

Relationship between Crop Diversification and Farm Income in Himachal Pradesh: An Agro-Climatic Zone-wise Empirical Analysis

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Abstract

The study examines the relationship between crop diversification and farm-income outcomes in Himachal Pradesh by adapting the analytical architecture of the Odisha diversification study to a mountain economy. The empirical base comprises 386 horticulturists drawn through a multistage stratified design from four agro-climatic zones: Low Hill (Kangra), Mid Hill (Chamba), High Hill (Shimla) and Cold Dry (Lahaul-Spiti). Diversification is measured by the Simpson Index of Diversification (SID) and its complementary Herfindahl concentration index (HI). The Mid Hill Zone records the highest survey-based SID (0.74), followed by the High Hill (0.72) and Low Hill (0.69) zones, while the Cold Dry Zone records 0.58. About 38.3 per cent of respondents report a shift from traditional cereal-based agriculture toward horticulture, motivated primarily by higher income prospects, market demand, government support and agro-climatic suitability. Income-related evidence shows that beneficiaries of horticulture schemes have a mean annual horticultural income of ₹4.85 lakh compared with ₹3.10 lakh among non-beneficiaries, along with higher productivity, irrigation access and use of improved varieties. Correlation and regression evidence from the survey further indicates that profitability, marketing facilities, government support, irrigation and training are central to farmers' willingness to continue horticulture. The findings suggest that diversification is most strongly associated with better income prospects when it is directed toward high-value horticultural crops and supported by infrastructure and institutions. The paper also identifies a data limitation: the currently compiled thesis tables do not provide respondent-level income-by-SID observations; therefore, the final causal income regression should be re-estimated from the original microdata before journal submission rather than inferred from grouped statistics.

Key words: Crop diversification; farm income; horticulture; Simpson index; Herfindahl index; agro-climatic zones; Himachal Pradesh

1. Introduction

The policy debate on Indian agriculture has gradually moved from production maximisation toward the quality, stability and distribution of farm income. This change is especially relevant in hill states, where production conditions are heterogeneous and the scope for scale expansion is restricted by small and fragmented holdings. In Himachal Pradesh, agricultural transformation has been closely associated with horticulture. Temperate fruit cultivation in the high hills, subtropical fruits in the lower belts, off-season vegetables in the mid hills and niche crops in cold dry regions have created a diverse commercial farm economy. At the same time,

dependence on a narrow crop portfolio exposes households to climatic shocks, pest incidence, fluctuating prices and marketing bottlenecks.

Crop diversification offers a possible response to these constraints. By distributing land and managerial effort across crops with different biological cycles, price patterns and climate sensitivities, farmers can potentially improve land returns and reduce income instability. Yet the effect is not automatic. Diversifying from one low-return crop to several low-return crops may lower risk without materially increasing income, whereas a shift toward fruits, vegetables and other high-value enterprises can raise returns per hectare. The distinction between 'more crops' and 'higher-value diversification' is therefore crucial.

Himachal Pradesh is particularly suitable for a zone-wise analysis because the feasible crop mix changes sharply with altitude. The Low Hill Zone supports mango, citrus, guava and vegetables; the Mid Hill Zone combines fruits with off-season vegetables; the High Hill Zone remains apple-centred but has scope for stone fruits and vegetables; and the Cold Dry Zone has a short growing season and a narrower crop basket. The same diversification policy cannot therefore be applied uniformly across the state.

The paper addresses three questions. First, how diversified are the horticultural crop portfolios across the four agro-climatic zones? Second, is the observed shift toward horticulture associated with stronger income and profitability outcomes? Third, which enabling factors appear to strengthen or weaken the diversification-income relationship? The contribution is to connect crop-portfolio structure with income-related evidence, infrastructure and farmer perceptions in a mountain context, while maintaining a clear distinction between descriptive association and causal inference.

2. Review of Literature and Analytical Perspective

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.

3. Data and Methodology

The analysis draws on the doctoral field survey of 386 horticulturists and on the statistical tables compiled in the thesis from the Directorate of Horticulture, Economic Survey of Himachal Pradesh and related official sources. The primary survey follows a multistage stratified design. One district represents each major agro-climatic zone, with respondents distributed nearly equally across zones to facilitate comparison. The selected districts are Kangra, Chamba, Shimla and Lahaul-Spiti. The questionnaire records crop-wise area and production, diversification shifts, annual horticultural-income class, share of horticulture in household income, irrigation, infrastructure, training, credit, policy awareness, market conditions and perception indicators.

Table 1. Sampling design and agro-climatic coverage

Agro-climatic zone	Selected district	Respondents	Share (%)
Low Hill	Kangra	97	25.1
Mid Hill	Chamba	97	25.1
High Hill	Shimla	96	24.9
Cold Dry	Lahaul-Spiti	96	24.9
Total	—	386	100.0

Source: Author's field survey.

