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Transforming Agrifood Systems in South Asia

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Solar Irrigation for Agricultural Resilience

The energy-irrigation nexus in Bangladesh

Implications of rapid rural electrification on informal groundwater markets

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ABOUT THIS NOTE

This brief provides a summary of research and findings on the impacts of rapid rural electrification in Bangladesh on the informal water markets during the last decade and how these markets in turn have affected irrigation access among smallholder farmers. The note emphasizes the importance of energy sources in determining the nature of groundwater access in Bangladesh, where groundwater remains central to irrigated agriculture and food production.

KEY STUDY FINDINGS

1. There has been a rapid substitution of diesel pumps by electric pumps between the period 2010 and 2018.
2. Share of the water buyers from diesel pumps significantly reduced from 70% to 55%, between 2011 and 2018, and for electric pumps, it significantly increased from 21% to 41%, during the same period.
3. After the rapid electrification of pumps, the competition among pump owners led to a reduction in prices and therefore average irrigation costs for buyers between 2011 and 2018.
4. Share of farmers who use groundwater sources increased from 52% to 56%, between 2011 and 2018.

BACKGROUND

- Despite being a country with limited land and high population density, Bangladesh has achieved food self-sufficiency since the 1990s.
- Diesel-based groundwater irrigation facilities were instrumental in achieving self-sufficiency in food production.
- Majority of the farmers in Bangladesh rely on the informal groundwater market to access irrigation facilities.
- The last decade saw a sharp increase in rates of rural electrification, including pump electrification, as well as increases in diesel prices and the emergence of new restrictive regulations on groundwater use.
- All of these factors, particularly, the changes in energy access and pricing affect the functioning of informal groundwater markets in Bangladesh.

CONTEXT

The newly independent Bangladesh faced considerable food security challenges in the 1970s but emerged as food self-sufficient by the late 1990s – a no mean feat for a country with one of the highest population densities and lowest per capita land ownership (Mukherji et al., 2021). The intensification of agriculture through Green Revolution technologies such as HYV seeds and irrigation was instrumental in this transformation (Mottaleb et al., 2015). The production of rice and wheat doubled from the 1970s to the 2020s due to agricultural intensification, including expansion in the area, as well as yields of crops (BBS, 2018; Mottaleb et al., 2019). Irrigation played an important role, and much of that irrigation was from groundwater through diesel operated shallow tube wells (STWs) (Mitra et al., 2021). The number of STWs has increased since the mid-1980s due to a plethora of policies in support of groundwater extraction including relaxation in import norms for agriculture machineries. Unique institution of informal water markets emerged where diesel STW owners sold irrigation services to farmers who did not own STWs, and in the process, benefits from irrigation could be accessed even without investing in groundwater extraction mechanisms (Rahman et al, 2015).

Diesel-run STWs still remain the main source of irrigation in Bangladesh, but starting from the early 2010s, the country has seen a sharp increase in rural pump electrification. The decade of the 2010s also saw emerging concerns regarding groundwater sustainability (Krupnik et al., 2017; Bhattacharjee et al., 2019), and new restrictions such as well spacing norms, and permits for groundwater wells were re-introduced. The last decade also saw sharp increase in diesel prices (Sajid, E., 2021). Against the backdrop of these changes, in this note, we examine how energy use affects the composition of who gets access to water through informal water markets with a particular focus on smallholder farmers.

DATA AND METHODOLOGY

We use the panel data corresponding to the years 2011 and 2018 generated by the Bangladesh Integrated Household Survey (BIHS) which provides nationally representative data for rural Bangladesh. It contains detailed information at the plot level on agricultural production and practices. For example, the crop level

