Environmental and economic impacts of agrivoltaics in Bangladesh

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- This brief explores findings from a study focusing on the potential of agrivoltaics in Bangladesh by estimating the upstream impacts on employment, emissions, land, and wage levels using an input-output model for the following sources: coal, gas, oil, hydropower, nuclear, solar, and agrivoltaics.
- Our research indicates that agrivoltaics will positively impact the creation of low-skilled and medium-skilled jobs and are expected to yield the smallest gender employment gap compared to other energy sources.
- Agrivoltaics are projected to require less land for energy than fossil fuels, offering a more sustainable and land-efficient approach.
- This policy brief highlights a potential alternative to fossil fuels: setting up agrivoltaic systems in less fertile and single-cropped land to achieve Bangladesh's 40% renewable energy target by 2041. The methodology used encapsulates key considerations within the food, energy, and environment nexus and provides policymakers with a framework that clearly presents the implications of energy choices.

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Policy motivation

Bangladesh, like many countries worldwide, finds itself at an energy crossroads. The country is poised to rise to middle-income status, which has implications for its energy needs. However, the prevailing low per capita energy intensity, low employment rates, and challenges in foreign exchange reserves mean that Bangladesh must choose how to address these needs. These choices have implications for local air pollution, affecting levels of pollutants such as sulphur dioxide (SO2) and nitrogen oxides (NOx), as well as for global climate change through carbon emissions. More importantly, within the context of the Bangladeshi economy, it has implications on employment and land intensity. Together, these factors capture the health, economic, environmental, and climate change implications of different energy pathways.

The government of Bangladesh (GoB) has expressed interest and made pledges, as reflected in several plans, to adopt more renewable energy sources. Some plans have been put in place to achieve this target by expanding energy generation from solar, wind, and nuclear sources. The Mujib Climate Prosperity Plan, an initiative undertaken by the GoB, aims to transform Bangladesh's future by promoting sustainable development and environmental resilience. The goal is to raise the share of renewable energy to 40% by 2041. By 2020, the GoB aimed to have 10% of its energy mix come from renewable sources (Chowdhury, 2023). However, the current renewable energy production is around 1205.87 MW, comprising just 4.12% of the total energy (SREDA 2024).

The existing land policy drafted by the Government of Bangladesh in 2016 bars agricultural land use for non-agricultural purposes such as energy generation or industrial development. Considering the growing need for renewable energy sources and the constraints on agricultural land in Bangladesh, it is worth exploring the possibility of adopting a dual-use system, where agricultural land for solar panel installation while continuing the production of crops that require less sun exposure and have shorter growth cycles. The dual use of less fertile, low-yielding, single-cropped agricultural land for setting up agrivoltaics holds promise for transitioning towards renewable energy without disrupting land productivity. Additionally, it offers opportunities for farmers to generate income from electricity production and creates local employment opportunities related to the solar panel market. Shade-tolerant crops such as garlic, onion, and yardlong beans are best suited for agrivoltaics. Apart from facilitating land optimisation through dual use, agrivoltaics have also been shown to reduce irrigation needs and soil erosion while improving carbon dioxide uptake (Barron-Gafford et al. 2019).

Sustainable sources of renewable energy can provide numerous advantages for densely populated and developing nations like Bangladesh. Bangladesh is densely populated, with extensive demand for land for agricultural purposes. The study proposes agrivoltaics as a viable option to meet Bangladesh's growing energy demands without hampering agricultural production. Establishing solar panels is more land-intensive compared to other renewable options. One of the obstacles to the growth of agrivoltaics in Bangladesh continues to be rigid policies. Any suitable land that can be used for growing food crops cannot be put to use for any other activity outside farming. Due to this, land acquisition for solar or other related projects has become challenging.

The study aims to demonstrate the potential of agrivoltaics and advocate for policy reforms allowing solar panel installation on less fertile agricultural land. This can address energy needs sustainably while supporting agricultural productivity and economic growth.

Overview of the research

This research aims to investigate the direct and upstream impacts of agrivoltaics and the practice of growing crops under solar panels in Bangladesh through employment, land usage, water resources, greenhouse gas emissions, and co-pollutants. Additionally, it assesses the comparative impacts of agrivoltaics with other energy options available in Bangladesh, including coal, gas, oil, hydropower, nuclear, and conventional solar power, considering both direct and broader economy-wide effects. The study aims to influence policy development, presenting agrivoltaics as a viable solution, addressing concerns about low per capita energy consumption, transitioning to middle-income status, and meeting renewable energy targets. The findings have been derived using the Input-Output (IO) method and data from the General Economic Division (GED) of the Planning Commission of Bangladesh. The methodology used encapsulates key considerations within the food-energy-environment nexus and provides policymakers with a framework that presents the implications of energy choices,

As the continuation of this macro-level study, the BRAC Institute of Governance and Development (BIGD) is planning to conduct an impact study at the micro-level to assess the effects of implementing agrivoltaics on farmers, local employment opportunities and the development of markets related to the parts and production of solar panel machinery and goods.

