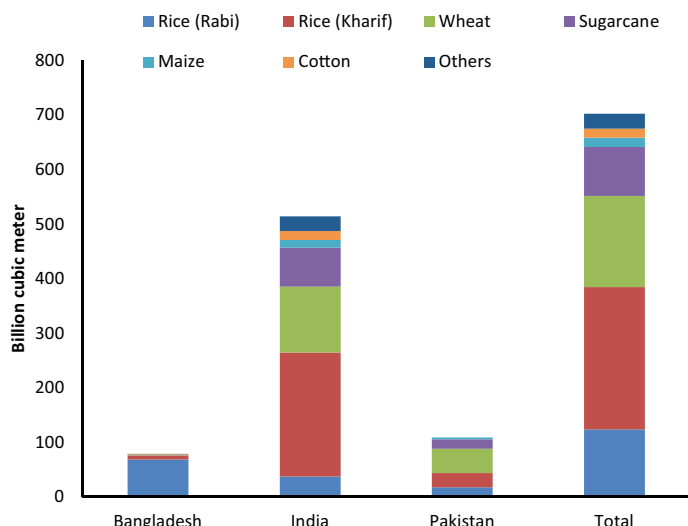


Figure 3 Annual water footprint for irrigated crop production in South Asia
(Source: Authors' estimation)

water is used for rice cultivation, whereas in India and Pakistan, rice cultivation uses 50% and 40% irrigation water, respectively. Wheat cultivation uses 23% and 40% of irrigation water in India and Pakistan, respectively (Figure 3). This discussion shows that irrigated agriculture in India and Pakistan is relatively diversified compared to Bangladesh, where rice cultivation dominates irrigated crop production.

3.2. Use of traditional flood irrigation systems for watering crops despite poor efficiency

Water supply to agricultural fields in this region is dominated by a low efficiency flood irrigation system.

In South Asia, 97% of the total irrigated cropland still uses flood irrigation because it is the cheapest method (Figure 4). However, its WUE is as low as 35%, equivalent to half of the WUE of sprinkler systems and nearly one third of the WUE of drip irrigation systems. The present area under efficient irrigation systems including both sprinkler and drip irrigation is only 3% of total irrigated land, which is very low compared with selected OECD countries, Eastern Europe and even Central Asia and Sub-Saharan regions (Figure 4). It indicates there is huge potential for a large-scale expansion of micro irrigation in South Asia.

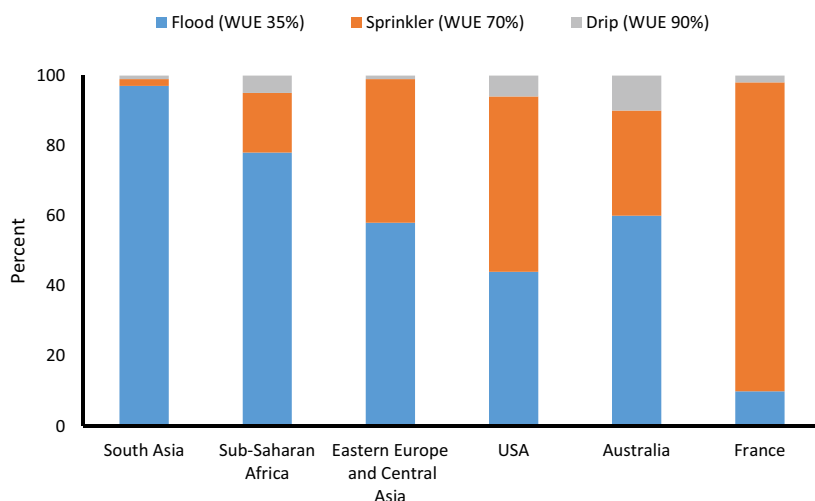


Figure 4 Methods of irrigation water application in South Asia and other regions
(Source: Prepared by Authors based on WRI and Rabobank, 2008)