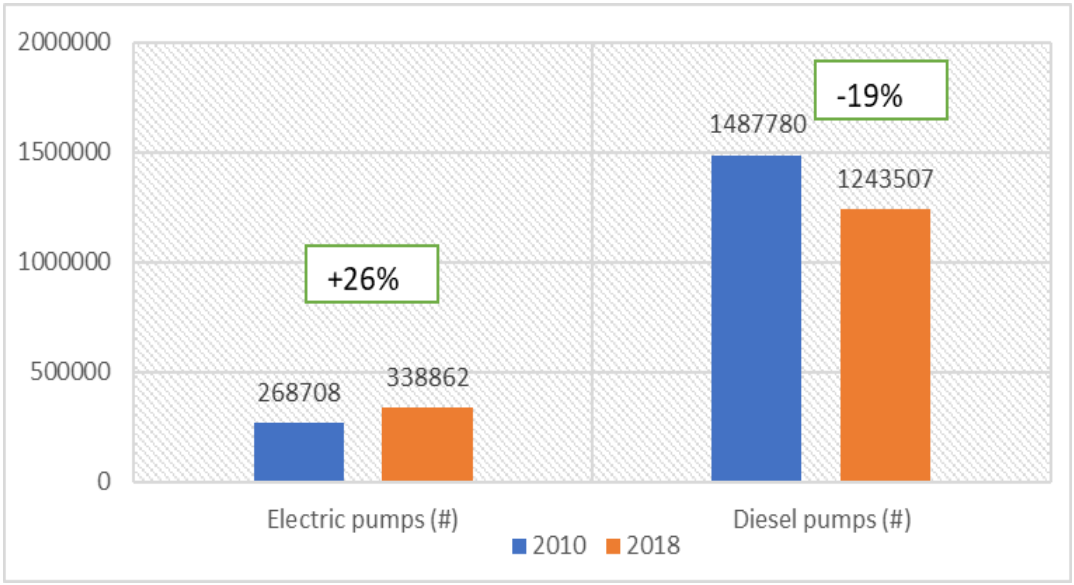
information provides details on sources of irrigation water, irrigation method, energy used for irrigation, payment method of irrigation, and the imputed value of the cost of irrigation. This information helps in identifying who buys water, from which source, and at what cost. A key limitation of BIHS is that it does not identify the water sellers. In addition to BIHS, we also compiled district-level data from the Minor Irrigation Survey report for the corresponding years.

Changing energy irrigation nexus in Bangladesh

The crucial role of irrigation facilities in achieving food self-sufficiency in Bangladesh is well documented, and it shows that diesel-based irrigation played a pivotal role in this transformation (Mottaleb et al., 2019). However, a sharp increase in diesel prices from 0.63 USD per liter in 2010 to 1.02 USD per liter in 2020 has had implications on diesel usage in the irrigation sector. This coupled with pro-active drive for rural electrification led to a large substitution of diesel pumps by electric pumps between 2010 and 2018 (Figure 1).

On the other hand, during this period, new restrictive regulations for groundwater access in Bangladesh emerged in the form of *Upazilla* Permits. This was in addition to existing policies such as National Water Policy (1999) and Bangladesh Water Act (2013).

Figure 1: Trends in electric and diesel pumps in Bangladesh



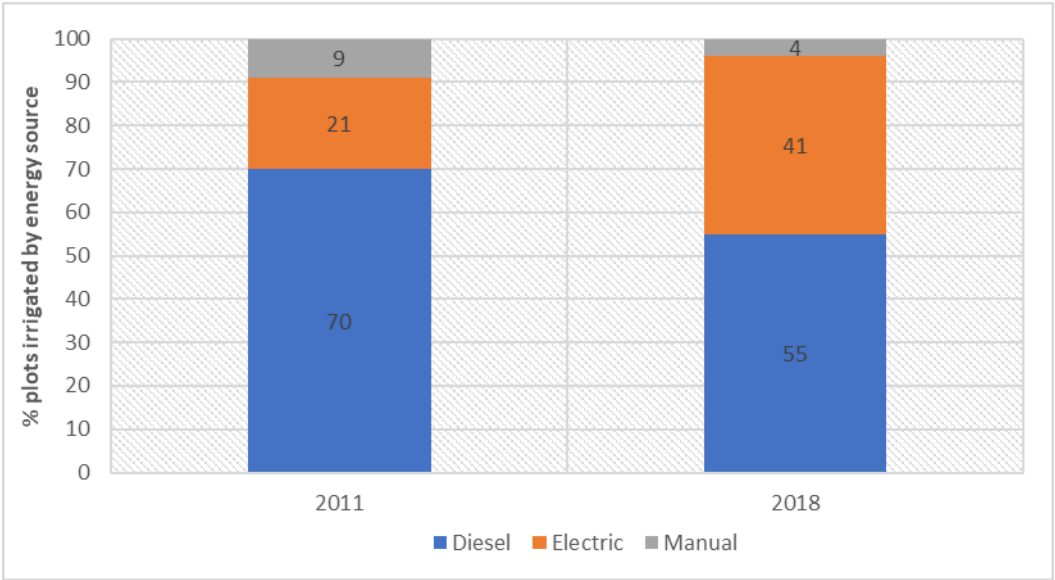
Source: Minor irrigation census report, 2010 and 2018

