

Despite these limitations, the study contributes to the increasing evidence about vegetable farming under protection in Nepal by offering household level information from an important vegetable producing area. In line with the suggestions of Lamichhane et al. (2023), future research should evaluate the long term economic, environmental, and climate resilience benefits of protected cultivation across different production systems and agro ecological zones. Comparative analysis of vegetable farming in plastic tunnels versus open fields, along with cost-benefit and value chain analysis would provide stronger evidence to support policy formulation and investment decisions. Such research would enhance understanding of how protected cultivation can contribute to sustainable agricultural commercialization and improved rural livelihoods in Nepal.

5 Conclusion and Prospects

The study assessed the role of plastic tunnel vegetable farming in household income generation and livelihood enhancement among farmers in Meghang Rural Municipality, Nuwakot. Plastic tunnels provide a favourable environment for crops to grow even in off-seasons with better quality and fetch high market prices. The findings suggest that tunnel-based vegetable farming is associated with higher reported income and perceived livelihood improvement among surveyed farmers.

The major findings from the survey are, tomato is the dominant crop grown inside tunnels with Sirjana being the major variety, most of the farmers use medium sized 6*12-dimension plastic tunnels, while 90 GSM plastic sheets are commonly in use. Most farmers practice drip irrigation and mulching to control weeds and maintain soil health. The products are mostly sold via middlemen or cooperatives, with a reported annual income of < 1 lakh to > 3 lakh depending on scale of farming. The income contributed to household expenditure such as food, education, healthcare and agricultural inputs, and savings. Overall, Plastic tunnels helped farmers overcome seasonal production limitations, produce them during times when open field cultivation is quite challenging and continuing the supply of vegetables in off-seasons to fetch higher market prices.

However, farming in Meghang Rural Municipality is affected by several challenges. Firstly, farmers expressed significant concerns regarding high initial cost for tunnel constructions which limits smallholder's ability to expand production. Secondly, access to quality inputs like seeds, fertilizers, organic manure, and other inputs remains unstable. Moreover, insufficient technical trainings and extension services affect pest and disease management and resource use efficiency. In addition, the lack of organized markets leads many farmers to rely on middlemen, weakening their bargaining power. Due to these obstacles in farming, smallholder farmers may not fully benefit from protected cultivation.

The future progress of tunnel based vegetable farming in the study area requires strengthening collaboration among local governments, cooperatives, financial institution, agriculture extension departments, and farmers to establish more stable mechanism for input supply, technical training, low-interest loans, and market linkages. Cooperative marketing, product grading and packaging, collective transportation, and connections with urban markets should also be emphasized to reduce dependence on middlemen and improve farmers' bargaining power.

Further studies should include larger sample sizes, cost benefit analysis, net income calculations, input-output ratios, and comparative studies of tunnel versus open field farming systems. This would help address the limitations of the present study which is based only on descriptive cross-sectional data and would also enhance the academic rigor of the paper.

Author's contributions

Aayushma Poudel conceptualized and designed the study, led the field work, performed the data analysis and prepared the manuscript. Krish Rauniyar helped in editing, data validation and manuscript revision. Chandani Begam and Asmita Oli assisted in field work, data collection and analysis. Bishnu Prasad Bhattarai supervised the data collection and contributed to data analysis and interpretation. All authors read and approved the final manuscript.