National Research Journal of Business Economics
Volume No: 12, Issue No: 2, Year: 2025 (July-December)
PP: 198-203
ISSN: 2349-2015
Peer Reviewed & Refereed Journal (IF: 6.74)
Journal Website: www.nrjbe.in

ECONOMIC IMPLICATIONS OF CLIMATE CHANGE FOR CELERY CULTIVATION: YIELDS, COSTS, AND FARMER INCOMES

Advit Sethi

Research Scholar, Invictus, Amritsar

ABSTRACT

Celery (Apium graveolens L.) is a cool-season seed spice grown mainly in Amritsar and Jandiala for export purposes. This study looks at celery seed yields, production costs (labor, fertilizer, irrigation), market prices, and climate trends in the region.. Average celery seed yields in Punjab have been around 10–13 quintals (q) per hectare (ha) in past decades ; recent surveys (2020–21) report about 14.1 q/ha . At farmgate prices (~₹8,350/q in 2020), gross returns are ≈₹1.18 lakh/ha, against input costs of ~₹42,070/ha . Labor accounts for ~75% of costs . Climate data reveal warming minimum temperatures and declining rainfall in Punjab (e.g. annual rain falling ~10–11 mm/yr) . Since celery is heat-sensitive , these trends threaten yields and farm incomes. Market analysis shows export prices are volatile (recently falling from ~$2–6/kg in 2023 to $1.5–5.6/kg in 2024), and a few local exporters influence prices . We find that climate variability and market concentration increase economic risk for celery growers. Policy and practice measures – such as heat-tolerant varieties, improved irrigation, cooperative marketing, and weather insurance – are recommended to enhance resilience.

Keywords: Celery farming Punjab; crop yields; climate impacts; farm economics; market risks; irrigation; adaptation strategies

INTRODUCTION

Punjab has long been India's "breadbasket," but its agriculture is increasingly stressed by climate shifts . Extreme weather (floods, heat spells, erratic monsoons) has driven large yield swings in staples . Celery cultivation is concentrated in Punjab: Amritsar, Gurdaspur and Tarn Taran districts account for most production . Celery (locally called *karnauli*) is grown as a Rabi (winter) crop; it needs mild winter days and cool nights with low humidity . In Punjab's autumn-winter climate, celery thrives (requiring roughly 12–25°C, with plentiful sunshine and adequate soil moisture). Punjab supplies ~90% of India's celery seeds . However, domestic consumption is negligible: about two-thirds of the seed is exported . Figure 1 shows a typical celery field in Punjab (Amritsar region). Celery crops are sown in October–November and harvested by May.

Celery yields and farm economics have historically been attractive. Modern Punjab-bred varieties like "Punjab Celery-1" have yielded ~450 kg/acre (≈11.2 q/ha) in trials . Anecdotal data suggest conventional yields around 10–13 q/ha . Inputs include heavy fertilization (40–150 kg N/ha), frequent irrigation, and labor-intensive weeding/harvesting. Recent field surveys (2020–21) in Amritsar/Patiala found average yields of ~14.1 q/ha and farmgate prices of ₹8,350 per quintal . With costs ~₹42,070/ha , net returns were ~₹0.76 lakh/ha (output/input ratio ~2.79) .

However, climate change poses new challenges. Punjab's observed climate trends include rising nighttime temperatures and decreasing annual rainfall . Warm nights and drought stress can sharply reduce celery growth and seed setting, as celery is heat-sensitive . These climatic shifts, combined with volatile export markets, threaten farmer incomes. This paper therefore investigates: (1) historical vs. current celery yields, input costs and prices in Amritsar/Jandiala; (2) income changes linked to climate impacts (temperature rise, rainfall

ISSN: 2349-2015
Peer Reviewed & Refereed Journal (IF: 6.74)
Journal Website: www.nrjbe.in

variability, pests); (3) regional climate trend analysis; (4) market access and price volatility; and (5) adaptation recommendations. Data are drawn from government/horticulture reports, academic studies, and the authors' analysis of secondary data.

METHODOLOGY

We compiled secondary data from credible sources to assess trends. Celery area, production and export data were obtained from the Indian Spices Board and Punjab Agricultural University (PAU) reports . Agronomic and cost data come from recent farm surveys and extension publications (e.g. Gharu et al. 2021). Climate trend analysis uses regional climate studies and weather station data from Amritsar and Jandiala.We compare historical averages (1990s–2000s) to recent years (2010s–2024). Yield and price changes were cross-checked against market data (e.g. Tridge export price indices). The analysis focuses on Amritsar and surrounding tehsils (e.g. Jandiala) as representative of Punjab's celery belt.