These include *upazilla* permits, well spacing norms, and the mandatory requirements for clearances for electricity connections. These regulations materially regulate access to and use of electric pumps, but they do not affect diesel pumps. These provide two opposing factors impacting electrification of pumps in Bangladesh. However, Bhattacharjee (2019) showed that these regulations are lagging in terms of effective implementation in terms of giving permissions, ensuring extraction limits, regular monitoring, and mandating recharge mechanisms. The number of electric pumps has increased significantly from 2,68,708 to 3,38,862 (a 26% increase) between 2010 and 2018. In contrast, the number of diesel pumps declined from 1.48 million to 1.24 million (a 19% decline) (Figure 1).

Implications for water markets

We now turn our attention to how the substitution of pumps has affected groundwater irrigation markets in terms of energy mix. In Bangladesh, the majority of the farmers rely on informal water markets to access irrigation facilities. 80% of all farmers buy irrigation facilities from these informal groundwater markets. Using BIHS, Figure 2 presents the distribution of water buyers by the energy source of pumps and shows that diesel-based irrigation service providers are replaced by electricity-based irrigation service providers. In particular, between 2011 to 2018, the percentage of water buyers who purchase diesel-based irrigation services fell from 70% to 55%.

Figure 2: Composition of water buyers, by energy source of pumps



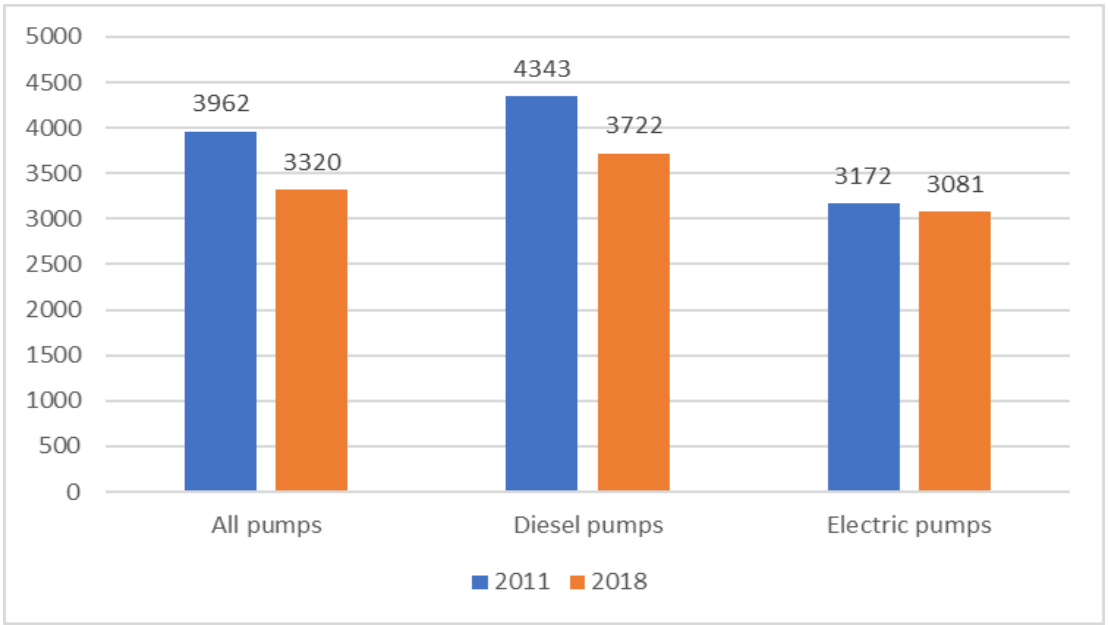
Source: BIHS 2011 and 2018

In contrast, the percentage of water buyers who purchase electric-based irrigation services increased from 21% to 41%. These statistics suggest a clear substitution of irrigation service providers from diesel to electric pumps.

