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Cost-Benefit Analysis of Modern Vegetable Farming in Bhaktapur DistrictSurya Prasad Poudel

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ABSTRACT

Modern vegetable farming presents a promising solution to the challenges facing traditional agriculture in Nepal, including low productivity, unsustainable input use, and environmental vulnerability. Despite its potential, adoption remains limited, especially in peri-urban districts like Bhaktapur. This study aims to assess the economic viability of modern farming methods for three high-value vegetables: tomato, cauliflower, and radish. The research employed a Cost-Benefit Analysis (CBA) framework to evaluate profitability using Net Present Value (NPV) and Benefit-Cost Ratio (BCR) indicators. Primary data were collected from 25 farmers in Madhyapur Thimi and Suryabinayak through structured surveys and field observations. Sensitivity analyses were conducted to assess how variations in price, cost, and yield affected profitability under modern farming systems. Findings revealed that all three crops were profitable, with cauliflower achieving the highest BCR (4.12) and NPV (NPR 525,940), followed by tomato and radish. Cauliflower demonstrated the greatest resilience to cost and yield fluctuations. Tomato had the highest gross income but required the largest investment. Radish, while profitable, was more sensitive to input cost and market price changes, making it less stable in adverse conditions.

The results confirm the economic advantage of modern vegetable farming and support prior studies advocating for improved agricultural techniques. However, the underutilization of these methods in Bhaktapur suggests structural and informational barriers that need addressing. This study provides localized evidence supporting the promotion of modern vegetable farming in Nepal. Policy support in the form of subsidies, credit access, training, and market infrastructure is essential to scale adoption. Future research should explore behavioral and institutional factors influencing technology uptake among farmers.

1. INTRODUCTION

Agriculture continues to serve as a cornerstone of Nepal's economy and a critical source of livelihood for the majority of its population. Despite employing over 60% of the labor force and contributing 24.1% to the national GDP, the sector is constrained by low productivity, unsustainable practices, and poor resilience to environmental change (MOALD, 2022; World Bank, 2023). Traditional farming methods, characterized by labor-intensive operations, excessive use of chemical inputs, and inefficient water management, have led to declining soil quality, reduced yields, and increased vulnerability to pests and climate-related shocks (FAO, 2022).

Amid these challenges, vegetable farming has emerged as a dynamic subsector offering economic potential, particularly in peri-urban districts such as Bhaktapur. Located within the Kathmandu Valley, Bhaktapur benefits from favorable agro-climatic conditions and strong market connectivity, making it a hub for vegetable production. Vegetables such as tomato, cauliflower, and radish not only provide higher returns than traditional cereal crops but also support multiple harvests per year (FAO, 2022; UNDP, 2021). However, the intensifying pressure on land, coupled with the need for efficient resource use, has prompted a re-evaluation of conventional practices in favor of modern agricultural technologies.

Modern farming practices—often encapsulated by terms like precision agriculture and sustainable intensification—incorporate techniques such as improved seed varieties, drip irrigation, integrated nutrient management, and protected cultivation systems (Zhang et al., 2002). While these practices demand greater initial investment, they offer the promise of increased productivity, cost-efficiency, and environmental sustainability (Tilman et al., 2002; Pretty, 2008). Nevertheless, widespread adoption among Nepalese farmers remains limited due to knowledge gaps, financial constraints, and unclear evidence about their cost-effectiveness under local conditions.

To support informed decision-making and encourage evidence-based policy and practice, a comprehensive evaluation of modern vegetable farming systems is essential. In this context, cost-benefit analysis (CBA) serves as a valuable tool to assess the economic viability of modern farming methods relative to conventional approaches (Reganold & Wachter, 2016). By examining production inputs, revenue generation, and profitability metrics such as Net Present Value (NPV) and Benefit-Cost Ratio (BCR), CBA provides critical insights into both short- and long-term benefits for farmers.

Through field-level data collected from 25 farmers in Madhyapur Thimi and Suryabinayak municipalities, this research aims to fill the empirical gap on the economics of modern vegetable farming in Nepal. The findings are expected to inform not only farmers but also policymakers, development agencies, and agricultural extension programs striving to promote sustainable and profitable agriculture in the region.

