AGWATER SOLUTIONS

Improved livelihoods for smallholder farmers

REGIONAL ANALYSIS OF MOTOR PUMPS

Potential for expansion in South Asia

JULY 2012

Introduction

South Asia (SA), including India, Pakistan, Bangladesh, Sri Lanka, Nepal, and Bhutan, is one of the most populous regions in the world. Agriculture is the backbone of the economies of SA nations and is the main source of livelihood for many rural poor households.

While parts of SA have experienced considerable agricultural sector growth in the last half-century, many other regions, including large parts of eastern India and Bangladesh, have lagged behind. Many farmers face water scarcity due to both physical constraints as well as lack of adequate water storage and management.

Inability to access or control water has a direct impact on agricultural productivity and reduces the potential payoff from other productivity-increasing inputs such as fertilizers and improved seed varieties. Furthermore, climate variability is one of the most influential factors affecting agricultural production, and long-term climate change raises concerns about the future feasibility of irrigated agriculture in the region.

A number of measures for improved agricultural water management have the potential to increase productivity and improve the well-being of poor agricultural producers in the region. Motor pumps are one example of a promising agricultural water management technology. These pumps generally consist of either diesel or electric engines coupled with a low-lift centrifugal pump.

The major advantage of motorized pumps is their considerable capacity relative to traditional water-lifting means, making it possible to expand irrigated surface areas. Their flexibility to move among different water sources and many farmers is another advantage. Disadvantages include high capital costs, high recurrent costs, high maintenance levels, and the emission of greenhouse gases.

Methodology

This brief is based on a study that uses an integrated modeling system that combines geographic (GIS) data analysis and predictive modeling tools to assess the regional potential for smallholder agricultural water management in Sub-Saharan Africa and SA.

It focuses on the potential for the expansion of motor pump–based irrigation throughout SA and includes an assessment of the impacts of climate change on the application potential of the technology.

The assessment process includes two components: ex-ante GIS and predictive modeling analyses. The ex-ante analysis uses a set of suitability criteria to identify areas where the technology could potentially be applied, pixel by pixel, across the region. The formulation of assessment criteria and the scoring scheme were developed through expert consultations and validation and reflect the best available expert knowledge. For motor pumps, the environmental suitability criteria for ex-ante GIS analysis are shown in Table 1.

A pixel with a score greater than 55 is considered to have irrigation potential. The application areas derived from the suitability analysis were also compared with the labor-constrained application areas obtained from rural population analysis at the basin level; the minimum of the two application areas in a river basin was selected as the final ex-ante estimates for the areas with irrigation potential in the river basin.

The results derived from the ex-ante GIS analysis are further refined through hydrological and crop simulations using the Soil and Water Assessment Tool (SWAT). SWAT is a hydrological and agricultural model that evaluates the long-term impacts of water and land management practices on water availability, water consumption, and yield of cultivated crops.

The agricultural system in SA is already intensively irrigated, and we consider that the expansion and intensification of irrigation in SA is primarily constrained by the physical scarcity of water. In this assessment, we first use the SWAT model to account for renewable water resources in SA river basins and water consumption over existing irrigated land, which in turn allows for an estimation of the amount of water resources that are still exploitable for irrigation.

Based on the estimates of exploitable water resources for irrigation and other information—including irrigation water-use intensity, rural population, and production costs—the potential for the expansion of motor pumps is calculated.

Table 1. Ex-ante GIS analysis criteria for motor pupmps in SA

Criteria for motor pumps	Scoring scheme
FAO fluvisols	False = 0, 1 - 15 % = 11, 16 - 50 % = 22, 51 - 100 % = 33
Groundwater	Safe = 0, Semi-critical = 0, Critical = Excluded, Over-exploited = Excluded, Restricted = Excluded, Saline = Excluded
Market access	5 km = 10 minutes = 34, 10 km = 20 minutes = 22, 20 km = 40 minutes = 11, 30 km = 60 minutes = 0, 60 km = 120 minutes = 0
Distance to surface water	< 0.5 km = 33, > 0.5 km = 0

Key assumptions in the predictive modeling assessment include the following:

- *Cultivation of Particular Crops*. Motor pump–based irrigation will be used for the cultivation of a limited set of crops based on evidence from field studies (rice, tomatoes, and onions during the winter season; a cultivation area ratio of 100:1:1 is assumed).