3.3. Subsidised electricity tariff for agriculture irrigation encourages overuse of water

The price of electricity is one of the main drivers of amount of water used for growing crops. To secure both food security and farmers' livelihoods, electricity is supplied at a subsidised tariff for agriculture in most of the South Asian countries. In Bangladesh, India and Pakistan electricity supply subsidies to irrigate cropland are about 55%, 41% and 23%, respectively

(Taheripour et al. 2016). This subsidised tariff has been blamed as one of the main factors of low irrigation WUE in the South Asia region (Gulati and Pahuja, 2015). This subsidised electricity supply for irrigation encourages expansion of water intensive crop cultivation with low efficiency irrigation systems, which leads to inefficient use of irrigation water and intensifies water scarcity.

4 Ways to improve irrigation WUE in South Asia

There are two ways to improve WUE in agriculture: reducing water consumption by growing low water-demand crops, and improving the WUE of the irrigation water supply. The first option requires replacing water-intensive crops with low water-consuming one. The second option would be achievable by promoting a water efficient irrigation supply system, and introducing improved management practices at farms.

4.1. Recommend crop diversification to reduce the share of water intensive crops

Rice is the main agricultural crop in South Asia. However, the rice cropping system is under threat owing to a shortage of water resources, and will not be sustainable as the region will face a shortfall of water by as much as 40% over the next couple of decades (IGES 2013). Therefore, enhancing crop diversification with low water-intensive crops such as gram, barley, jowar, soybeans, and groundnuts can help to mitigate the water shortage, particularly in the

water-stressed zones. The data in Table 1 indicates that shifting from rice cultivation to other crops would save a large amount of water. For example, gram, jowar, bajra, barley, wheat, and maize cultivation require 84%, 73%, 73%, 73%, 70%, and 57% less water than for rice cultivation, respectively.

However, large-scale shifting from a rice-monoculture system to a non-rice crop system may conflict with traditional food habits. To avoid this conflict we recommend to conduct a detailed spatial assessment to identify water-stressed hotspots where actions will be most urgent, and to identify crop diversification alternatives for these hotspots that are high value but low water-consuming and also region-specific. Growing high valued crops will raise per capita income, so purchasing ability will be improved. Reduced availability of local staple foods could be filled by purchases from outside of the local area or imports. The success of crop diversification will also require various measures to

Table 1 Water requirements for the cultivation of various crops

Crops	Water requirement (m3/ha)	% change in water requirement compared to rice
Gram	2400	- 84%
Jowar	4000	-73%
Bajra	4000	-73%
Barley	4000	-73%
Wheat	4500	-70%
Maize	6500	-57%
Soybean	6700	-55%
Rice	15000	

Source: Author's estimation based on Fishman et al. 2015

minimise the potential risk for farmers, such as financial investment for new infrastructures, building capacity of farmers to grow new crops, providing incentives to grow low water-consuming crops and ensuring a market for the new crops.

4.2. Promoting water-saving technologies in agriculture

There are several available options to improve WUE in the field including no tillage farming, adjusting the water supply depending on the crop's growth stage, uniform distribution of water in the field and promoting micro irrigation to minimise water loss in the system. Some of these options can improve WUE at no or low cost such as no tillage, but the extent of reduction in overall water consumption is negligible. Therefore, other options of WUE improvement including micro irrigation and levelling of the field surface for uniform water distribution would play a key role to improve WUE to a satisfactory level. These are, however, relatively more costly options.

In a previous study, Fishman et al. (2015) reported on the suitability of different water-saving technologies for different crops. Their report concluded that micro irrigation is not an appropriate solution for wet land rice cultivation, which is the pre-eminent crop in South Asia. However, sprinkler irrigation is suitable for most of the major crops in the region. It indicates that sprinkler irrigation has a greater potential towards a water smart agriculture in the region. Drip irrigation is suitable for only

three major crops: cotton, groundnuts and soybeans, which cover a small portion of the irrigated area in the region.

Use of laser levelling at the land preparation stage could save a large amount of water. Many field level studies in this region showed that laser levelling of the fields alone could generate savings of up to 20-30% for irrigation water.