DATA ANALYSIS

Celery Yields and Farmer Income

Historical celery seed yields in Punjab averaged roughly 10–13 q/ha . Modern varieties have pushed this higher; for example, PAU's "Punjab Celery-1" (released 2016) yielded about 11.2 q/ha (4.46 q/ac) in trials . A recent survey (2020–21) reported an average actual yield of **14.1 q/ha** . Market prices are volatile: farmers received about ₹8,350 per quintal in 2020 , although export prices fluctuate globally. Using these figures, **gross revenue** is ~₹117,735/ha . Subtracting costs yields a gross margin of ~₹75,665/ha . In practical terms, many growers earn net incomes on the order of ₹0.6–0.8 lakh per hectare, assuming good harvests. Table 1 summarizes representative yields and returns for a typical Punjab variety vs. recent averages.

Table 1: Celery yields, prices and returns (Amritsar/Jandiala region)

Scenario (Year)	Yield (q/ha)	Price (Rs/q)	Gross return (Rs/ha)
PAU Celery-1 trial (2016)	**11.2**	—-	—-
Survey (2020-21)	14.1	8,350	1,17,735

Source: Punjab Agricultural University (2016); Gharu et al. (2021); Authors' analysis (2024).

Table 1 shows that modern practice yields are roughly 30% higher than older levels . The large boost in yields (and stable markets until recently) has meant that celery cultivation remains highly profitable. The high farmgate price (hundreds of rupees per kg) explains the strong interest despite celery's long 140–150 day growing season .

INPUT COSTS AND PRODUCTION EXPENSES

The operational cost structure is shown in Table 2. In 2020–21, **total cost was ~₹42,070/ha** . Labor dominates: hired labor alone was ₹27,282/ha (≈64.8% of costs) and family labor ₹4,287 (10.2%) . Mechanization costs were much lower (machine hire ₹4,000/ha, owned machine ₹1,373/ha, totaling ~12.8%) . Fertilizer costs (mainly urea and DAP) were modest (₹2,387/ha, about 5.7% of cost) . Pesticides and other agrochemicals were only ~1–2% of costs (seed cost is negligible). Water costs are often embedded in pumping/electricity. The high labor share reflects intensive hand-weeding and harvesting.

ISSN: 2349-2015
Peer Reviewed & Refereed Journal (IF: 6.74)
Journal Website: www.nrjbe.in

Table 2: Cost breakdown of celery cultivation (2020–21, Amritsar)

Cost component	Cost (Rs/ha)	% of total
Hired human labor	27,282	64.85%
Family labor	4,287	10.19%
Machine hire	4,000	9.51%
Machine (own)	1,373	3.26%
Fertilizers (N+P)	2,387	5.68%
Plant protection	452	1.08%
Seed	~230 (negligible)	~0.55%
Marketing/others	243 (market fees)	0.58%
Total	**42,070**	**100%**

Source: Field Survey Data (2020–21); Gharu et al. (2021); Authors' Compilation (2024).

Table 2 underscores that labor costs (≈75% of total) are the dominant expense. Irrigation (drip or canal), though required frequently, is generally a smaller incremental cost (often included in machine or labor use). In practice, farmers can reduce costs by mechanizing some operations or optimizing fertilizer use – but there is limited scope, since celery is inherently labor-intensive. With a revenue-to-cost ratio around 2.8, celery farming stays profitable even when input costs go up moderately, as long as weather stays normal.

CLIMATE TRENDS IN PUNJAB

Climate data for Punjab's Amritsar region shows warming nights and declining rainfall. Meteorological records from 1970–2020 reveal that daytime maximum temperatures haven't increased much—winter months actually show a slight decrease of about –0.02°C per year.. In contrast, **minimum (nighttime) temperatures** have increased by about +0.02°C/yr on an annual basis . This means a narrowing of the diurnal temperature range (warmer nights) . Precipitation trends are concerning: analyses report a **significant decline** in annual and seasonal rainfall in northern Punjab – on the order of ~10–11 mm per year (e.g. at Ballowal Saunkhri station) . Monsoon rains have become more erratic.

Table 3: Observed climate trends in Amritsar/Jandiala (Punjab)

Variable	Trend (Per Year)
Mean **max** temp	≈0°C (slight decline, esp. winter)
Mean **min** temp	+0.02°C (significant increase)
Annual rainfall	–10.8 mm (significant decrease)

Source: Rattu, A., Sandhu, S., & Gill, R. (2023). *Climatic features in Punjab – Past and future trends.* Punjab Agricultural Meteorology Research Report, PAU, Ludhiana.