2. LITERATURE REVIEW

2.1. Profitability of Modern Vegetable Farming: Global Perspectives

Empirical studies from various countries demonstrate that modern farming practices often outperform conventional systems in terms of profitability and sustainability. Brumfield et al. (2000) found that Integrated Crop Management (ICM) in tomato farming in the USA led to greater economic returns than traditional methods. In Ghana, Kuwornu et al. (2018) concluded that ICM techniques in cabbage farming generated higher net returns and superior cost-benefit ratios. Similarly, Fachrista et al. (2021) showed that organic vegetable farming in Indonesia provided enhanced income when adequate market access was available. Nezhad and Zohoori (2010) observed that both organic and conventional radish farming in Iranian greenhouses were profitable, though highly sensitive to input costs. Sgroi et al. (2015) reinforced this trend in Italy, reporting that organic lemon production achieved higher profits than conventional systems, highlighting the broader economic appeal of sustainable farming.

2.2. Evidence from Nepalese Agricultural Systems

In Nepal, modern farming practices—particularly in vegetable cultivation—are gaining traction, especially in peri-urban areas. K.C. and Paudel (2023) conducted a cost-benefit analysis in Bhaktapur and found that tomato, cauliflower, and radish farming under modern methods yielded high profitability. Shrestha et al. (2014) noted the superior economic and ecological performance of organic vegetable farming in the Kathmandu Valley. Paudel and Adhikari (2018) emphasized the income advantages of off-season tomato cultivation in Dhading District, underlining the strategic value of market-oriented planning. Though focused on rice, Acharya et al. (2021) found mechanized farming to be more profitable than traditional methods, suggesting broader benefits of modern technologies. Likewise, Raut et al. (2009) and Bastakoti et al. (2011) demonstrated the financial and environmental advantages of organic farming, though in non-vegetable contexts like mushrooms and kiwis.

2.3. Identified Research Gaps

Despite growing interest, there remains a lack of crop-specific, comparative studies in Nepal that evaluate the costs and benefits of modern versus conventional vegetable farming practices. Existing literature tends to be general or regionally focused, with limited analysis dedicated to Bhaktapur District—a major vegetable production hub. In particular, studies that differentiate among tomato, cauliflower, and radish farming under modern systems are rare. Moreover, research often overlooks local factors such as market dynamics, input availability, land pressure, and farmer decision-making processes that influence adoption.

Additionally, while modern farming techniques are being promoted, their adoption in Bhaktapur remains limited. There is insufficient empirical understanding of why farmers continue to rely on traditional practices, despite the reported economic advantages of modern methods. Gaps persist in examining the economic feasibility of modern farming under real-world conditions—such as price volatility, rising input costs, and limited access to technical support. Without addressing these gaps, efforts to scale modern agricultural practices risk being ineffective or misaligned with local realities.

3. RESEARCH METHODS

3.1 Study Area and Sampling Design

This study was conducted in Bhaktapur District, Nepal, a peri-urban agricultural hub recognized for intensive vegetable farming under the Prime Minister Agriculture Modernization Project (PMAMP). Among the four municipalities—Madhyapur Thimi, Bhaktapur, Changunarayan, and Suryabinayak—two (Madhyapur Thimi and Suryabinayak) were randomly selected for primary data collection due to their active participation in vegetable farming initiatives and presence of designated "pocket areas" with at least 10 hectares under cultivation.

A multistage sampling technique was employed. From a population of 105 registered farmers engaged in six promoted vegetable crops (tomato, cauliflower, radish, cabbage, carrots, and eggplant), three crops—tomato, cauliflower, and radish—were selected using simple random sampling. Subsequently, 25 farmers (12 from Madhyapur Thimi and 13 from Suryabinayak) cultivating at least one of the selected crops using modern farming methods were randomly chosen for the study.

3.2 Data Collection Methods

A mixed-methods approach was utilized to ensure reliability and depth. Quantitative data were gathered through structured questionnaires, while qualitative insights were collected via personal interviews and field observations. Information included input costs, labor usage, crop yields, market prices, and farming techniques. Cross-validation was carried out through repeated farm visits and consultations with local agricultural extension officers.