Figure 5 shows the total potential of irrigation WUE improvement with the above mentioned three water saving options in Bangladesh, India and Pakistan, separately. In Bangladesh, more than 90% of irrigated land is covered by rice cultivation, indicating that the potential role for micro-irrigation for WUE improvement is very limited, unless the cultivated crop could be diversified away from rice. Laser levelling of fields could contribute to a 20% improvement of irrigation WUE, but micro irrigation could account for only 1% at most in Bangladesh. Both in India and Pakistan, wheat, which is suitable for water efficient sprinkler irrigation, is cultivated in a large portion of the irrigated area. Therefore, sprinkler irrigation has a greater potential to increase irrigation WUE from current levels (below 40%) to a satisfactory level (more than 60%) compared to other methods. Utilisation of the full potential of micro irrigation and laser levelling in rice cultivation irrigation would improve WUE by 31% in India and 28% in Pakistan (Figure 5).

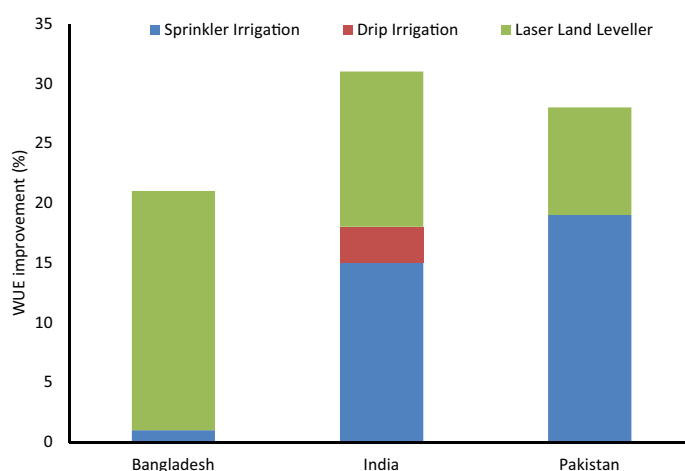


Figure 5 Potential of irrigation WUE improvement using water-saving technologies in South Asian countries
(Source: Author's estimation)

5 Potential sources of investment for WUE improvement in South Asia

The previous section demonstrated that adoption of water-saving technologies would save 20-31% of water used for irrigation in South Asian countries. Given the huge potential of WUE improvement in irrigated agriculture, one good thing is that water-saving technologies are mature and ready to be adopted on a large scale. In fact, a number of favourable policies are already being implemented to promote WUE in agriculture in South Asian countries. For example, India has introduced subsidy schemes for sprinkler irrigation and drip irrigation, but mainly for horticultural crops, which account for only a small part of the water used in agriculture.

Additional efforts therefore will be needed for large-scale WUE efficiency improvement, and a major investment will be required to use the full potential of WUE in the region. Using an advanced computable general equilibrium model, a recent study estimated the capital investment cost for different levels of WUE (Taheripour et al., 2016). Estimates from that study indicated that Bangladesh, India and Pakistan would need USD 0.5 billion, USD 4.7 billion, USD 1.4 billion, respectively, to improve WUE by 20%. To improve WUE by 30%, the required capital investment would increase to USD 1.1 billion, USD 10.6 billion and USD 3.2 billion, respectively, in these three countries. These estimations also showed that WUE improvement

would increase GDP for some levels of investment, after allowing for the opportunity cost of the resources allocated (Figure 6). The analysis shows that GDP rises more than the costs for investments of up to a 20% improvement in WUE. However, the cost of further investment increasing WUE from 20% to 30% would be greater than the increase in GDP.

Additional investment is always a great challenge for developing countries, given limited financial resources. It is also unlikely that private investment for irrigation in these countries would increase substantially because of various constraints including a low water price, market distortions and country-specific risks, especially political, that are not easily mitigated. Therefore, this paper suggests the following possible sources of investment for WUE improvement.

