

# Agricultural Diversification and its Impact on Farm Income: Evidence from Himachal Pradesh

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## Abstract

This paper analyses agricultural diversification and its relationship with farm-income outcomes in Himachal Pradesh using a holistic farm-enterprise framework adapted from the Bihar case study of Sen et al. (2017). The study combines primary evidence from 386 horticulturists across four agro-climatic zones with secondary indicators on infrastructure and horticultural growth. Diversification is measured through Simpson and Herfindahl indices and is interpreted as a structural movement from cereal-dominated farming toward fruits, vegetables, floriculture and other high-value activities. Survey-based SID values range from 0.58 in the Cold Dry Zone to 0.74 in the Mid Hill Zone. A separate secondary-data diversification series, constructed for infrastructure comparison, ranges from 0.55 to 0.81 and shows a strong positive relationship with composite infrastructure. Recalculation from the four displayed zonal values gives  $r \approx 0.97$  between the secondary diversification and infrastructure indices, indicating that stronger infrastructure is closely associated with a broader commercial horticultural portfolio. From 2015-16 to 2023-24, the thesis series records an increase in the composite infrastructure index from 0.52 to 0.75, horticultural area from 233 to 270 thousand ha and production from 1.85 to 2.32 million MT. Beneficiary farmers report higher horticultural income (₹4.85 lakh versus ₹3.10 lakh) and stronger technology access than non-beneficiaries. Because diversification and income can be jointly determined, the paper specifies a two-stage least-squares model for final estimation from the respondent-level dataset. The results indicate that income-enhancing diversification in mountain agriculture depends on the quality of the enterprise mix and complementary investment in irrigation, markets, storage, technology and institutions.

**Keywords:** *Agricultural diversification; farm income; high-value enterprises; infrastructure; 2SLS; horticulture; Himachal Pradesh*

## 1. Introduction

Agricultural diversification is a central element of structural transformation because it changes the composition of farm output, the timing of cash flows and the exposure of households to production and price shocks. In smallholder economies, the most important transition is often from subsistence cereals toward higher-value crops and allied enterprises. This transition can raise income per unit of land, but it also increases dependence on markets, irrigation, quality inputs and post-harvest systems.

The mountain economy of Himachal Pradesh makes this relationship especially complex. A farmer's enterprise set is bounded by altitude, temperature, snowfall, moisture and road accessibility. Consequently, agricultural diversification is spatially differentiated. A mid-hill

farmer can combine fruit trees with off-season vegetables, while a cold-dry farmer faces a shorter growing season and fewer crop choices. Income effects must therefore be interpreted relative to the local production frontier rather than against a uniform state-wide benchmark.

The Bihar study of Sen et al. (2017) is particularly useful because it treats diversification and farm income as endogenous. Income can relax liquidity constraints and enable entry into new crops, while diversification can raise or stabilize income. Ignoring this two-way relationship can bias an ordinary least-squares estimate. The present paper adopts this conceptual insight while expanding the discussion of infrastructure and agro-climatic heterogeneity that is central to Himachal Pradesh.

The study has four objectives: (i) to measure the extent and direction of agricultural diversification; (ii) to examine the infrastructure and policy environment associated with diversification; (iii) to assess the descriptive evidence linking diversification-oriented horticulture with farm income and productivity; and (iv) to develop a defensible simultaneous-equation framework for estimating the causal income effect from the original household microdata.

## **2. Conceptual Framework and Literature**

Diversification has long been regarded as a route to both higher farm returns and lower exposure to production risk, but the empirical literature also cautions that its effect depends on the composition of the portfolio. A simple increase in the number of crops does not necessarily raise income. Income gains are more likely when resources move toward enterprises with higher value per unit of land, when output has reliable market access, and when the farmer possesses sufficient capital, irrigation and technical knowledge. This distinction is important in Himachal Pradesh because holdings are small, slopes restrict mechanisation and many commercially attractive outputs are perishable.

The Odisha study by Basantaray and Nancharaiah (2017) measured crop concentration through the Herfindahl Index and compared net returns across highly, moderately and least diversified districts. Its central empirical contribution was to connect the degree of crop concentration with differences in returns and to examine household-level determinants of diversification. The Bihar study by Sen et al. (2017) broadened the concept from crops to agricultural and allied enterprises, adopted the Simpson Index of Diversification, and treated diversification and farm income as potentially endogenous. The two-stage least-squares approach used in that study is important because income can finance diversification just as diversification can influence income.

For mountain agriculture, diversification has an additional agro-ecological dimension. Altitude, temperature, snowfall, water availability and road access alter the crop opportunity set over relatively short distances. Consequently, a diversification index should be interpreted together with the type of crops grown and the enabling environment. A moderate index in a cold dry area may represent an economically efficient adaptation to a narrow growing season, while the same index in a well-connected mid-hill area may indicate unexploited market opportunities. This paper therefore uses both the numerical index and the direction of crop

change.