3.3 Analytical Tools and Techniques

Cost-Benefit Analysis (CBA) was the primary evaluation framework used to measure the economic performance of modern vegetable farming. Two financial indicators were employed: Net Present Value (NPV) and Benefit-Cost Ratio (BCR). Costs were categorized into fixed (e.g., land rent) and variable (e.g., seeds, fertilizers, labor) components, while revenues were calculated by multiplying crop yield per ropani by the prevailing market price.

Data analysis was performed using Microsoft Excel, including calculation of NPV and BCR, generation of charts, and sensitivity analyses. A discount rate of 10% was applied to future cash flows, in line with conventional agricultural economic analysis (Pretty, 2008; Reganold & Wachter, 2016).

3.4 Assumptions and Sensitivity Analysis

Several key assumptions guided the financial modeling. Input costs were projected to increase by 5% annually, and land rent was expected to rise by 10% every two years. Revenue was assumed to grow at 10% per year based on historical vegetable price trends. Cropping frequency differed between methods: tomatoes and cauliflower were cultivated in two seasons conventionally or three under protected structures; radish was grown in three seasons conventionally or four in modern systems.

Sensitivity analysis was conducted to assess economic resilience by simulating ±30% variations in prices, input costs, and yields. These scenarios helped evaluate the impact of market volatility and input fluctuation on crop profitability.

3.5 Conceptual Framework

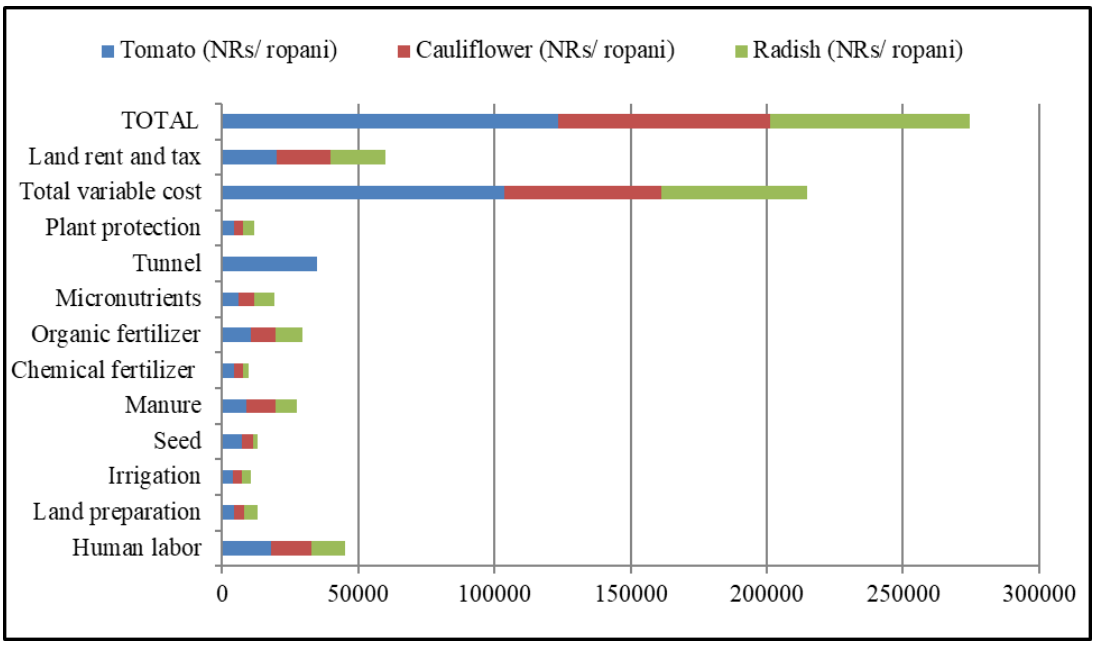
The study followed a seven-stage conceptual model: (a) input scenario, examining modern techniques and technologies; (b) output and marketing, focusing on yield quality and post-harvest handling; (c) cost estimation, analyzing input expenses; (d) benefit estimation, quantifying financial returns; (e) CBA application, assessing viability; (f) aggregation of results, and (g) decision-making support for farmers and policymakers.

