

vegetable intake has grown from 60 kg to 128.04 kg (Gyawali et al., 2022). An estimated 3,243,521 households cultivate vegetables, with women leading 17% of these households (CASA, 2020).

Despite the growing significance of vegetable farming in Nepal, production is highly influenced by seasonal climate changes, particularly in the mid-hills and high-hills of Nepal. Farmers often face challenges such as disease and pest outbreaks, heavy rainfall, frost, low temperature and limited production opportunity during off-seasons. These challenges impact crop yield, market supply and profitability. Therefore, the adoption of protected cultivation technology including plastic tunnels has emerged as a potential approach to mitigate climatic constraints and boost vegetable production.

Growing out of season crops in a controlled environment within plastic tunnels is generally referred as tunnel farming. Usually, this kind of farming is employed to grow summer vegetables during the off seasons (Sarmah et al., 2022). With the use of these protected cultivation technologies, farmers can design controlled environments that are suited to the unique requirements of their crops, increasing crop quality, productivity, and resource efficiency. The most popular type includes shade houses, polyhouses, greenhouses, and others (Rana and Sahu, 2024). These structures help regulate temperature, conserve soil moisture, protect crops from frost, excessive rainfall and wind damages. These structures reduce the impact of adverse weather conditions and provide favourable environment, improves crop quality, fetch higher market price and extend production periods. According to Atreya et al. (2020), Nepal's estimated 1,000 hectares of protected farming, 70% are used for vegetable production and 30% are used for fruit and flower cultivation.

Protected vegetable cultivation is especially important for small holder's farmers in the mid-hill areas of Nepal, where restricted land and climate uncertainties hinder year round yields. Tunnel production allows farmers to cultivate high value vegetable crops like tomatoes, cucumbers, leafy greens with optimum utilization of land and resources. Studies have shown that tunnel technology contributes to improved crop productivity and supports livelihood improvement by increasing production opportunities and strengthening income generation among smallholder farmers (Kc et al., 2021).

Meghang Rural Municipality in the Nuwakot district is emerging as a significant area for vegetable production under tunnel technology. Due to favourable agro-climatic conditions and the growing farmers interest in protected vegetable cultivation, the area has been recognized as a vegetable production zone under the National Agriculture Modernization Program (NAMP). However, few studies have investigated the socio-economic impacts of plastic tunnel vegetable farming at a local level, particularly regarding farmer's production practices, marketing systems, and how they utilize the income generated for their livelihoods.

Therefore, this study aimed to assess the contribution of tunnel based vegetable farming to household income and livelihood improvement among smallholder farmers in Meghang Rural Municipality, Nuwakot. This study examined farmer's socioeconomic characteristics, tunnel production practices, vegetable marketing channel, income generation and major constraints affecting vegetable production.

2 Materials and Methods

2.1 Study area

The study was carried out in Meghang Rural Municipality, Nuwakot (Figure 1). Meghang is a Rural Municipality located in Nuwakot District of Nepal, it has total 6 wards and 98 square kilometers of geographical area, according to 2011 census, it had total population of 13,479 (Karki, 2019). The data was taken from 5 different wards namely, Panera (ward No.6), Samari (ward No.5), Kimtang (ward No.4), Deurali (ward No.3), Bungtang (ward No.2).

The research area represents a mid-hill agro ecological setting ideal for commercial vegetable cultivation. The area has a temperate climate with seasonal changes, where cold winter temperature and significant rainfall during the monsoon season frequently impact open-field vegetable cultivation. These climatic constraints lead farmers to utilize protected methods like plastic tunnels to prolong the growing season and enhance crop yield.