The economic effect of diversification can be decomposed into a portfolio effect, a productivity effect and a commercialization effect. The portfolio effect arises when returns from different enterprises are imperfectly correlated, reducing income variance. The productivity effect arises when land moves from low-return uses to crops that better exploit agro-climatic comparative advantage. The commercialization effect arises when households become more integrated with markets and value chains. These channels can work in opposite directions if diversification spreads scarce labour and capital too thinly or if high-value crops face severe post-harvest constraints.

### 3. Data and Methodology

The primary dataset comprises 386 horticulturists: 97 each from the Low Hill and Mid Hill zones and 96 each from the High Hill and Cold Dry zones. The survey captures crop area, production, landholding, diversification shifts, annual horticultural-income class, irrigation, extension, credit, market conditions, government programmes and perception variables. Secondary tables cover infrastructure indices and year-wise horticultural area and production.

**Table 1. Sample distribution**

| Zone      | District     | n   |
|-----------|--------------|-----|
| Low Hill  | Kangra       | 97  |
| Mid Hill  | Chamba       | 97  |
| High Hill | Shimla       | 96  |
| Cold Dry  | Lahaul-Spiti | 96  |
| Total     | —            | 386 |

*Source: Author's field survey.*

**Interpretation.** Balanced zone representation is important for a 2SLS or fixed-effect analysis because it allows ecological controls to be introduced without one zone dominating the sample.

The survey-based Simpson Index is  $SID = 1 - \sum P_i^2$ , where  $P_i$  is the area share of crop  $i$ . A broader enterprise version can use value-of-output shares, which is preferred when livestock, flowers or other activities use little land but contribute significant revenue. The thesis also contains a secondary diversification series paired with the composite infrastructure index. Because that series is derived from a different data base and aggregation procedure, it is analysed separately and is not pooled with the survey SID.

**Table 2. Survey-based diversification indices**

| Zone     | SID  | HI   |
|----------|------|------|
| Low Hill | 0.69 | 0.31 |
| Mid Hill | 0.74 | 0.26 |



| Zone      | SID  | HI   |
|-----------|------|------|
| High Hill | 0.72 | 0.28 |
| Cold Dry  | 0.58 | 0.42 |

Source: Author's survey calculations reported in the thesis.

**Interpretation.** The survey measure shows a wide crop portfolio in the Mid Hill Zone and greater concentration in the Cold Dry Zone. The complementary HI values confirm the ordering.

**Table 3. Secondary-data infrastructure and diversification indices**

| Zone      | Composite infrastructure index | Secondary SID |
|-----------|--------------------------------|---------------|
| Low Hill  | 0.61                           | 0.62          |
| Mid Hill  | 0.72                           | 0.75          |
| High Hill | 0.8                            | 0.81          |
| Cold Dry  | 0.42                           | 0.55          |

Source: Thesis Tables 4.8–4.9; compiled from Directorate of Horticulture, HPMC/APMC and Economic Survey sources.

**Interpretation.** The displayed values move closely together. Recalculation from the four tabulated points gives a Pearson correlation of 0.969. This is stronger than the narrative value reported elsewhere in the thesis and should be corrected consistently in the final manuscript. With only four zonal observations, the statistic is descriptive and should not be presented as a definitive significance test.

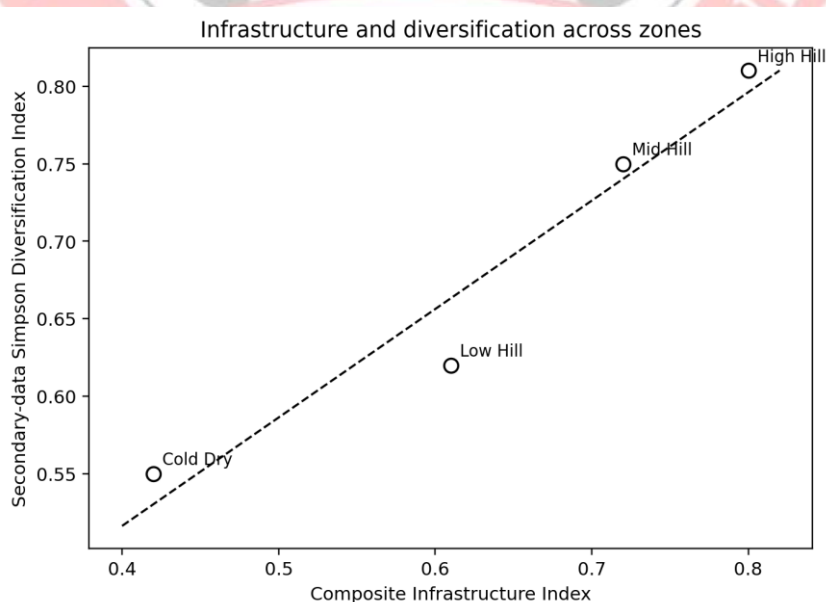


**Figure 1. Infrastructure and secondary-data diversification across agro-climatic zones**

**Interpretation.** High and Mid Hill zones combine stronger infrastructure with broader diversification, while the Cold Dry Zone occupies the low-infrastructure, low-diversification corner. The scatter is consistent with infrastructure enabling entry into perishable and market-oriented crops.