4. RESULTS

4.1. Cost of Production

A cost analysis of modern vegetable farming in Bhaktapur shows clear cost differences among tomato, cauliflower, and radish. Tomato is the most expensive to grow at NRs 123,565 per ropani, mainly due to tunnel farming and high input costs. Cauliflower, at NRs 77,750, focuses on soil health without infrastructure expenses, while radish is the most economical at NRs 73,400, with balanced spending. Fixed land rent is constant at NRs 20,000, but variable costs vary—84% for tomato, 74% for cauliflower, and 73% for radish. A stacked bar graph illustrates these cost patterns and crop strategies.

Figure 1: Cost of Production of Modern Farming



Source: Survey Data, 2024

4.2. BCR of Modern Farming

Modern vegetable farming in Bhaktapur is economically viable, with all studied crops—cauliflower, tomato, and radish—showing Benefit-Cost Ratios (BCR) above 1. Cauliflower is the most profitable, with a BCR of 4.12 and a net profit of NRs. 242,250 per ropani, due to low costs and good market prices. Tomato, despite higher production costs, has a strong BCR of 3.08 thanks to high yield and income. Radish, with a BCR of 2.72, is the least profitable but still yields positive returns. These results underline the value of selecting high-BCR crops for better farm income. The benefit cost ratio of tomato, cauliflower and radish produced by modern practice in Bhaktapur district is estimated, whose result along with averages and per unit cost are shown in Table 1.

Table 1

BCR of Modern Farming

	Total cost of production (NRs./ ropani)	Average production cost (Kg/ ropani)	Per unit production cost (NRs./ Kg)	Average price per Kg (NRs.)	Total income (NRs.)	Net profit per ropani (NRs.)	Benefit cost ratio (BCR)
Tomato	123565	9500	24	35	380000	256435	3.08
Cauliflower	77750	4500	22	32	320000	242250	4.12
Radish	73400	6000	17	25	200000	126600	2.72

Source: Survey Data, 2024

4.3. NPV of Modern Farming

A three-year NPV analysis at a 10% discount rate confirms the strong economic potential of modern vegetable farming in Bhaktapur. Cauliflower is the most profitable crop with an NPV of NRs. 525,940, thanks to low costs and steady returns. Tomato follows with an NPV of NRs. 518,990, offering high annual profits despite greater initial investment. Radish, with the lowest NPV of NRs. 241,640, presents a modest return, making it more suitable for low-risk or supplementary farming. Overall, cauliflower and tomato are the best options for maximizing long-term farm profitability. The results of NPV for tomato, cauliflower, and radish are shown in Figure 2.