5.1. Transferring subsidy from electricity for pumping water to irrigation WUE improvement for capturing multiple benefits

Governments in South Asian countries provide major subsidies for the electricity used to pump irrigation water. This not only increases the financial burden but also leads to inefficient and unsustainable use of energy and water resources, while the region is struggling to achieve water and energy security. The financial burden on the national budget due to power

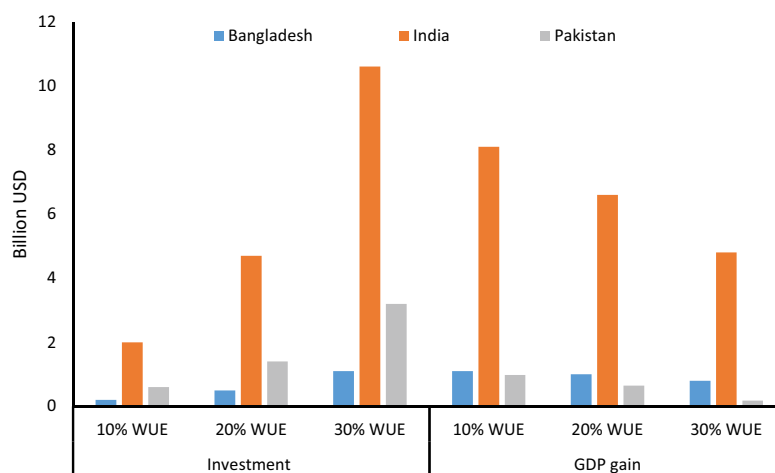


Figure 6 Economic implications of WUE improvement in South Asian countries
(Source: Prepared by authors based on Taheripour et al., 2016)

subsidies for running water pumps is nearly USD 5 billion in India and USD 36 million in Bangladesh per year⁴. Such large subsidies encourages farmers to over use water, which leads to the depletion of finite water resources and low efficiency of energy use. In South Asian countries, removing this subsidy from agriculture would be politically sensitive, because it is directly linked with farmers’ livelihoods and also to national food security.

A policy to shift the subsidy amount from the electricity supply to WUE improvement could become a win-win solution for both the government and farmers. This new allocation of subsidies could generate multiple social and environmental benefits including increased crop production, water saving, energy saving, increased overall income for farmers,

reduced stress on water resources, GHG emissions reduction which will contribute to overall GDP growth of the country as shown in Table 2.

For example, currently, Indian farmers receive USD 5 billion in subsidies resulting in low electricity tariffs for pumping irrigation water. This amount is sufficient to pay for the necessary investment to improve WUE improvement by 20%. Shifting the subsidy amount from electricity supply to WUE improvement would have a positive impact on GDP, resource management and climate change mitigation. Estimates have shown that a 20% increase WUE efficiency in India would increase GDP by USD 6.6 billion, while also saving 102 billion m³ of water and 82,000 GWh of electricity, as well as reducing CO₂ emissions by 72 million tons, as shown in Box 1.

Table 2 Impact of WUE improvement resulting from shifting subsidies from electricity supply to directly support WUE improvement in agriculture

Beneficiaries	Variable	Indicative impact
Farmers	Crop yield	+
	Water cost	-
	Electricity cost	+
	Income	+
Government	Financial cost of subsidies	-
	Food Security	+
	Energy security	+
	Economic growth	+
Environment	Balance between water availability and demand	+
	GHGs emission reduction	+

Source: Prepared by authors

Box 1. Utilisation of full potential of micro irrigation in India would result in

USD 6.6 billion increased in GDP	102 billion m ³ water saved	82000 GWh electricity saved	CO ₂ emissions reduced 72 million tons
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⁴ The subsidy amount was calculated based on the following formula:
 Total power subsidy for irrigation= (Generation cost of electricity-Tariff for irrigation use) X Agriculture sector electricity use

5.2. Introduce mutually beneficial compensation mechanism for WUE improvement in agriculture

Water is an essential input for industrial production and power generation. It is likely that South Asia's industrial and power sectors will grow rapidly in the coming decades. However, water may become a critical limiting factor for the future growth of both sectors, unless appropriate measures are taken immediately. Sectoral conflicts over water have already been reported in some places in this region.