### 3.1 Simultaneous-equation specification

The preferred empirical system follows the endogeneity logic of Sen et al. (2017). Let FI denote annual farm income and MSID a monotonic transformation of the diversification index where required. The income equation is  $\ln(FI_i) = \alpha_0 + \alpha_1 MSID_i + \alpha_2 HVE_i + \alpha_3 CI_i + \alpha_4 IRR_i + \alpha_5 INST_i + \alpha_6 CREDIT_i + \alpha_7 EDU_i + \alpha_8 NFI_i + \alpha_9 ZONE_i + u_i$ . The diversification equation is  $MSID_i = \gamma_0 + \gamma_1 \ln(FI_i) + \gamma_2 LAND_i + \gamma_3 ALT_i + \gamma_4 MARKET_i + \gamma_5 EXT_i + \gamma_6 POLICY_i + v_i$ . HVE is the share of high-value enterprises; CI is cropping intensity; IRR denotes irrigation; INST institutional linkages; CREDIT formal credit; EDU education; NFI non-farm income; ALT altitude; MARKET market accessibility; EXT extension contact; and POLICY programme participation.

The model should be estimated by 2SLS only after confirming endogeneity with a Durbin-Wu-Hausman test. Instruments must satisfy both relevance and exclusion. Altitude or agro-climatic variables can strongly predict diversification, but they are not automatically valid instruments because they may directly affect income through yields and market access. The final paper should therefore report first-stage F-statistics, weak-instrument diagnostics and, where overidentified, Hansen/Sargan tests. These diagnostics are not optional in a Scopus-level empirical paper.

## 4. Results and Discussion

**Table 4. Year-wise infrastructure and horticultural growth**

| Year    | Composite infrastructure index | Area ('000 ha) | Production ('000 MT) |
|---------|--------------------------------|----------------|----------------------|
| 2015-16 | 0.52                           | 233            | 1850                 |
| 2016-17 | 0.55                           | 238            | 1920                 |
| 2017-18 | 0.58                           | 242            | 1980                 |
| 2018-19 | 0.6                            | 247            | 2030                 |
| 2019-20 | 0.63                           | 250            | 2080                 |
| 2020-21 | 0.66                           | 255            | 2120                 |
| 2021-22 | 0.69                           | 260            | 2180                 |
| 2022-23 | 0.72                           | 265            | 2250                 |
| 2023-24 | 0.75                           | 270            | 2320                 |

*Source: Thesis Table 4.11; Directorate of Horticulture, Economic Survey of Himachal Pradesh and author's index construction.*

**Interpretation.** The series shows a sustained rise in infrastructure, area and production. Between 2015-16 and 2023-24, the composite infrastructure index increases by about 44 per cent, horticultural area by about 16 per cent and production by about 25 per cent. The parallel movement is consistent with an enabling-infrastructure hypothesis, although the time series is too short for a strong causal claim without additional controls.

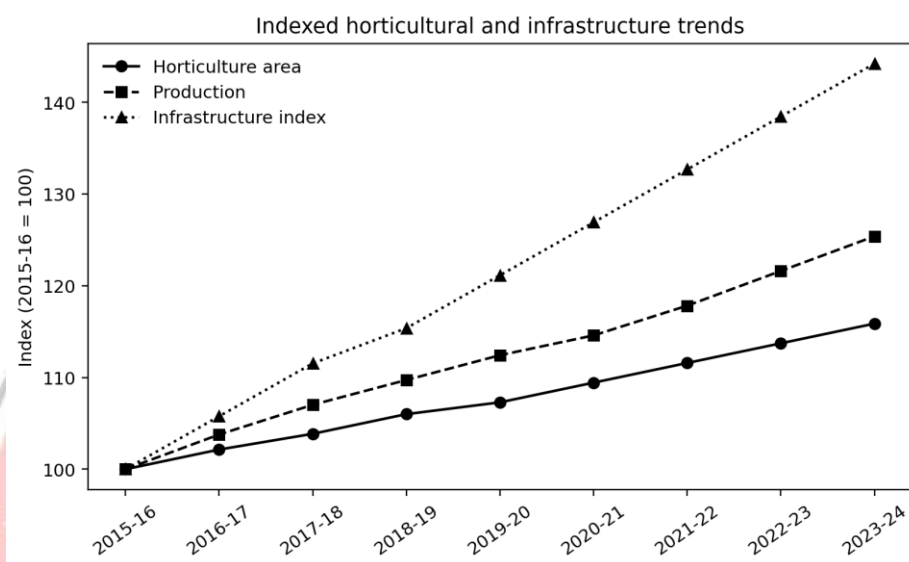


**Figure 2. Indexed trend of infrastructure, horticultural area and production**

**Interpretation.** Normalising all series to 2015-16 = 100 reveals that infrastructure grows more rapidly than area and production. The widening infrastructure index suggests an expanding enabling base, while production grows faster than area, indicating that intensification and productivity improvements accompany spatial expansion.