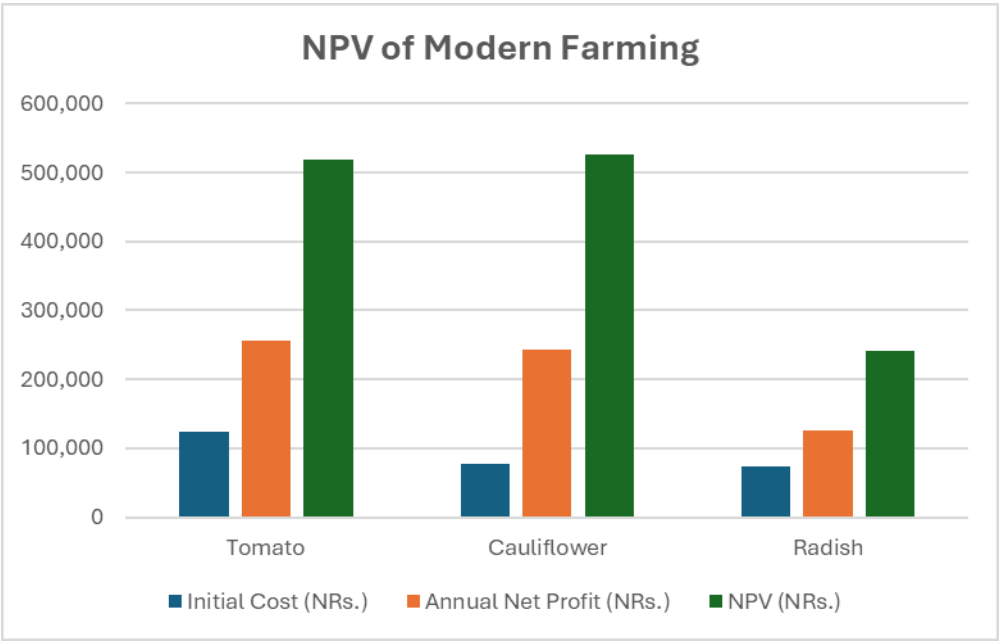


Figure 2: NPV of Modern Farming
Source: Survey Data, 2024

4.4. Price Sensitivity Analysis

A sensitivity analysis assessing ±10%, ±20%, and ±30% changes in market prices for tomato, cauliflower, and radish in Bhaktapur reveals the strong influence of price fluctuations on profitability. Holding production costs and yields constant, the analysis shows that increases in market price significantly enhance total income, net profit, BCR, and NPV for all three crops. Cauliflower consistently performs best, with NPV values rising from NRs. 229,141 to 659,941 as prices increase, reflecting its cost-efficiency and stable returns. Tomato also shows strong profitability, with NPV ranging from NRs. 148,843 to 649,543, benefiting from high yield and market value despite higher costs. Radish, though initially less profitable, improves from an NPV of NRs. 55,233 to 280,533 under better price conditions, showing potential as a low-risk or supplementary crop. Overall, the analysis highlights cauliflower and tomato as more robust and lucrative investments, while radish's profitability depends more heavily on favorable market pricing.

Table 2

Price Sensitivity Analysis of Modern Farming

Vegetable	Variation (%)	New Price (NRs./Kg)	New Total Income (NRs.)	New Net Profit (NRs.)	New BCR	Profitability Status	New NPV (NRs.)
	-30%	24.5	232750	109185	1.88	Marginally Profitable	148,843
	-20%	28	266000	142435	2.15	Marginally Profitable	232,293
	-10%	31.5	299250	175685	2.42	Profitable	315,743
	0%	35	332500	208935	2.69	Profitable	399,193
	10%	38.5	365750	242185	2.96	Profitable	482,643
	20%	42	399000	275435	3.23	Highly Profitable	566,093
Tomato	30%	45.5	432250	308685	3.5	Highly Profitable	649,543
	-30%	22.4	201600	123850	2.59	Marginally Profitable	229,141
	-20%	25.6	230400	152650	2.96	Marginally Profitable	300,941
	-10%	28.8	259200	181450	3.33	Profitable	372,741
	0%	32	288000	210250	3.7	Profitable	444,541
	10%	35.2	316800	239050	4.07	Profitable	516,341
	20%	38.4	345600	267850	4.44	Highly Profitable	588,141
Cauliflower	30%	41.6	374400	296650	4.82	Highly Profitable	659,941
	-30%	17.5	105000	31600	1.43	Marginally Profitable	55,233
	-20%	20	120000	46600	1.63	Marginally Profitable	92,783
	-10%	22.5	135000	61600	1.84	Profitable	130,333
	0%	25	150000	76600	2.04	Profitable	167,883
	10%	27.5	165000	91600	2.25	Profitable	205,433
	20%	30	180000	106600	2.45	Highly Profitable	242,983
Radish	30%	32.5	195000	121600	2.66	Highly Profitable	280,533

Source: Survey Data, 2024

4.5. Cost Sensitivity Analysis

The cost sensitivity analysis in Table 3 illustrates how fluctuations in production costs impact the profitability of tomato, cauliflower, and radish farming in Bhaktapur. Tomato remains highly profitable even under increased cost scenarios, with BCRs ranging from 4.39 (at 30% cost reduction) to 2.37 (at 30% cost increase), and an NPV of NPR 433,128. Cauliflower shows the highest resilience, with a peak BCR of 5.88 and solid profitability even when costs rise. Radish, while offering steady returns under reduced costs (BCR 3.89), is more sensitive to cost increases, with profitability dropping to a marginal BCR of 2.09. Overall, the analysis underscores the importance of managing production costs, with tomato and cauliflower showing greater economic stability compared to radish.

