# Potential of agrivoltaic production systems to alleviate poverty within resource poor communities in dryland areas

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**Abstract.** This opinion paper briefly describes the potential value of agrivoltaic systems for resource poor smallholder farmers in dryland areas of Central and West Asia and North Africa, with general applicability to regions that are characterized by similar environments for economic, policy and climate related challenges. Agrivoltaic systems - where both food and energy is produced from the same plot of land – provide an avenue for improving optimality in crop production, improving water use efficiency and productivity, potentially reducing the pressure on grasslands through intensive livestock production systems, improving soil health; and delivering much needed energy to support primary production and value added activities.

## INTRODUCTION

As the world population continues to grow, the global energy demand is expected to double by the mid-century (Adeh et al., 2018). This calls for including more renewable forms of energy. There has been a lot of push to use bioenergy as one of the main sources to alleviate this problem; however, bioenergy is not sufficient to meet increasing demands (Santra et al., 2017). Not only is bioenergy incapable of fulfilling all of society's energy requirements, but its demand for land to replace fossil fuels greatly exceeds the available cropland area (Santra et al., 2017). While PV also requires a large amount of land, it shows the largest potential as these systems generate the greatest amount of power per area in terms of land-use efficiency when compared to other sources of renewable energy (Hernandez et al., 2014). A further benefit of solar energy is that it can be obtained in a few different ways. The majority of the global demand for PV can be achieved by adding panels to existing rooftops or by integrating it directly into buildings (Dinesh and Pearce, 2016). This can help decrease the competition for land use between energy and agricultural sectors.

As the use of PV panels becomes increasingly more common, the cost to purchase the panels have decreased by 10% per year over a 30-year period and solar energy production has increased by 30% per year (Adeh et al., 2018). This decrease in cost and increase in production aids in making PV a more realistic option as the benefits of solar energy are better studied. Additional positives of solar energy include reduced carbon dioxide gas emissions, helping the country in the international energy market, a strengthened economy, added job opportunities, stabilization of degraded land, and an overall improved quality of life (Adeh et al., 2019, Hernandez et al., 2014). Solar energy not only improves human quality of life, but it can also help improve crop and animal lives. For example, the panels can serve as shelter for grazing animals, but also for birds who can build their nests there (Hernandez et al., 2014). Additionally, a higher soil moisture achieved by the installation of PVPs can be a more water efficient means of farming, leading to a significant increase in late season biomass of forages (Santra et al., 2017). Because of findings like these, the study of agrivoltaics is becoming more common.

Resource-poor rural populations in dry areas of the world derive a major share of their livelihoods from subsistence-level crop and livestock farming activities. Smallholder farmers and agropastoralists play a key role in rural development and in supporting local food systems including affordable animal-sourced food sources. Food produced by smallholder farmers accounts for 70–80% of the world's total food production and is critical for meeting the demands of increasing populations within the developing world. However, the sustainability and resilience of smallholder farming continues to be threatened by climate change, degradation of natural resources, poor infrastructure, political instability, and generally a lack of enabling economic and social environments to support profitable and efficient production systems.

Risk of disaster from natural causes (landslides, flooding, mudflows) is intertwined with ‘poor’ land use and grazing management practices. In post-Soviet Central Asia, poor management of land and water use together with a depleted forest base has increased the vulnerability of rural communities to damage from spring floods that result from intensive rainfall and snowmelt. Three key factors - deforestation, unsustainable land-use and extensive grazing contribute to the occurrence and severity of disasters within this mountainous environment. While not as acute, a similar set of challenges and circumstance persist in North Africa and West Asia. These are exacerbated by price subsidies, exchange rate and trade policies which have led to the persistence of production systems that are heavily oriented towards the production of cereals (mainly wheat). This has necessarily resulted in unsustainable farming practices and degradation of land and water resources through extensive cultivation on marginal lands.

## POTENTIAL BENEFITS OF AGRIVOLTAICS FOR RURAL COMMUNITIES IN DRYLAND AREAS

Agrivoltaics production system has several benefits, including improving crop production, the environment, energy production, land productivity, and livelihoods of farmers. As AV is considered a complex system, it is more resilient to climate change than monocultures are (Dupraz et al., 2011). While it is more complex than monocultures, it does provide a more stable environment. The solar panels allow for the shading pattern to remain consistent yearly, which prevents competition for below-ground resources (Dupraz et al., 2011). The excess shading helps to save 14-29% water, which is especially beneficial for dry season, severe drought, and water limited areas (Dinesh and Pearce, 2016, Adeh et al., 2018). One common characteristic of dryland production systems within developing and transitional economies, such as in the regions of interest for this paper, is strong crop-livestock interactions and more specifically strong interlinkages between crop production, livestock rearing and effective pasture management. Agrivoltaic systems, within these environments, can potentially alleviate a number of significant challenges to productivity, profitability and asset wealth (in the form of healthy livestock):

- Intensive cultivation of feed crops on marginal lands, under the cover of solar panels, can limit the need for extensive grazing on mountain pastures thereby permitting regeneration, or at the least, a decline in degradation without having to reduce the amount of land under nationally strategic crops (enforced in some cases by edicts).

Potential for ‘modernizing’ management practices of grazing areas exists, in so far as a move towards extensive ranch and/or community-based rangeland management systems but requires further investigation and targeted investments for proof of concept. Equally important is the potential for protecting biodiversity through the use of seed aisles for threatened species, in line with the need for contextually relevant climate change adaptation strategies.

• Poor access to electricity and other fuel sources for heating and cooking has naturally led to deforestation within these regions. Improved access to electricity, through renewable solar energy could potentially reverse the rate of deforestation, provide for improved livestock health and productivity through access to shade in the summer and provide communities with opportunities to expand value added (processing) activities through the creation of cottage and niche industries.

• Within these regions, access to electricity to support pumping of irrigation water (surface; groundwater) is limited by erratic supply both in terms of consistency in supply as well as quality of electricity supplied (voltage spikes or under voltage supply). Dual use of solar panels for production of food and feed crops together with more reliability in electricity supply is of critical importance in supporting both resilience and sustainable intensification of agricultural production systems.

• Based on current energy production and consumption statistics, if 0.0004%, 0.0015% and 0.0001% of agricultural land is converted to agrivoltaics in Central Asia, West Asia and North Africa, respectively, the energy produced could potentially meet the demand of populations within these regions (Table 1).

**TABLE 1.** Land area required for conversion to agrivoltaics to meet energy demand in CWANA region.

| Region | Energy production (TWh) | | Area to be converted to agrivoltaics | |
|---|---|---|---|---|
| | Carbon based[1] | Green energy | $km^2$ | % area |
| Central Asia | 1.8 | 0.05 | 15 | 0.0004% |
| West Asia | 11 | 0.25 | 92.5 | 0.0015% |
| North Africa | 2 | 0.01 | 17 | 0.0001% |

[1]https://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE?locations=US-CN

Agrivoltaic systems hold significant promise for facilitating a paradigm shift in land use management practices, consistent with effective measures for adaptation to both short-term fluctuations in weather and long-term climate change. This necessarily includes more stable environments for production, and well-being within communities, through reduced exposure to the risk of natural hazards that are interlinked with poor land use management practices. While significant interest and evidence is being built within developed economies, there is urgent need for international investment in testing the potential benefits for agrivoltaics within many dryland production environments in resource poor economies.

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