**Table 5. Awareness and participation in major horticulture schemes**

| Scheme        | Awareness (%) | Farmers benefited (%) | Participation gap (pp) |
|---------------|---------------|-----------------------|------------------------|
| MIDH          | 78            | 54                    | 24                     |
| PMKSY         | 72            | 48                    | 24                     |
| RKVY          | 63            | 38                    | 25                     |
| HPMC          | 69            | 44                    | 25                     |
| Cold chain    | 52            | 31                    | 21                     |
| Input subsidy | 81            | 59                    | 22                     |

*Source: Thesis Table 4.65; Directorate of Horticulture and Economic Survey of Himachal Pradesh.*

**Interpretation.** Awareness exceeds realised participation for every programme. The largest absolute gaps occur where procedural, infrastructural or eligibility barriers may prevent conversion of awareness into actual benefit. Cold-chain support has the lowest awareness and benefit rates, which is important because post-harvest infrastructure is crucial for high-value diversification.

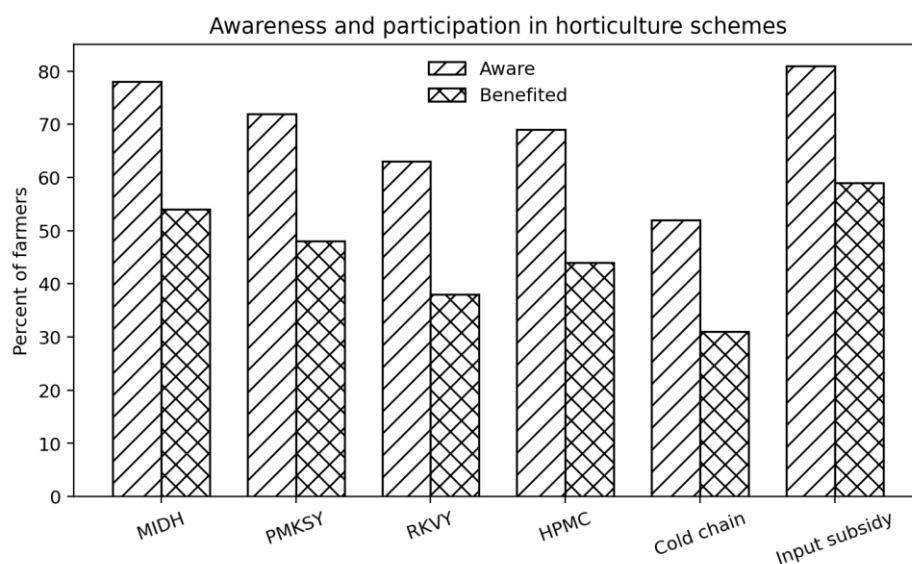


**Figure 3. Awareness and participation in horticultural schemes**

**Interpretation.** Input subsidies and MIDH show the strongest reach, whereas cold-chain support remains weak. This asymmetry can bias diversification toward production expansion without an equivalent strengthening of post-harvest capacity.

**Table 6. Beneficiary and non-beneficiary performance**

| Indicator                    | Beneficiaries | Non-beneficiaries | Difference (%) |
|------------------------------|---------------|-------------------|----------------|
| Area under horticulture (ha) | 1.85          | 1.2               | 54             |
| Productivity (MT/ha)         | 19.6          | 14.8              | 32             |
| Annual horticultural income  | ₹4.85 lakh    | ₹3.10 lakh        | 56             |
| Irrigation access (%)        | 68            | 39                | 29             |
| Improved varieties (%)       | 74            | 42                | 32             |

*Source: Thesis Table 4.66.*

**Interpretation.** Beneficiary farmers combine higher income with greater area, productivity, irrigation and technology use. This pattern is consistent with the hypothesis that institutional

support relaxes constraints to commercial diversification. It should not be interpreted as a causal programme impact without controlling for selection into schemes.