Table 3

Cost Sensitivity Analysis of Modern Farming

Vegetable	Cost Variation (%)	New Total Cost (NRs.)	New Total Income (NRs.)	New Net Profit (NRs.)	New BCR	Profitability Status	New NPV (NRs.)
	-30	86495.5	380000	293504.5	4.39	Highly Profitable	632599
	-20	98852	380000	281148	3.84	Highly Profitable	599353
	-10	111208.5	380000	268791.5	3.42	Profitable	566108
	0	123565	380000	256435	3.08	Profitable	532863
	10	135921.5	380000	244078.5	2.79	Profitable	499618
	20	148278	380000	231722	2.56	Less Profitable	466373
Tomato	30	160634.5	380000	219365.5	2.37	Marginally Profitable	433128
	-30	54425	320000	265575	5.88	Highly Profitable	582607
	-20	62200	320000	257800	5.14	Highly Profitable	563907
	-10	69975	320000	250025	4.57	Profitable	545207
	0	77750	320000	242250	4.12	Profitable	526507
	10	85525	320000	234475	3.74	Profitable	507807
	20	93300	320000	226700	3.43	Less Profitable	489107
Cauliflower	30	101075	320000	218925	3.17	Marginally Profitable	470407
	-30	51380	200000	148620	3.89	Highly Profitable	325125
	-20	58720	200000	141280	3.41	Highly Profitable	307985
	-10	66060	200000	133940	3.03	Profitable	290845
	0	73400	200000	126600	2.72	Profitable	273705
	10	80740	200000	119260	2.48	Profitable	256565
	20	88080	200000	111920	2.27	Less Profitable	239425
Radish	30	95420	200000	104580	2.09	Marginally Profitable	222285

Source: Survey Data, 2024

4.6. Yield Sensitivity Analysis

The yield sensitivity analysis for vegetable farming in Bhaktapur highlights the significant impact of yield variations on the profitability of tomato, cauliflower, and radish cultivation. Tomato farming shows strong profitability at baseline yield with a BCR of 2.69 and NPV of NPR 399,193, rising sharply with yield increases but becoming marginal with a 30% yield decline. Cauliflower demonstrates the highest economic resilience, maintaining a BCR above 2.5 even under reduced yields and reaching a BCR of 4.82 and NPV near NPR 660,000 with a 30% yield increase. Radish, while profitable at baseline (BCR 2.04), shows greater sensitivity to yield drops, with profitability becoming marginal at a 30% decline (BCR 1.43). Overall, the analysis emphasizes the importance of yield optimization and improved farming practices, especially for radish, to sustain profitability in Bhaktapur's vegetable farming sector. In this regard, yield sensitivity analysis is shown in Table 4.

Table 4

Yield Sensitivity Analysis of Modern Farming

Vegetable	Yield Variation (%)	New Yield (Kg/Ropani)	New Total Income (NRs.)	New Net Profit (NRs.)	New BCR	Profitability Status	New NPV (NRs.)
	-30%	6650	232750	109185	1.88	Marginally Profitable	148,843
	-20%	7600	266000	142435	2.15	Marginally Profitable	232,293
	-10%	8550	299250	175685	2.42	Profitable	315,743
	0%	9500	332500	208935	2.69	Profitable	399,193
	10%	10450	365750	242185	2.96	Profitable	482,643
	20%	11400	399000	275435	3.23	Highly Profitable	566,093
Tomato	30%	12350	432250	308685	3.5	Highly Profitable	649,543
	-30%	3150	201600	123850	2.59	Marginally Profitable	229,141
	-20%	3600	230400	152650	2.96	Marginally Profitable	300,941
	-10%	4050	259200	181450	3.33	Profitable	372,741
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	20%	5400	345600	267850	4.44	Highly Profitable	588,141
Cauliflower	30%	5850	374400	296650	4.82	Highly Profitable	659,941
	-30%	4200	105000	31600	1.43	Marginally Profitable	55,233
	-20%	4800	120000	46600	1.63	Marginally Profitable	92,783
	-10%	5400	135000	61600	1.84	Profitable	130,333
	0%	6000	150000	76600	2.04	Profitable	167,883
	10%	6600	165000	91600	2.25	Profitable	205,433
	20%	7200	180000	106600	2.45	Highly Profitable	242,983
Radish	30%	7800	195000	121600	2.66	Highly Profitable	280,533

Source: Survey Data, 2024

The findings of this study reveal that modern vegetable farming in Bhaktapur District is not only economically viable but also highly profitable for smallholder farmers, particularly when cultivating cauliflower and tomato. The Benefit-Cost Ratio (BCR) values for all three crops exceed the profitability threshold of 1.0, indicating positive returns on investment. Among the crops analyzed, cauliflower achieved the highest BCR (4.12) and Net Present Value (NPV) (NPR 525,940), signifying its exceptional economic performance. This supports the results of K.C. and Paudel (2023), who reported high returns from cauliflower and tomato farming in Bhaktapur using modern methods.