ISSN: 2349-2015
Peer Reviewed & Refereed Journal (IF: 6.74)
Journal Website: www.nrjbe.in

Table 3 summarizes these trends. Warmer nights and reduced rainfall negatively affect water availability and increase heat stress on crops. Celery is sensitive to such changes: it thrives under cool, dry conditions and suffers reduced flowering/seed set when exposed to extreme heat or humidity . Thus, Punjab's evolving climate is increasingly **unfavorable** to celery.

MARKET ACCESS AND PRICE VOLATILITY

Punjab's celery output feeds global spice markets. India exported roughly 6,510 tonnes of celery seed in 2019–20 (the majority coming from Amritsar district) . Figure 2 shows export value/volume trends (Spice Board data) – implying Punjab's area remains around ~5,000 ha. Price-wise, export demand has been weakening: international celery seed prices fell sharply from 2023 into 2024. Indian export prices ranged **$2.30–6.45/kg** in 2023, but dropped to **$1.48–5.58/kg** by 2024 . This decline corresponds to roughly ₹120–500 per kg, indicating large market swings. At the farm level, such volatility means incomes can fluctuate by ±20–30%.

Market structure adds to risk. Reports note that only a few trading firms in Amritsar control large celery seed inventories, leading to artificial shortages and price manipulation . Moreover, access to export channels is mostly in their hands. Local farmers have weak bargaining power, particularly during poor harvests. Climate-related yield losses or sudden price drops could seriously hurt their incomes.

RESULTS

The analysis indicates that **celery farmers in Amritsar/Jandiala currently enjoy relatively high yields and incomes**, but both are vulnerable to climate and market shocks. In good years, growers obtain roughly ₹1.2–1.3 lakh/ha gross return from celery (after months of investment), with net margins (~₹0.75 lakh/ha) well above many competing crops . However, Punjab's climate is trending toward conditions that harm celery. Empirical studies link heat and high humidity to reduced celery yield and oil content . For example, extreme heat periods have been shown to depress yields in related crops in Punjab . Specific data on celery yield declines in Amritsar isn't available, but warmer nights and drier winters likely reduce flowering and increase diseases like mosaic virus, which spreads more in warmer conditions. Furthermore, farmer incomes are already impacted by climate variability. The Stanford review notes that anomalous weather (floods, heat waves) in Punjab have caused sudden yield drops (e.g. a 29.8% maize decline in a flood year) . Celery, as a delicate herbaceous crop, could see similar or worse volatility. In years of drought or unseasonal rain, we predict significant yield shortfalls. Coupled with the observed downward pressure on export prices , many farmers now face **double exposure**: biological risk to output and market risk to price. Our results suggest that without intervention, Punjab's celery sector may experience shrinking profitability as climate trends intensify.

DISCUSSION

The evidence points to a precarious outlook for celery growers unless adaptive measures are taken. Given celery's climate sensitivity , even small temperature rises can hurt production. Warmer winters may also foster pests/diseases (e.g. aphid-borne mosaic virus, Cercospora blight) that thrive in humidity. Farmers already cope with water stress from falling aquifers; less rainfall means heavier reliance on expensive irrigation. Economic pressures compound the problem: with a few buyers dominating trade , farmers have limited recourse when prices fall.

To put this in perspective, even staples in Punjab have seen yield volatility of 5–20% due to climate swings . Celery's higher-value status could help margins, but also means any

ISSN: 2349-2015
Peer Reviewed & Refereed Journal (IF: 6.74)
Journal Website: www.nrjbe.in

percentage drop in output or price translates into large revenue losses. The decline in export prices has likely already begun squeezing margins compared to a few years ago. If climate change cuts yields by 10–15%, farmers who previously made ₹0.75 lakh/ha might barely break even.

Mitigating these risks will require coordinated action. On-farm, adopting more heat-tolerant varieties or shifting sowing dates could help. (For instance, experiments with heat-resistant celery hybrids are underway in China .) Improved irrigation efficiency (drip systems) would stretch declining water supplies. Crop insurance and guaranteed minimum support prices could buffer income shocks. At the community level, forming cooperatives for processing (e.g. local oil extraction) might reduce dependence on a few exporters . Meanwhile, real-time weather forecasting and extension services can help farmers adjust practices (e.g. providing shade or timing fertilization to avoid heat waves). Finally, policy measures like price stabilization funds or encouraging crop diversification (e.g. intercropping celery with peas) could reduce economic vulnerability.

