

1 Introduction

- Agrochemical overuse degrades soils and drives emissions in smallholder systems.
- Precision drone spraying promises lower input loads with higher yields.
- Field evidence on its efficiency and profitability in South Asia is scarce.
- Aim: quantify per-acre input-use efficiency and economic returns of commercial drone spraying.

2 Materials and methods

- Cross-sectional farm survey in Southern Punjab.
- Respondents: clients of the only commercial drone-spraying provider in the province.
- 124 questionnaire responses analysed (2022 season).
- Paired-sample t-tests on before- and after-adoption values; SPSS 25.0 and MS Excel.

3 Benefit–cost analysis

- Stage 1 — per-acre change in fertiliser, pesticide and labour expenditure.
- Stage 2 — per-acre change in yield and gross revenue.
- Stage 3 — benefit–cost ratio before and after adoption.

Respondent profile

- 124 cotton growers, all male
- 76.6 % aged 35–55 years
- 70.9 % illiterate or primary schooling
- 55.7 % medium landholders (5–10 ha)
- 5 union councils surveyed

Converted at the 2022 average rate of 1 USD = 205 PKR. 1 maund = 40 kg. Sugarcane farm-gate price PKR 300 per maund (2022–23).

4 Results: input savings

– 5,728 PKR

total input cost per acre (28 USD)

+ 131 maunds

yield gain per acre (5.24 t)

+ 39,327 PKR

revenue gain per acre (192 USD)



Fig. 1 Mean per-acre saving on each input after adoption (n = 124). Fertiliser – 2,415 PKR, pesticide – 2,226 PKR, labour – 1,748 PKR.

5 Paired-sample t-tests

Measure	Before	After	t
Input cost (PKR)	52,850	47,115	26.53
Yield (maunds)	890.3	1,021.4	21.33
Revenue (PKR)	267,085	306,411	21.33
Benefit–cost ratio	5.30	6.94	17.24

Table. 1 Mean per-acre values before and after adoption. All four paired differences significant at $p < 0.001$ (n = 124).