Governments in the region have already introduced regulatory measures to improve WUE in the industrial and power sectors. For example, India has introduced legally binding limits on water use for cooling thermal power plants. In order to meet the new limit, existing power plants will need major retrofitting, resulting in significant financial costs. Dharmadhikary (2016) estimated that, USD 3 billion would be needed for retrofitting old power plants as well as for new power plants of the country's largest power company, National Thermal Power Corporation Limited (NTPC).

Introducing a mutually beneficial compensation mechanism would provide a win-win solution among major water users including agriculture, industry and power plants. Under this mechanism, which involves water rights trading, the industry or thermal power sectors would provide financial compensation to the farmers to adopt water-saving technologies, and in return they will use saved agricultural water for industrial production and electricity generation. Financial compensation could be paid to farmers in the form of a subsidy for water-saving technologies. From an economic perspective, purchasing the rights to water use may be a cheaper option for industries

to secure their water supplies, but this could have significant negative environmental effects if it is not properly regulated and monitored. Water right trading should be regulated and institutionalised both at national and local level for effective development of financial compensation mechanism between agriculture and no-agriculture water users.

5.3. Opportunity for private investment in agricultural WUE improvement

Private investment has played a major role in delivering inclusive growth in agriculture. Private investment accounts for about half of the total agricultural water investment (WRI and Rabobank, 2008). As noted in earlier sections, major investment will be required for WUE improvement in South Asia, including water efficient technology intervention and marketing, infrastructure development. It is also necessary to provide training and capacity building for farmers. The importance of WUE is recognised in national and global agendas, and policies have been initiated to provide incentives for WUE improvement, which will create large private investment opportunities in the region. However, financial support from multilateral banks and other donors has declined for agricultural irrigation and, developing countries have limited financial resources and overstretched public finances. Private investment is already playing a significant role in financing overall inclusive growth in agriculture, so scaling up of private investment would also play a vital role in financing agricultural WUE improvements. Creating an enabling policy environment that would reduce risks and provide a positive signal to encourage private investment in agricultural WUE improvement is essential to upscale current efforts.

6 Conclusions

It is likely that the development in South Asia, the world's fastest growing region, will be hindered due to increasing pressure on water. The way water is used, particularly in agriculture, is the major determinant of water demand in this region. If the prevailing inefficient and excessive water usage in agriculture is not changed, water scarcity will lead to an inefficient water supply for other users, resulting in a decline in food production and economic growth. This policy brief shows that the dominance of the water intensive rice crop, use of a low efficiency flood irrigation system and subsidised electricity supply for pumping irrigation water are the major causes of the agriculture sector's high water footprint in South Asia's major economies. Therefore, some policy changes are essential, together with other technical measures to reduce agricultural water demand. This policy brief suggests the following measures to improve irrigation water use efficiency in South Asia:

- i. Crop diversification should be enhanced to promote low water-intensive crops such as gram, barley, jowar, soybean, groundnuts, particularly in water-stressed zones. For this, a spatially-detailed assessment is critical to assess where action will be most urgent.
- ii. Given the huge potential of irrigation water use efficiency in South Asia, adopting suitable water-saving technologies including micro irrigation and laser land levelling, together can improve water use efficiency by almost twice the current levels. When the costs of adopting water-saving technologies are too onerous for farmers in South Asia, economic incentives such as subsidies for water-saving technologies should be considered for all major crops.
- iii. The subsidy programmes for WUE improvement can be financed by a policy of shifting the subsidies from electricity supply to water-saving technologies. Introducing a financial compensation mechanism using water rights trading between agriculture and other users can also help to generate financing for the WUE improvement subsidy programme.
- iv. As the private sector plays a vital role in the overall inclusive growth of agriculture, scaling up of private investment will play a critical role in financing WUE improvements in agriculture. Creating an enabling policy environment that would reduce risks and provide a positive signal for private investment is essential to upscale current efforts to improve WUE.

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