- *Water Availability*. The water balance is accounted for at a river basin scale. Exploitable water resources in a river basin are calculated as the runoff during the winter (dry) season plus safe yields of groundwater (m^3H_2O/yr) (average rate of groundwater recharge, m^3H_2O/ha-yr × basin area, ha) and adjusted for existing irrigation water use and environmental needs.

- *Production and Irrigation Costs*. Costs assumed for the estimation of costs and benefits of the intensification of motor pump–based irrigation are shown in Table 2.

Table 2. Irrigation and production costs

Irrigation costs-capital (US$/ha/yr)	Irrigation costs-other (US$/ha/yr)	Production costs (US$/ha/yr)
280	80	180 (rice), 1,000 (tomatoes and onions)

Potential for expansion of ex-situ water harvesting in SA

The ex-ante results show that motor pump-based irrigation has the potential to be expanded to 8.5 million ha in the region and reach 55 million people, with the largest potential in Bangladesh, central and eastern India, and Pakistan. The results are shown in Figure 1 and Table 3. The area is relatively low compared to other interventions as a result of the limited set of crops considered.

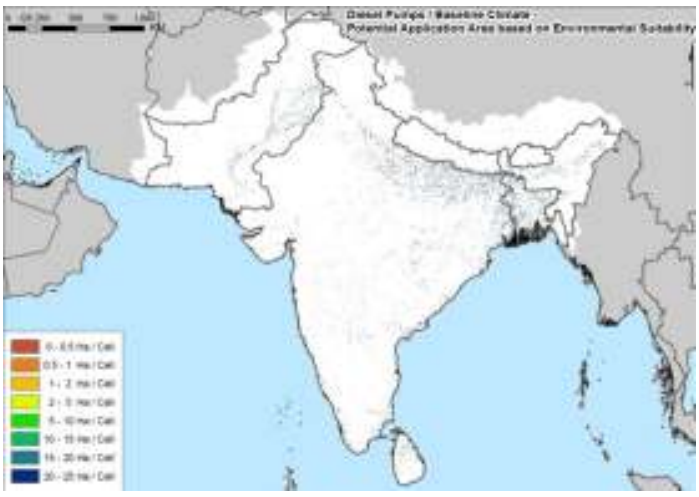

Figure 1. Suitable area for expansion of motor pump irrigation, ex-ante results
Source: IFPRI Team

Table 3. Ex-ante potential for motor pump-based irrigation in SA, assuming 100 percent adoption

	Area (thousand ha)	Population reached (thousand)
Bangladesh	1,147	6,739
Bhutan	250	2
India-Central	1,746	19,692
India-Eastern	2,369	14,511
India-Far-East	457	2,800
India-Northern	246	1,509
India-Southern	809	4,956
Indian-Western	339	2,076
Nepal	250	1,562
Pakistan	931	8,492
Sri Lanka	226	1,358
South Asia Total	8,521	54,697

Source: IFPRI Team

Taking river basin hydrology, environmental constraints, yield improvements, and costs of the investment into account results in lower potential for adoption of motor pumps in the region compared to the ex-ante assessment.

The results of the SWAT assessment for motor pump–based irrigation are summarized in Table 4 and Figure 2 for the baseline scenario. The results indicate a potential area expansion of 6.5 million ha, which is considerably less than the area potential shown in the ex-ante analysis.