6 Reported cost concerns

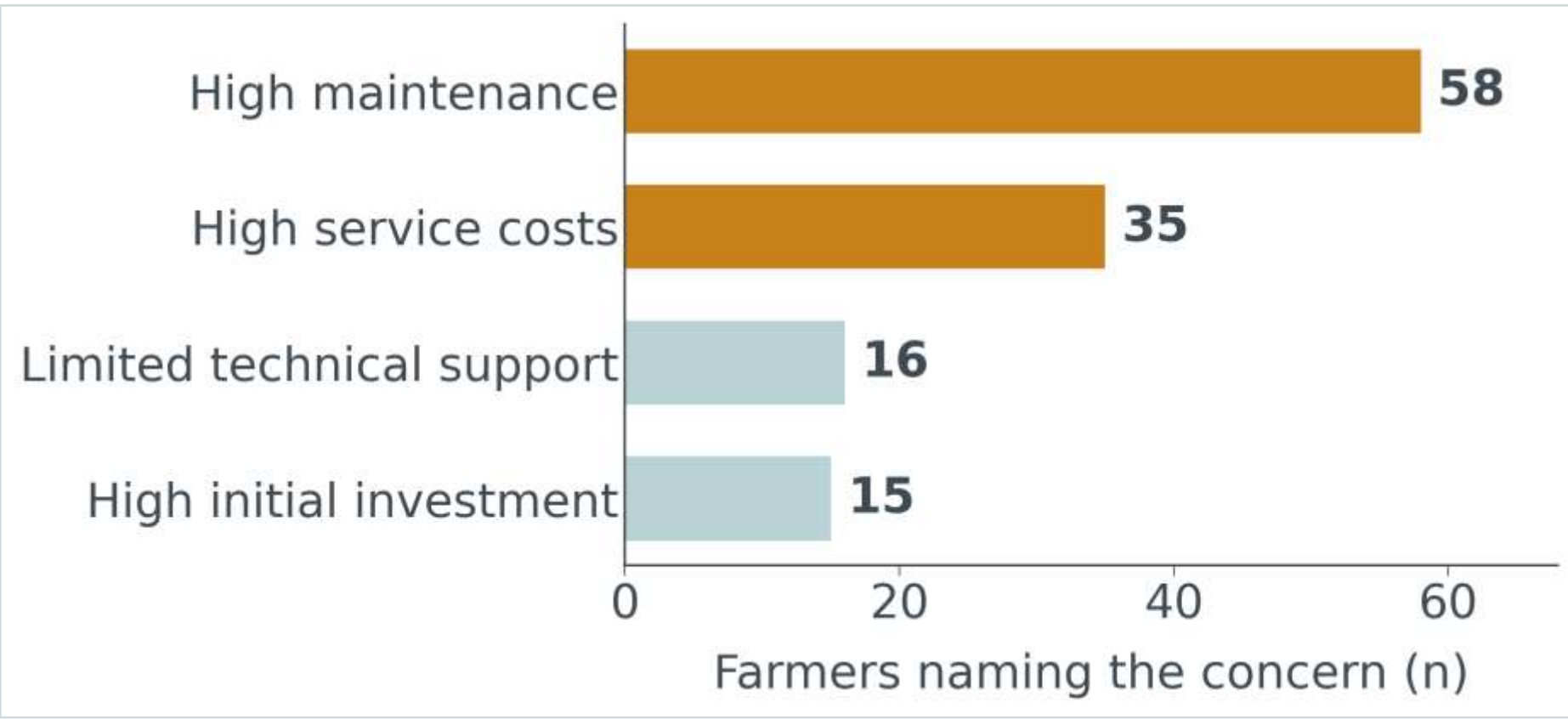


Fig. 4 Concerns that still limit uptake. Maintenance and service fees outweigh the initial investment.

7 Results: profitability

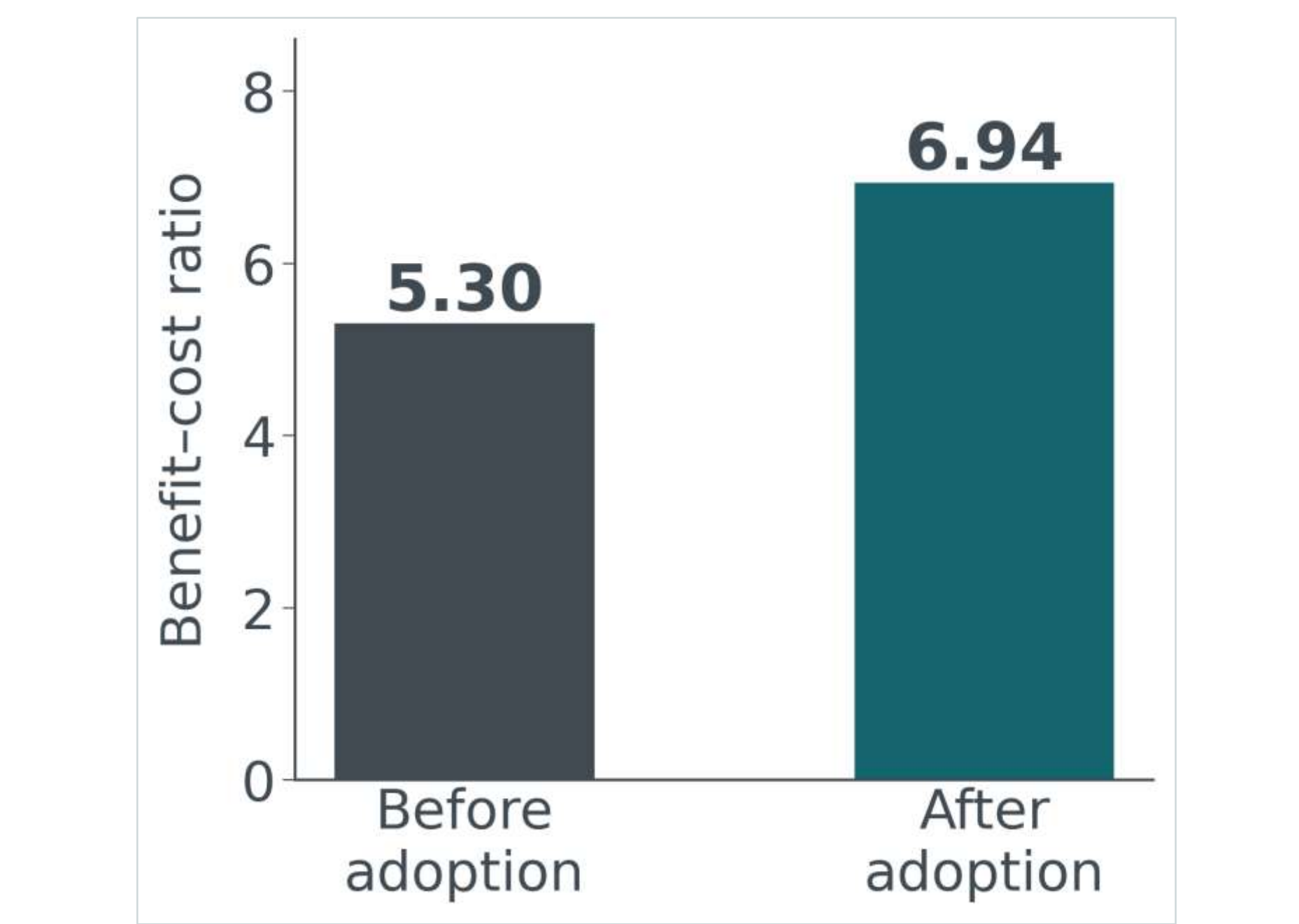


Fig. 2 Benefit–cost ratio rose from 5.30 to 6.94 — a mean gain of 1.64 (SD = 1.06; $t = 17.24$; $p < 0.001$).