Tomato farming, despite requiring the highest initial investment (NPR 123,565), also showed strong profitability (BCR = 3.08, NPV = NPR 518,990), largely due to its high market price

and yield potential. This aligns with Paudel and Adhikari (2018), who found that off-season tomato production in open fields significantly increased farmer income. The high sensitivity of tomato farming to price and yield changes observed in this study also echoes the findings of Brumfield et al. (2000), who emphasized the importance of market premiums and input optimization in tomato-based Integrated Crop Management systems.

Conversely, radish, while profitable (BCR = 2.72, NPV = NPR 241,640), demonstrated the lowest economic return among the three crops. Its lower market price and yield fluctuations made it more vulnerable to input cost increases and price drops. This finding is comparable to Nezhad and Zohoori (2010), who showed that while radish farming in greenhouses in Iran was profitable, its margins were significantly affected by production costs. Similarly, in this study, a 30% increase in input cost or a drop in yield sharply reduced radish profitability, demonstrating its limited resilience.

Cauliflower stood out as the most resilient crop across all sensitivity analyses. Even under adverse scenarios—such as a 30% rise in cost or a decline in yield—it maintained profitability, making it a stable choice for farmers seeking risk mitigation. This supports the conclusions drawn by Kuwornu et al. (2018) in Ghana and Fachrista et al. (2021) in Indonesia, where cabbage and other leafy vegetables showed better performance under modern methods due to consistent market demand and efficient input use. Similarly, Shrestha et al. (2014) highlighted the profitability of organic vegetable farming, including cauliflower, in the Kathmandu Valley, reinforcing its adaptability in local contexts.

The comparison with previous Nepalese studies such as Raut et al. (2009) and Bastakoti et al. (2011) further underscores the relevance of modern practices. These studies documented the profitability of organic and climate-resilient farming systems, though not vegetable-specific. The present findings validate their claims by demonstrating the tangible economic benefits of adopting improved practices—such as protected cultivation, organic fertilization, and efficient irrigation—in vegetable farming.

Despite the evident advantages, the adoption of modern methods in Bhaktapur remains limited. This research suggests that the high initial investment, lack of financial access, and limited technical knowledge are likely barriers. These observations resonate with the broader concerns raised by Pretty (2008) and Reganold and Wachter (2016), who emphasized that the uptake of sustainable practices often depends not just on profitability but also on enabling institutional support and market systems.

In summary, the results confirm that modern vegetable farming in Bhaktapur is economically beneficial, especially for cauliflower and tomato. While radish remains a viable option, its profitability is more context-dependent. These findings contribute to a growing body of evidence supporting the transition toward resource-efficient, market-responsive, and climate-smart farming systems in Nepal and beyond.

5. CONCLUSION AND IMPLICATIONS

This study provides robust evidence that modern vegetable farming practices in Bhaktapur District—specifically for tomato, cauliflower, and radish—are economically viable and profitable, with significant potential for income generation and resilience. Among the crops, cauliflower emerged as the most stable and profitable, offering the highest Benefit-Cost Ratio (4.12) and Net Present Value (NPR 525,940) even under fluctuating market and production conditions. Tomato farming, while requiring greater investment, yielded the highest annual income and remained consistently viable. Radish, though less profitable, proved suitable for quick returns with lower input needs. These findings reinforce existing national and international literature on the advantages of modern farming (e.g., K.C. & Paudel, 2023; Brumfield et al., 2000), but offer a novel contribution through their localized, crop-specific economic analysis in the peri-urban context of Bhaktapur.