Key findings

Using an Input-Output (IO) Model, the study employs a dollar-for-source approach to analyse the upstream impacts across dimensions, including employment, land use, gas emissions, and wage levels. We also disaggregate

employment data by gender and skill levels for each energy source, including coal, gas, hydropower, solar, nuclear, oil, wind, and agrivoltaics.

Impact on employment

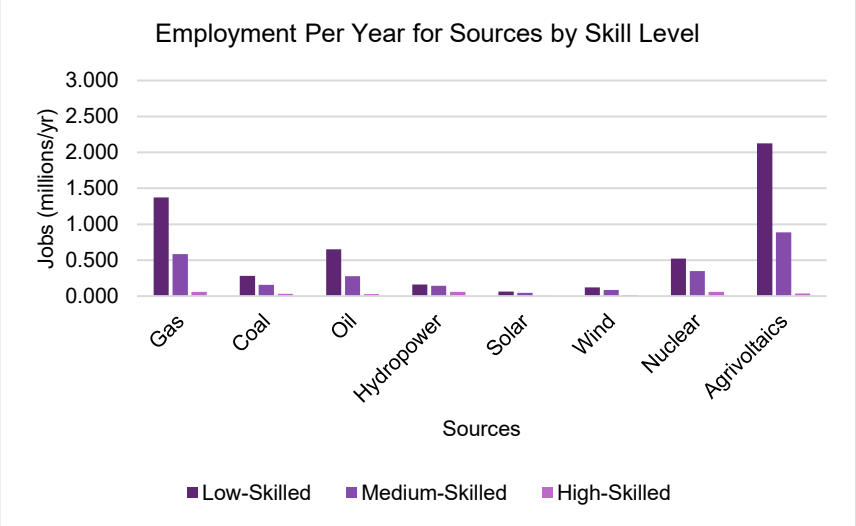
To understand the effects on employment, we assume a 10,000 MW increase in capacity for each energy source by 2041. We find that agrivoltaics has the potential to employ more people per year compared to unit power generated under existing sources. We also find that for every 10,000 MW increase in power generation, agrivoltaics projects the highest levels of male and female employment compared to other sources.

In terms of direct employment, solar generates less employment relative to fossil fuel sources, as the latter involves land works and more construction. This issue is addressed by agrivoltaics, where agriculture generates employment, as it remains one of the most labour-intensive sectors. The labour intensity value for agrivoltaics is estimated at 6.7x10-9 million jobs per dollar, which is higher than that of solar (1.7x10-10 million jobs per dollar).

Impact of agrivoltaics on wage distribution

Our research indicates that agrivoltaics are poised to have a notable impact on the employment landscape, particularly in terms of low-skilled and medium-skilled labour (see Figure 1). Specifically, it is projected to create opportunities for approximately 2.12 million low-skilled workers and 880,000 medium-skilled workers annually. In comparison, the next highest contributor, gas, is anticipated to employ 1.37 million low-skilled workers and 580,000 for medium-skilled roles. However, the number of high-skilled workers for agrivoltaics is expected to remain similar to other sources, at 35,000 per year.

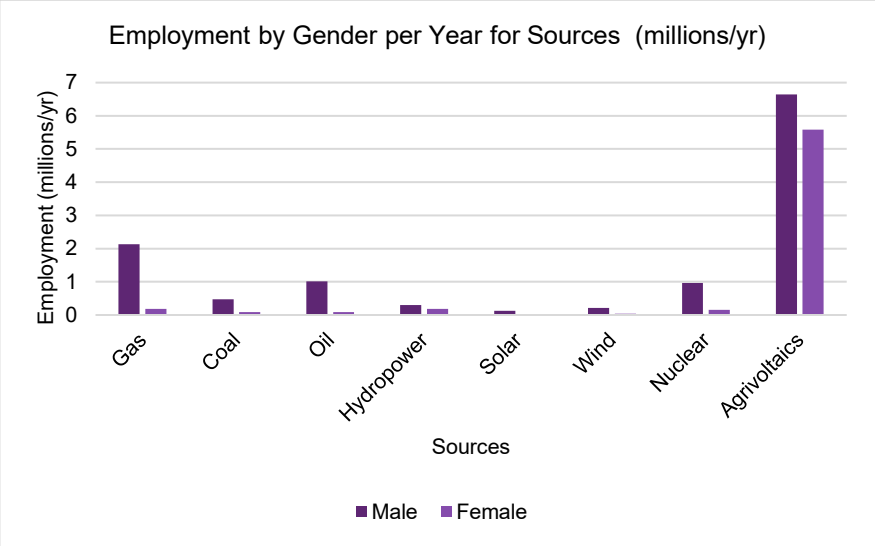
FIGURE 1: Annual job input from different fuel sources disaggregated by skill level (millions/year)