8 Farmer-reported benefits

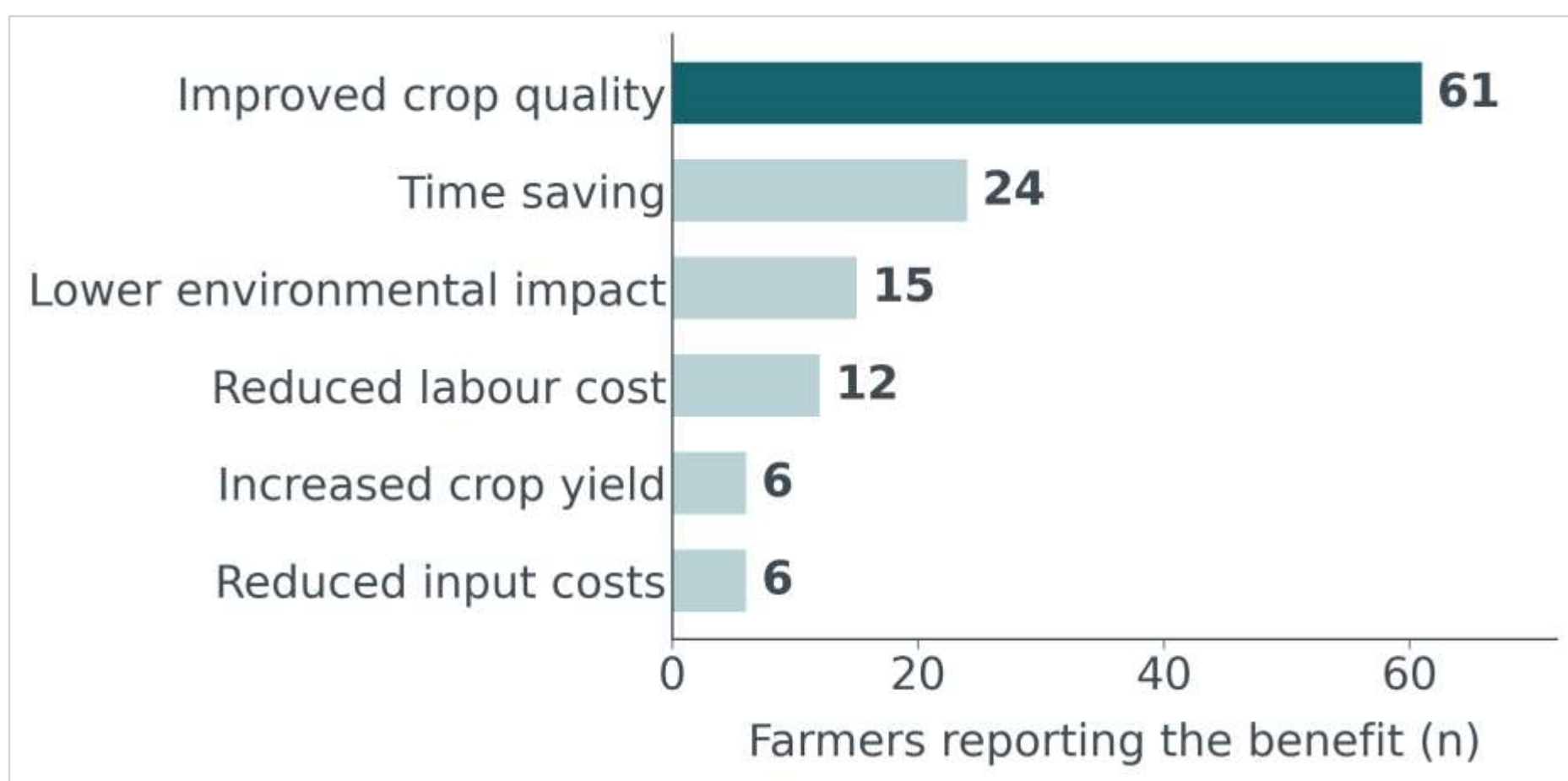


Fig. 3 Benefits named by respondents (n = 124). Improved crop quality dominates, ahead of time saving.

9 Conclusions

- Precision spraying cuts agrochemical and labour use while raising yield, a joint gain.
- Lower fertiliser and pesticide loads reduce pressure on the agro-ecosystem directly.
- Profitability improved by roughly a third within a single season.
- Drone services are a scalable, resource-efficient option for climate-vulnerable smallholder systems.

10 Implications

- Service-fee and maintenance costs, not purchase price, are the binding constraint.
- Demonstration plots can convert observed quality gains into wider uptake.
- Licensing more commercial operators would increase competition and lower fees.