Implications for irrigation access

Irrigation accounts for nearly one-fifth of the cost of cultivation (Mainuddin et al., 2021). To assess the change in the cost of irrigation for farmers over the last decade, we compare the average price paid by water buyers to access irrigation for *boro* rice cultivation (in *taka*/acre at 2010 prices), for 2011 and 2018. Note that, we cannot adequately interpret these simple comparisons as the causal effect of the rapid electrification of pumps within the limits of this data set. Nonetheless, these statistics are useful for examining the overall trends in the price of irrigation after the rapid electrification of pumps and provide important insights. Figure 3 shows that the average price of irrigation price paid by water buyers has fallen from 3962 to 3320 taka/acre between 2011 and 2018. The average price of irrigation from electric pumps fell from 3172 to 3081 taka/acre, between 2011 and 2018. However, we also see this decline in the case of diesel pumps where the price of water for buyers has fallen from 4343 to 3722 taka/acre during the same period, despite the rising price of diesel.

Figure 3: Irrigation price paid by water buyers for boro rice cultivation (Taka/Acre at 2010 prices)



Source: BIHS 2011 and 2018

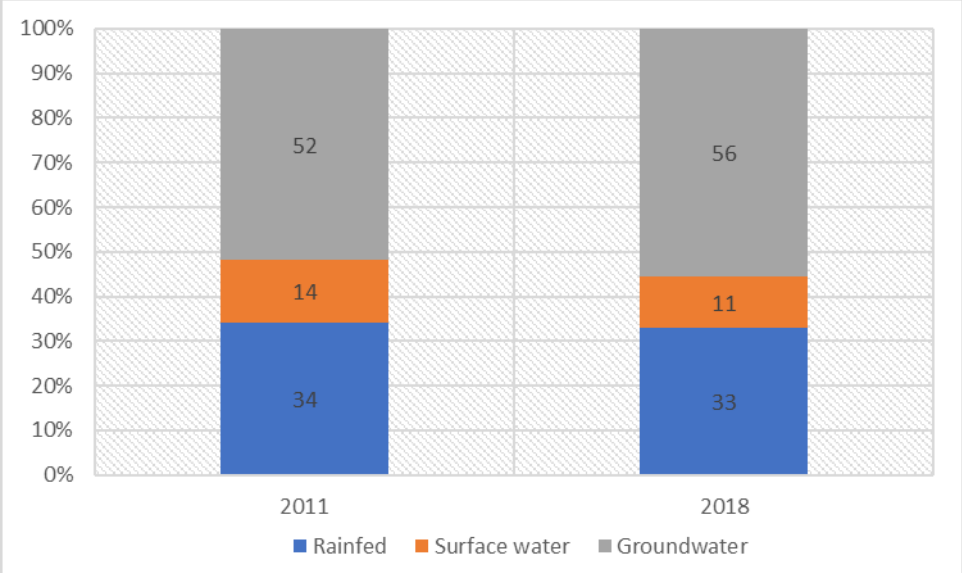
A study by Mottaleb et al. (2019) on informal water markets in Bangladesh could hold the answer to this conundrum as they showed that competition among pump owners is an important factor in determining the choice of irrigation services and hence prices. Mottaleb et al. (2019) also showed that the irrigation service providers gross irrigation service revenue is significant. Therefore, we argue that this fall in average price is a result of more competition among pump owners.