Empowering women in energy employment

Agrivoltaics is projected to yield the smallest gender employment gap compared to other energy sources, with only a 16% difference between male and female employment (see Figure 2). In contrast, the difference in employment rates between men and women is much larger in oil and gas, reaching 91%. We see that employment under power generation tends to be male-dominated. Pursuing agrivoltaics reduces the gender gap, which is expected, as agriculture is one of the primary sources of employment for women. These values are for the formal sector. There is significant potential for employment generation in the informal sector through agriculture, particularly benefiting women in Bangladesh (Asian Development Bank 2010). Therefore, the actual gains for women and the gender gap are potentially even lower under agrivoltaics than what is found in this study.

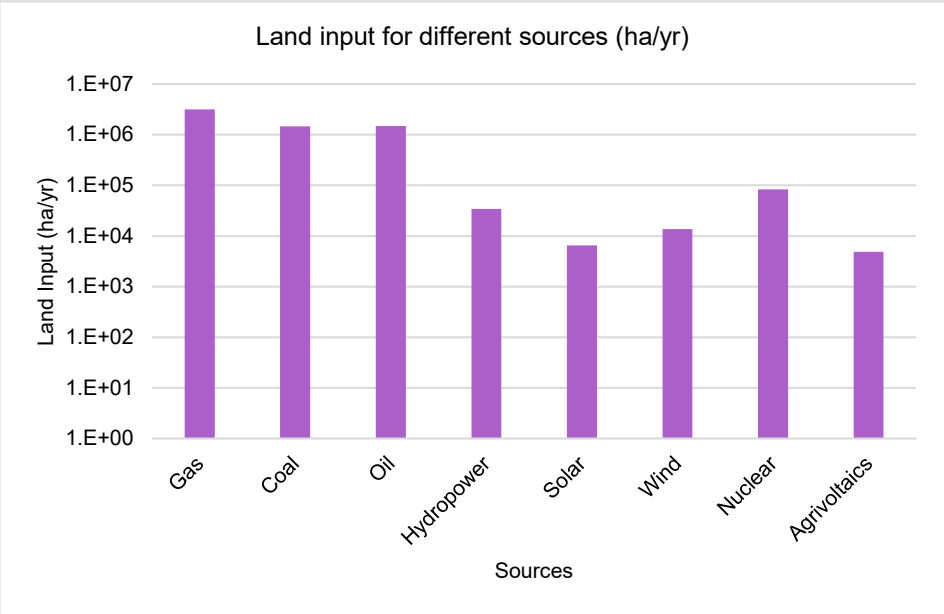
FIGURE 2: Annual job input from different fuel sources disaggregated by gender (millions/year)



Land efficiency in energy production

Though direct land use shows solar to be more land intensive than fossil fuels, when analysing upstream impacts, we see that this is no longer true. Land intensity, particularly when considering land use from upstream activities, shows agrivoltaics to be the least land-intensive option. Figure 3 shows that the land input required for agrivoltaics stands at 4,845 hectares per year, significantly lower than that for fossil fuels.

FIGURE 3: Annual land input from different fuel sources (ha/year)



Policy implications

The study demonstrates that adopting agrivoltaics could be a promising approach to help Bangladesh achieve its renewable energy targets. Several specific policy implications emerge from this finding, including:

1. The land policy draft by the Government of Bangladesh in 2016 discourages the use of agricultural land for non-agricultural purposes like industrial or infrastructural development. The findings indicate relaxing this policy in using low-yield, less fertile, and single-crop agricultural land for agrivoltaics could be beneficial.
2. Assess the impact of agrivoltaics on the yield of different crops over different seasons in Bangladesh and consider different land-sharing agreements and incentives for farmers and solar producers to promote uptake.
3. Incorporate agrivoltaic systems into broader national energy strategies and land-use planning efforts to maximise their potential benefits and minimise potential conflicts with agricultural practices.

By implementing these policy recommendations, Bangladesh can harness the potential of agrivoltaics to advance its renewable energy goals while promoting sustainable agriculture and rural development, without putting additional pressure on land use. With this study, we encourage the government to reconsider the paradigm that there is a trade-off between agriculture land use and increasing capacity for renewable energy.

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