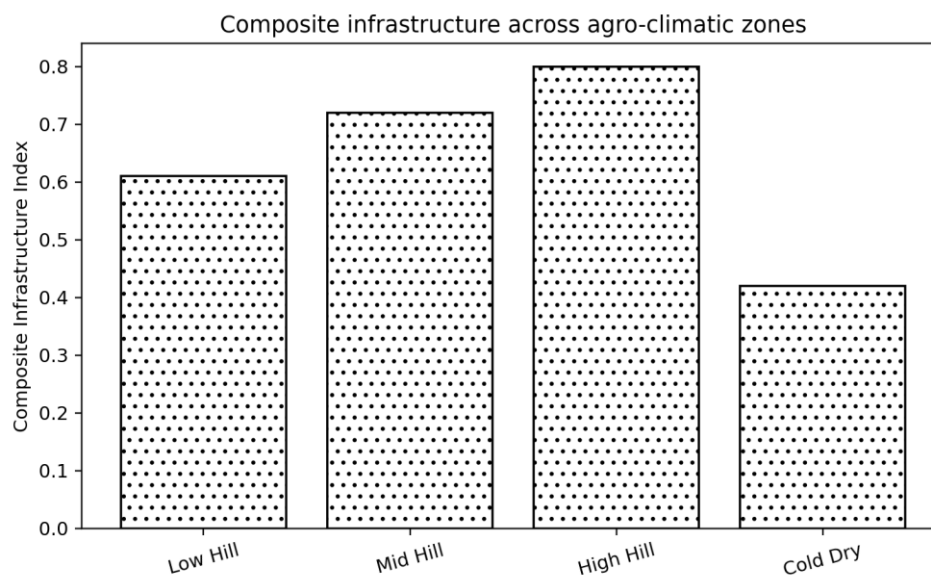


**Figure 4. Composite infrastructure index by agro-climatic zone**

**Interpretation.** The High Hill Zone has the strongest infrastructure base, followed by the Mid and Low Hill zones; the Cold Dry Zone lags substantially. This gradient helps explain why the range and commercial intensity of farm enterprises differs across zones.

#### 4.1 Direction of diversification and high-value enterprises

The income effect depends strongly on where diversification is directed. In the Low Hill Zone, diversification combines citrus, mango and guava with commercial vegetables. The Mid Hill Zone has perhaps the broadest opportunity set because temperate and subtropical fruits overlap with off-season vegetables. The High Hill Zone remains anchored by apple, but stone fruits and vegetables provide alternative revenue streams. The Cold Dry Zone has a narrower set of feasible crops, so diversification is better understood as strategic specialisation in niche products rather than as maximum portfolio breadth.

This distinction mirrors the Bihar finding that diversification within ordinary crop husbandry may have a different income effect from diversification toward horticulture and ancillary high-value enterprises. For Himachal Pradesh, a final regression should therefore include both overall SID and the share of high-value enterprises. An interaction term between HVE share and SID can test whether very high diversity dilutes the gains from high-value specialisation.

Cropping intensity is another likely channel. Short-duration vegetables can generate more than one marketable crop from a small holding, while orchard systems involve long gestation and lower annual land-use flexibility. The income model should therefore distinguish permanent orchard area from seasonal crop intensity. Without this distinction, an index based only on number or area shares can obscure economically important differences in the timing and capital requirements of enterprises.

## 4.2 Infrastructure as a conditioning variable

The infrastructure evidence is one of the strongest features of the Himachal case. Irrigation, roads, cold storage and market connectivity jointly determine whether high-value diversification is technically possible and commercially viable. A farmer located near a reliable road and market can exploit short market windows for peas, tomato, flowers or stone fruits. A similarly endowed farmer in a remote valley may rationally choose fewer, less perishable crops.

The recalculated cross-zone correlation between the displayed secondary diversification and infrastructure indices is about 0.97. Because it is based on only four aggregated zones, the coefficient should be treated as an illustrative spatial association, not a stand-alone hypothesis test. The household-level analysis should instead interact SID with individual measures of irrigation and market access, which would provide many more observations and reduce ecological-inference risk.

The year-wise series also suggests that infrastructure expansion and horticultural growth have moved together over the last decade. However, common trends can generate spurious correlation. A stronger secondary-data paper would require longer annual series, stationarity checks and controls for weather, prices and policy. The present manuscript therefore uses the trend to contextualise the household evidence rather than to claim causal time-series effects.

## 4.3 Farm income, policy and technology

The ₹1.75 lakh difference in mean annual horticultural income between beneficiaries and non-beneficiaries is economically substantial. Yet the same table shows that beneficiaries have more horticultural area, better irrigation and higher adoption of improved varieties. These are potential confounders as well as mechanisms. A credible micro-econometric model should therefore treat programme participation carefully, preferably controlling for pre-existing farm characteristics or using an identification strategy if a suitable exogenous eligibility rule exists.

Farmer perceptions are consistent with these quantitative patterns. Profitability, marketing, irrigation and training receive relatively high mean scores, and the correlation between marketing facilities and perceived profitability is positive. These responses suggest that households do not view diversification as merely an agronomic choice; they evaluate it through expected price, marketability, water reliability and institutional support.