However, this has potential implications for profitability of irrigation service provision for water sellers, i.e. decline in prices for irrigation water while cost of diesel increased, reveals a potential loss of revenue or declining profit margins for diesel pump owners and water sellers. This may offer some indication towards motivations for electrification for pump owners. However, this suggested implication needs further exploration for establishing a causal linkage, which this secondary database does not allow.

Implications for Groundwater extraction

Groundwater is a key source of irrigation, and about 79% of the cultivated area is irrigated by groundwater (Qureshi et al., 2014). Using BIHS, we compare the sources of water for irrigation over the period 2011 and 2018. Figure 4 shows a significant change in the sources of water for irrigation over the period suggesting farmers are shifting away from the surface to groundwater.

Figure 4 : Tends in the source of water for irrigation, % farmers



Source: BIHS 2011 and 2018

In particular, there was a significant change in the number of farmers who reported groundwater use (52% to 56%), surface water (15% to 11%), and rainfed (34% to 33%). To corroborate the above findings, we also tried to look at the trends in deep tube well and found a substantial increase in the number of deep tube wells from 33670 to 37634 (an 11% increase), over the period 2010-11 and 2018-19. Therefore, it is likely that the electrification of tubewells and the declining cost of irrigation over the period may have resulted in increased dependence on groundwater irrigation and thereby increased groundwater extraction. A study by Qureshi et al. (2014) using data from Bangladesh Development Water Board showed that areas with water tables less than 8m depth had increased significantly over time, while another recent study by Shamsudduha et al. 2023 showed that there has been longer term declines in water levels in 2/3rd of observation wells, while the remaining 1/3rd had no such trend.

Conclusion and way forward

Until 2010, diesel-based irrigation Until 2010, diesel-based irrigation services played a major role in providing irrigation services to smallholders and accounted roughly three-fourth of the water market. However, during the last decade, the situation has significantly changed, and only 55% of the water buyers now rely on diesel-based irrigation facilities and the rest on electricity-based irrigation facilities. We suggest that a potential increase in competition among pump owners after the rapid electrification of pumps could have resulted in the decline of average prices of water.

Although, access to cheaper irrigation facilities is very important from the perspective of farmers' welfare. However, on sustainability grounds, the transition from diesel-based pumps to electric-based pumps is not a permanent solution. It is only the first step toward the transition away from diesel-based pumps. Given that, the power sector in Bangladesh is already under stress and largely dependent on imported diesel and natural gas and projections suggests that it will deplete by the next decade (Das et al., 2020).

Therefore, policymakers should consider renewable energy options such as solar irrigation to address the accessibility of irrigation facilities and the sustainability of the power sector (Mukherji, 2022). To address groundwater sustainability, as argued by Mitra and Mukherji (2022) grid-connected solar pumps can play an instrumental role by providing incentives to farmers for the judicious use of water.

While the above study has provided important insights into the shifting energy-irrigation nexus in Bangladesh and highlights the importance of further empirical exploration into the following research questions a) has the sharp increase in fuel prices cause led to the substitution of diesel pumps and rapid electrification of pumps? b) how have these new regulations on well spacing and permits for new wells affected the rapid electrification of deep tubewells and what role has it played in the substitution of diesel pumps? and c) to what extent has this increase in fuel price and new regulations affected the relative profit of water sellers as (dis)incentives for rapid electrification of pumps? Under the TAFSSA initiative, these questions will be explored through a field-based primary survey of the energy-groundwater nexus in Bangladesh in 2023.

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ABOUT TAFSSA

TAFSSA is One CGIAR regional integrated initiative to support actions that improve equitable access to sustainable healthy diets, improve farmers' livelihoods and resilience, and conserve land, air, and water resources in South Asia. For more details about the initiative see https://www.cgiar.org/initiative/20-transforming-agrifood-systems-in-south-asia-tafssa/

ABOUT SoLAR

Solar Irrigation for Agricultural Resilience (SoLAR) is a South Asia regional initiative involving Bangladesh, India, Nepal, and Pakistan, implemented by IWMI and funded by the Global Programme of SDC. The project aims to support the climate-compatible development of energy and water systems in rural South Asia for resilient livelihoods. For more details see: https://solar.iwmi.org/

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