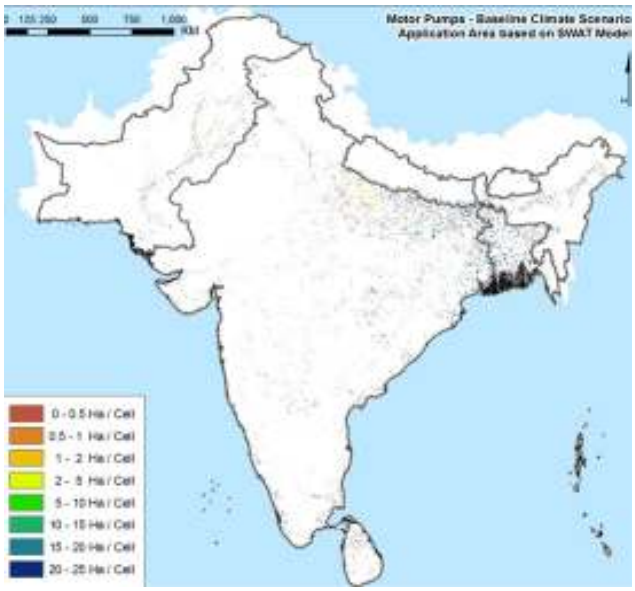

Figure 2. Suitable area for expansion of motor pump irrigation, SWAT results
Source: IFPRI Team

Table 4. Predictive modeling results for the potential expansion of motor pump-based irrigation, baseline results (no climate change)

	Area (thousand ha)	Population reached (thousand)	Net revenue (US$ billion/yr)	Water consumption (billion m3/yr)	Water consumption increase (%)
Bangladesh	1,266	7,436	0.3	6.2	56.8
Bhutan	0.2	2	0.0002	0.001	4.5
India-Central	854	5,231	0.5	5.8	4.2
India-Eastern	2,259	13,837	1.8	13.0	19.8
India-Far-East	415	2,539	0.3	2.1	62.2
India-Northern	56	341	0.03	0.3	0.3
India-Southern	761	4,664	0.7	4.8	5.9
Indian-Western	339	2,074	0.3	2.3	4.2
Nepal	238	1,490	0.1	1.6	28.9
Pakistan	81	740	0.05	0.5	0.9
Sri Lanka	241	1,445	0.2	1.0	15.1
South Asia Total	6,510	39,800	4.3	37.6	6.9

Source: IFPRI Team

The total number of people reached is reduced to 40 million, compared to 55 million in the ex-ante assessment. Total net revenues as a result of the expansion of motor pump–based irrigation throughout the region would be US$4 billion per year.

This expansion would be accompanied by a significant increase in water consumption. The total increase in water consumption as a result of the expansion of motor pump–based irrigation in SA is estimated at 38 billion m^3/yr.

To investigate the impacts of climate change on the potential application of motor pump–based irrigation across SA, results were also estimated under two climate scenarios projected by the CSIRO-Mk3.0 model (Csia), using the SRES A2 emission scenario; and the MIROC 3.2 medium resolution model (Mira), using the SRES A1B emission scenario. In a preliminary analysis, the two scenarios were identified as the "driest" and "wettest" scenarios, respectively, among 12 future climate change scenarios projected by general circulation models for SA.

The results (Table 5) show that, under the dry scenario, the estimated application area decreases by 1 million ha; while under the wet scenario, the application area increases by 1 million ha.

Conclusions

This assessment combines geographic (GIS) data analysis and predictive modeling tools to assess the regional potential for the expansion of motor pump–based irrigation in SA.

The estimated expansion area could reach almost 7 million hectares and 40 million people in rural areas, and generate $4.3 billion in net revenue per year.

A constraint on groundwater availability, assuming "no overdraft" was assumed for this intervention. Further adoption of motor pumps in SA will increase rural incomes and agricultural production, but it will also raise tension in water allocation and undermine the sustainability of aquatic environments. To address concerns associated with pump expansion, regulations and policies that help to internalize externalities of irrigation development should be developed hand in hand with further investments in this area.

Table 5. Predictive modeling (SWAT) results for the potential expansion of motor pump-based irrigation under climate change

	Baseline	Csia	Mira
Area (thousand ha)	6,510	5,365	7,151
Population reached (thousand)	39,800	33,032	43,762
Net revenue (US$ billion)	4.3	3.0	3.5
Water use (billion m^3)	37.6	32.6	40.2
Water consumpion increase (%)	6.9	6.0	7.4

Source: IFPRI Team

Note: Results shown are for all of SA. Climate factors were not part of the ex-ante analysis criteria for motor pumps.