## 5. Proposed 2SLS Results Table for Final Estimation

**Table 7. Publication-ready 2SLS structure to be populated from the 386-household microdata**

| <b>Dependent variable:<br/>ln(farm income)</b> | <b>Expected sign</b> | <b>Coefficient</b> | <b>Robust SE</b> | <b>p-value</b> |
|------------------------------------------------|----------------------|--------------------|------------------|----------------|
| Diversification<br>(MSID / SID)                | +                    | To estimate        | To estimate      | To estimate    |

| <b>Dependent variable:<br/>ln(farm income)</b> | <b>Expected sign</b> | <b>Coefficient</b> | <b>Robust SE</b> | <b>p-value</b> |
|------------------------------------------------|----------------------|--------------------|------------------|----------------|
| High-value enterprise share                    | +                    | To estimate        | To estimate      | To estimate    |
| Cropping intensity                             | +                    | To estimate        | To estimate      | To estimate    |
| Irrigation                                     | +                    | To estimate        | To estimate      | To estimate    |
| Institutional linkage                          | +                    | To estimate        | To estimate      | To estimate    |
| Formal credit                                  | + / ambiguous        | To estimate        | To estimate      | To estimate    |
| Education                                      | +                    | To estimate        | To estimate      | To estimate    |
| Non-farm income                                | ambiguous            | To estimate        | To estimate      | To estimate    |
| Zone controls                                  | —                    | Included           | —                | Joint test     |

*Source: Model specification adapted from Sen et al. (2017) and the variables available in the author's survey.*

**Interpretation.** This is intentionally not filled with simulated coefficients. For a Scopus submission, the numbers must be generated from the actual household dataset and accompanied by first-stage statistics, an endogeneity test and instrument-validity diagnostics.

## 6. Policy Implications

First, diversification policy should target the composition of output. Expanding high-value crops with demonstrated agro-climatic suitability is more likely to raise income than simply increasing the number of crops. Zone-specific crop planning should therefore be based on profitability, market windows, water use and climate risk.

Second, infrastructure should be treated as part of the diversification technology. Irrigation, roads, grading, pack houses, cold storage, processing and market information determine whether perishable crops can be transformed into realised income. The large infrastructure deficit in the Cold Dry Zone warrants targeted and decentralised solutions rather than replication of infrastructure models used in apple-dominant belts.

Third, programme design should close the gap between awareness and actual participation. High awareness of input subsidies is useful, but the relatively weak reach of cold-chain and storage support indicates an imbalance between production support and value-chain support. Diversification can create gluts and price crashes if market and storage capacity do not expand simultaneously.

Fourth, smallholder inclusion requires collective institutions. Producer organisations, cooperatives and shared logistics can reduce per-unit transaction costs, strengthen bargaining

power and make grading, storage and transport accessible to marginal farms. Credit products should match the gestation period of orchards and the working-capital cycle of vegetable cultivation.

Finally, diversification policy should incorporate climate resilience. Changing chilling conditions, frost, hail and rainfall variability can alter the profitability frontier of existing crop systems. Crop choice, varieties, irrigation and insurance should therefore be planned jointly rather than as separate interventions.

## **7. Conclusions**

Agricultural diversification in Himachal Pradesh is a spatially differentiated process of commercial transformation. Survey evidence shows relatively high diversification in the Mid, High and Low Hill zones and greater concentration in the Cold Dry Zone. Secondary evidence shows that zones with stronger infrastructure also display broader diversification, and decade-long trends show simultaneous expansion of infrastructure, horticultural area and production. Beneficiary households report higher income, productivity and technology access than non-beneficiaries.

The principal analytical conclusion is that the effect of diversification on income is likely to be conditional on the direction of diversification and on complementary resources. Diversification toward high-value horticulture can raise land productivity and income, but only where irrigation, roads, markets, storage, quality inputs and knowledge are adequate. Maximum diversification is therefore not the policy objective; economically efficient, climate-compatible and market-supported diversification is.

The final empirical contribution should come from a respondent-level 2SLS analysis of the 386-household dataset. That analysis should explicitly test endogeneity, instrument strength and robustness and should separate the effect of overall diversity from the share of high-value enterprises. Completing that step would make the paper methodologically comparable to the Bihar specimen while retaining a distinct contribution centred on mountain agriculture and agro-climatic heterogeneity.

## **6A. Identification Strategy and Econometric Diagnostics**

A convincing 2SLS analysis requires more than replacing SID with a predicted value. The first-stage equation must explain a substantial share of variation in diversification using variables that are theoretically relevant but excluded from the second-stage income equation. In the Himachal context, possible candidates include agro-climatic crop-suitability measures, historical extension exposure or predetermined village-level access variables. However, each candidate requires a defensible exclusion argument. Altitude, for example, clearly influences crop choice, but it may also influence income directly through yield potential, transport cost and climate risk; it is therefore not automatically valid as an instrument.