To scale the benefits of modern vegetable farming, this study recommends targeted policy interventions, including subsidies for protected farming infrastructure, access to affordable credit, and farmer training in climate-smart practices. Strengthening market linkages, establishing cold storage facilities, and promoting cooperative models can further reduce input costs and post-harvest losses. A key novelty of this research lies in its integration of multi-crop sensitivity analysis under real-world scenarios—enabling more nuanced, risk-aware decision-making for smallholder farmers. Future research could expand this work by conducting a comparative study of adoption behavior between modern and conventional farmers, exploring the socio-psychological and institutional factors influencing technology uptake. Such insights would deepen understanding of transition pathways toward sustainable agriculture in Nepal and similar developing economies.

REFERENCES

Acharya, P. K., Thapa, R. B., & Ghimire, Y. N. (2021). Mechanization in rice farming and its impact on profitability in Nepal. *Nepal Agricultural Journal*, *39*(1), 15–27.

Bastakoti, B., Gautam, R., & Adhikari, J. (2011). Sustainability and profitability of organic farming in Nepal: A case study on kiwis and mushrooms. *Nepal Journal of Sustainable Farming*, *3*(2), 44–59.

Brumfield, R. A., Rimal, A., & Reiners, S. (2000). Integrated crop management for tomato farming in the USA: Economic analysis and profitability. *Journal of Agricultural Economics*, *51*(1), 23–35.

Fachrista, F., Nurmalina, R., & Suharno, S. (2021). Profitability of organic vegetable farming in Indonesia: A case study of cabbage farming. *Indonesian Journal of Agronomy*, *19*(1), 10–20.

Food and Agriculture Organization (FAO). (2022). Nepal country programming framework 2023–2027. *Food and Agriculture Organization of the United Nations*.

K.C., P., & Paudel, R. (2023). Cost-benefit analysis of vegetable farming in Bhaktapur District, Nepal. *Nepal Journal of Agricultural Economics*, *6*(1), 75–88.

Kuwornu, J. K. M., Amoah, E., & Essel-Gaisey, F. (2018). Economic viability of integrated crop management in Ghana: A case study on cabbage farming. *Journal of Agricultural Economics and Development*, *7*(4), 89–97.

Ministry of Agriculture and Livestock Development (MOALD). (2022). Statistical information on Nepalese agriculture 2021/22. *Government of Nepal*.

Nezhad, M. A., & Zohoori, S. (2010). Profitability of organic vs conventional radish farming in greenhouses: A study in Iran. *Journal of Agricultural Science and Technology*, *12*(3), 225–231.

Paudel, B., & Adhikari, R. (2018). Off-season tomato farming in Dhading District, Nepal: Economic analysis and profitability. *Journal of Agricultural Planning and Economics*, *4*(2), 61–72.

Pretty, J. (2008). Agricultural sustainability: Concepts, principles and evidence. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *363*(1491), 447–465.

Raut, R. P., Karki, M., & Subedi, B. P. (2009). Profitability and sustainability of organic farming in Nepal. *Journal of Organic Agriculture and Climate Resilience*, *2*(1), 12–24.

Reganold, J. P., & Wachter, J. M. (2016). Organic agriculture in the twenty-first century. *Nature Plants*, *2*(2), Article 15221.

Sgroi, F., Tudisca, S., & Di Trapani, A. M. (2015). Profitability and sustainability in organic lemon farming in Italy. *Journal of Organic Farming and Economics*, *8*(2), 101–108.

Shrestha, S., Sharma, D., & Bhattarai, S. (2014). Economic and environmental viability of organic vegetable farming in the Kathmandu Valley, Nepal. *Journal of Sustainable Agriculture*, *6*(3), 29–41.

Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R., & Polasky, S. (2002). Agricultural sustainability and intensive production practices. *Nature*, *418*(6898), 671–677.

United Nations Development Programme (UNDP). (2021). Accelerating progress: An integrated approach to the sustainable development goals. *UNDP Nepal*.

World Bank. (2023). World development indicators: Nepal. https://data.worldbank.org

Zhang, Y., Wang, C., Skibniewski, M. J., & Golparvar-Fard, M. (2002). Modern agriculture and its efficiency: A global review. *Journal of Agricultural Systems*, *74*(3), 217–236.