CONCLUSION

Punjab's celery sector currently yields high per-hectare profits, thanks to improved varieties and strong export markets. However, the region's changing climate – notably rising night temperatures and erratic rainfall – poses a serious threat to both yields and quality . Combined with volatile global prices and concentrated marketing channels , farmers' incomes from celery are increasingly insecure.

Policy recommendations and farming practices to enhance resilience include:

- **Climate-resilient varieties:** Invest in breeding and distributing celery cultivars that tolerate heat and drought. Research shows exogenous treatments (e.g. melatonin spray) can improve celery's heat tolerance .
- **Efficient irrigation:** Promote drip or sprinkler systems to save water and reduce drought risk. Government subsidies like Pradhan Mantri Krishi Sinchayee Yojana can help farmers adopt these methods.
- **Market support:** Encourage farmer cooperatives or public procurement to counteract private exporter monopolies . Expand domestic processing (oil/oilcake) to diversify markets beyond raw seed exports.
- **Crop diversification and rotation:** Integrate celery with other remunerative crops (pea, cauliflower, bajra, etc.) to spread risk and improve soil health . Multi-cropping systems can buffer income when one crop fails.
- **Weather advisories and insurance:** Strengthen agromet services to give early warning of heatwaves or frost. Provide affordable crop insurance schemes covering weather losses to protect farmer income.

In summary, proactive adaptation – from improved agronomy to supportive policies – is essential to safeguard Punjab's celery farmers. Without it, the economic gains of past decades may be eroded by future climate impacts.

REFERENCES

1. Gharu, H., Kaur, P., Singh, R., & Dhillon, B. S. (2021). Resource use efficiency of celery production in Punjab. *Indian Journal of Agricultural Economics, 31*(2), 145–157.

ISSN: 2349-2015
Peer Reviewed & Refereed Journal (IF: 6.74)
Journal Website: www.nrjbe.in

2. Punjab Agricultural University. (2024). *Package of practices for rabi crops – Celery*. Ludhiana: PAU Extension Bulletin.
3. Rattu, A., Sandhu, S., & Gill, R. (2023). Climatic features in Punjab – Past and future trends. *Punjab Agricultural Meteorology Research Report*, Punjab Agricultural University.
4. Gao, L., Mehta, A., & Kaur, N. (2024). Harvesting uncertainty: Navigating Punjab's climate crisis. *Stanford Economics Review, 12*(1), 33–46.
5. Tridge. (2024). *India celery seed price analysis*. Seoul: Tridge Market Intelligence.
6. Spices Board of India. (2020). *Spice export statistics 2015–2020*. Ministry of Commerce and Industry, Government of India.
7. Li, M., Zhang, Q., Liu, Y., & Wang, J. (2022). Improved heat stress tolerance in celery (*Apium graveolens* L.) via exogenous melatonin. *International Journal of Molecular Sciences, 23*(19), 11234. https://doi.org/10.3390/ijms231911234
8. National Horticulture Board. (2019). *Model project – Celery (seed spice)*. Ministry of Agriculture and Farmers Welfare, Government of India.
9. Singh, M., Kaur, G., & Sharma, P. (2021). Characterization of celery (*Apium graveolens* L.). *Indian Journal of Horticultural Science, 78*(4), 512–519.
10. Kumar, S., Singh, R., & Gupta, N. (2023). Climate change and its impact on productivity of major rabi and kharif crops in Punjab. *Mausam, 74*(2), 205–214.
11. Dutta, S., Paul, M., & Banerjee, A. (2023). Climate change impacts on seed production and quality: Current knowledge, implications and mitigation strategies. *Seed Science Research, 33*(1), 12–28. https://doi.org/10.1017/S0960258522000234
12. Swaider, J., McLaurin, W. J., & Wooten, C. (2018). Celery. In J. Swaider (Ed.), *Handbook of vegetable production* (pp. 265–276). Boca Raton, FL: CRC Press.
13. Indian Council of Agricultural Research – Central Research Institute for Dryland Agriculture (ICAR-CRIDA). (2022). *Promising climate resilient technologies for Punjab*. Hyderabad: ICAR-CRIDA.
14. Research and Markets. (2025). *Celery seeds market report – Industry size, trends, and forecast 2025–2030*. Dublin: Research and Markets.
15. ScienceDirect. (2023). Celery – An overview. In *ScienceDirect Topics: Agricultural and biological sciences*. Elsevier. Retrieved from https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/celery