The first-stage F-statistic on excluded instruments should be reported to assess weak-instrument risk. If more instruments than endogenous variables are used, a Hansen or Sargan over-identification test should be presented. The Durbin-Wu-Hausman test should establish whether treating diversification as endogenous is empirically necessary. If endogeneity is not

supported, OLS with robust standard errors may be more efficient and easier to interpret. Reporting both OLS and 2SLS side by side would allow readers to see how much simultaneity changes the estimated diversification coefficient.

Functional form also matters. If farm income is positively skewed, a logarithmic transformation is appropriate and coefficients on continuous regressors can be interpreted approximately as semi-elasticities. If only the four questionnaire income categories are available, 2SLS with a continuous outcome is not appropriate without reconstructing actual income. In that case, a control-function ordered probit approach or an alternative endogenous ordered-response model should be considered. The final choice must follow the structure of the raw data rather than the preferred method of the specimen paper.

The model should additionally test heteroskedasticity and multicollinearity and use robust or cluster-robust standard errors where justified by the sampling design. Since respondents are clustered within selected villages and blocks, village-level clustering may be appropriate if the number of clusters is sufficiently large. If it is not, heteroskedasticity-robust standard errors and explicit zone controls are safer. These diagnostics are essential for a journal-ready paper because they demonstrate that the reported significance is not an artefact of model specification.

#### **6B. Comparison with the Bihar Diversification Model**

The Bihar specimen uses a value-of-output approach to capture diversification across agricultural and allied enterprises and reports a positive coefficient on overall diversification but a negative coefficient on diversification confined to ordinary crop husbandry. Its interpretation is that diversification toward horticulture and ancillary high-value enterprises is more income-enhancing than simply spreading production across conventional crops. This distinction is highly relevant to Himachal Pradesh, where horticulture itself is the central commercial sector.

The Himachal adaptation should therefore retain two separate concepts: overall enterprise diversity and the high-value-enterprise share. A farm specialising in high-return apple may have a lower diversity score but a high income, whereas another farm growing several low-value crops may have a high diversity score but modest income. Including both SID and HVE share prevents the index from being interpreted as a direct measure of commercialisation. An interaction between the two can test whether the effect of adding enterprises depends on how strongly the farm is already oriented toward high-value production.

The Bihar paper also includes cropping intensity, irrigation, institutional linkage, education, non-farm income and credit-related variables. These controls are suitable for the Himachal setting but need mountain-specific additions. Market distance, altitude, protected cultivation, orchard share, access to cold storage and exposure to climate hazards are plausible determinants of both diversification and income. Adding them would make the Himachal model an adaptation rather than a replication and would create a distinct contribution for the mountain-agriculture literature.

### **6C. Diversification Quality, Commercialisation and Income Stability**

A high SID should not be treated as an end in itself. The welfare objective is to identify a portfolio that raises expected income while keeping risk within the household's capacity. In this sense, diversification quality has at least four dimensions: the expected return of the added enterprise, its covariance with existing income sources, its demand for scarce resources, and its marketability. An off-season vegetable may have high expected returns but also high price volatility and labour demand. A fruit orchard may provide large returns but involve a long gestation period. A cereal may provide low cash income but protect household food consumption. Optimal diversification balances these functions.

Commercialisation introduces another trade-off. As farms move toward market-oriented horticulture, the share of output sold rises and dependence on external input and output markets increases. This can raise income but can also expose households to price shocks. The survey finding that marketing facilities are positively associated with perceived profitability is therefore important. A diversified high-value portfolio without grading, storage and transparent price discovery can produce large physical output yet weak net income. For this reason, post-harvest and marketing variables should enter the empirical model alongside production variables.

Income stability deserves explicit attention in future research. If respondent records contain year-to-year income or crop-loss information, the paper could estimate whether higher SID reduces the coefficient of variation of income or the probability of a severe income decline. Such a result would broaden the contribution from 'diversification raises mean income' to 'diversification changes the risk-return frontier of mountain farming.' That framing is more policy-relevant under increasing climate uncertainty.

### **6D. Research Contribution and Publication Positioning**

The strongest contribution of the Himachal paper lies in combining enterprise diversification with agro-climatic heterogeneity and infrastructure. Much of the Indian diversification literature treats states or districts as relatively homogeneous production spaces. In Himachal Pradesh, however, elevation creates distinct crop economies within a small geographical area. The paper can therefore show that the diversification-income relationship is conditioned by ecological opportunity and by the infrastructure needed to commercialise perishable output.

A second contribution is methodological transparency. The current draft separates verified descriptive findings from coefficients that still require estimation from the raw household dataset. This is preferable to presenting synthetic or back-calculated regression results. Once the microdata are available, the paper should include a reproducible variable-definition table, summary statistics, OLS benchmark, endogeneity test, first-stage regression, 2SLS second stage and robustness checks. That sequence would closely match the empirical expectations of Scopus-indexed agricultural-economics journals.

A third contribution is the policy distinction between diversification breadth and diversification direction. The empirical hypothesis is not that every increase in SID raises income, but that diversification toward suitable high-value enterprises, when matched with irrigation,

infrastructure and market access, improves farm-income opportunities. This conditional formulation is more realistic for mountain agriculture and can explain why a low-diversity niche system may still be economically rational in the Cold Dry Zone.

### **6E. Additional Robustness and Heterogeneity Tests**

The first robustness test should replace the Simpson index with the Herfindahl concentration index. Since HI and SID are algebraically complementary when constructed from the same shares, the signs should reverse while the substantive conclusion remains unchanged. Any failure of this relationship would indicate that the indices were calculated from different underlying enterprise sets or data sources. This check is especially important here because the thesis contains both a survey-based diversification series and a separate secondary-data series used with infrastructure indices. They should never be mixed in the same regression without explicit harmonisation.

The second robustness test should separate diversification within crops from diversification across broad enterprises. A crop-only SID can be constructed from fruit, vegetable, cereal and flower shares, while a broader enterprise SID can incorporate livestock or other allied activities if value-of-output data are available. Comparing the two coefficients would reveal whether income gains arise from spreading production within horticulture or from combining horticulture with other farm enterprises. This is directly comparable to the conceptual distinction in the Bihar paper.

Third, quantile regression or income-group interactions could test whether diversification benefits are concentrated among better-off farmers. If capital and market access are prerequisites, the effect may be larger in the upper part of the farm-income distribution. Conversely, marginal farmers may benefit more because diversification raises returns to scarce land. Establishing which mechanism dominates would give the paper a stronger distributional contribution.

Fourth, the analysis should test zone interactions and, if observations permit, estimate separate models for lower/mid hills and high/cold-dry regions. Pooling all 386 households imposes a common diversification coefficient across sharply different ecological systems. A significant interaction between SID and zone would demonstrate that the income return to diversification is conditional on agro-climatic context, which is one of the paper's core theoretical propositions.

### **6F. Implications for Mountain-Agriculture Theory**

The Himachal evidence suggests that diversification in mountain agriculture is best viewed as constrained portfolio choice. Farmers do not choose from the same set of crops: altitude, water and market access define a feasible subset, after which expected returns and risk determine allocation. This differs from a flat-land framework in which most crops are technically feasible and relative prices dominate. Incorporating the feasible-set concept helps explain why low diversification in the Cold Dry Zone need not indicate inefficiency.

The analysis also highlights the role of infrastructure in expanding the feasible set itself. A road, irrigation scheme or cold store does more than reduce cost for existing crops; it can make

entirely new enterprises economically possible. Infrastructure therefore changes the diversification frontier. This is a stronger proposition than the conventional statement that infrastructure raises agricultural productivity, and it provides a useful conceptual contribution for research on mountainous regions.

### **6G. Directions for Final Empirical Implementation**

For the final estimation, the dataset should be organised at the household level with one row per respondent and transparent variable construction. Crop-area shares should be checked to sum to one within each farm before SID is calculated. Income components should be reconciled so that farm income, horticultural income and non-farm income are not double-counted. Missing values and outliers should be documented rather than silently deleted. A short data-cleaning appendix can substantially improve replicability.

The journal version should then present a sequential empirical strategy: summary statistics; zone-wise diversification; OLS benchmark; endogeneity test; first-stage diversification equation; 2SLS income equation; and robustness checks using alternative indices and interaction terms. This ordering mirrors the logic of the Bihar specimen while making the Himachal contribution clearer. It also allows reviewers to distinguish the descriptive evidence from the causal identification argument.

If valid instruments cannot be defended, the paper should not force a 2SLS design simply to resemble the reference study. A carefully specified OLS or ordered-response model with rich controls, combined with explicit acknowledgement of simultaneity, is preferable to weak or invalid instruments. Methodological credibility is more important for Scopus publication than mechanical replication of a technique used in another state.

### **6H. Final Analytical Synthesis**

The evidence assembled in the paper therefore supports a conditional structural-transformation hypothesis. Diversification is associated with stronger farm-income opportunities when it broadens the portfolio toward high-value enterprises and when complementary infrastructure reduces production and transaction costs. The same numerical increase in SID can have very different economic meanings across zones: in a well-connected mid-hill village it may represent market-led expansion into vegetables and fruits, whereas in a remote cold-dry village the feasible set may remain narrow despite strong managerial capability. The econometric model should therefore estimate not only an average diversification effect but also its interaction with infrastructure and agro-climatic location.

This interpretation gives the Himachal study a distinct contribution relative to the Bihar specimen. The Bihar framework establishes the importance of endogeneity and high-value enterprises; the Himachal extension shows why the return to diversification itself is geographically conditioned. A properly estimated 2SLS model with zone and infrastructure interactions would therefore connect household portfolio choice, mountain ecology and rural infrastructure within one empirical framework.



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