Interpretation. The near-equal allocation is methodologically useful because the state contains sharply different ecological production systems. The design prevents the apple-dominated high hills or the more populous lower belts from mechanically dominating the state-level averages and permits meaningful zone-wise comparison.

Crop diversification is measured as $SID = 1 - \sum P_i^2$, where P_i denotes the share of cultivated area under the i th crop. SID rises as the distribution of area becomes more even across crops. The complementary Herfindahl Index is $HI = \sum P_i^2$; lower HI values indicate lower concentration. The use of both measures is useful because the two indices communicate the same structure from opposite directions and help detect transcription inconsistencies.

For income analysis, the questionnaire records annual horticultural income in ordered classes and the thesis contains a separate beneficiary/non-beneficiary comparison with mean

annual income. The present paper therefore uses verified descriptive income evidence and does not manufacture household-level regression coefficients that are absent from the compiled tables. The preferred final model is $\ln(FI_i) = \alpha + \beta_1 SID_i + \beta_2 LAND_i + \beta_3 IRR_i + \beta_4 MARKET_i + \beta_5 TRAIN_i + \beta_6 POLICY_i + \beta_7 ZONE_i + \varepsilon_i$ when exact income is available; if only ordered income classes remain, ordered logit/probit should be used. This distinction is essential for a publishable empirical paper.

4. Results and Discussion

Table 2. Zone-wise crop diversification and concentration

Zone	SID	HI	Diversification level
Low Hill	0.69	0.31	High
Mid Hill	0.74	0.26	Very high
High Hill	0.72	0.28	High
Cold Dry	0.58	0.42	Moderate

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

Interpretation. The Mid Hill Zone has the broadest crop portfolio (SID 0.74; HI 0.26), reflecting the coexistence of fruit crops and commercial vegetables. The High Hill Zone is also diversified despite the continuing importance of apple. The Low Hill Zone records substantial diversification into subtropical fruits and vegetables. The Cold Dry Zone has the highest concentration (HI 0.42), which is economically consistent with a short growing season, severe cold and fewer feasible crops.

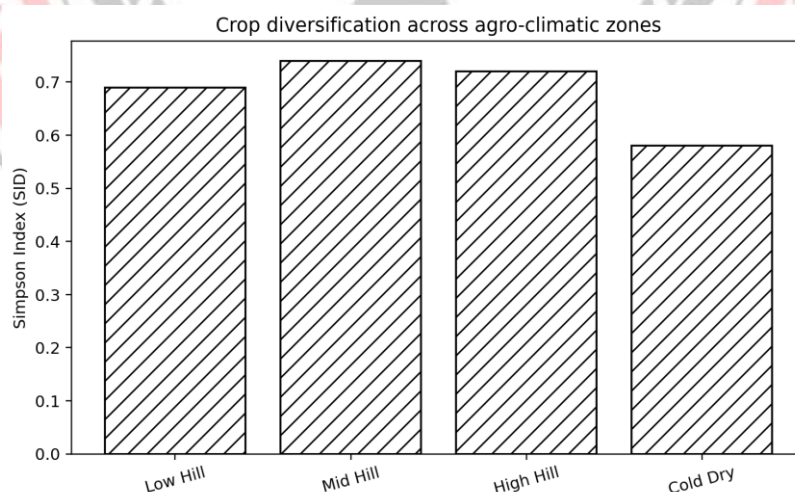


Figure 1. Simpson diversification index across agro-climatic zones

Interpretation. The figure makes the spatial gradient explicit. Diversification is highest in the Mid Hill system and lowest in the Cold Dry system. The difference is not simply a matter of farmer preference; it reflects the interaction of climate, crop suitability, infrastructure and market access.

Table 3. Dominant horticultural crop portfolio by zone

Zone	Major fruits	Major vegetables / high-value crops	Structural implication
Low Hill	Mango, citrus/kinnow, guava	Tomato, capsicum, cauliflower	Subtropical fruit–vegetable mix
Mid Hill	Apple, mango, plum	Tomato, peas, cauliflower	Broad mixed horticulture
High Hill	Apple, plum, peach, cherry	Tomato, peas	Temperate fruit system with diversification
Cold Dry	Apple, apricot, pear	Peas and niche crops	Narrow climate-constrained portfolio

Source: Author's field survey and thesis crop-profile tables.

Interpretation. The crop mix confirms that the index values have substantive meaning. Mid- and low-hill diversification is driven by combining fruits and vegetables, while high-hill diversification occurs around an apple core. Cold dry diversification is narrower and oriented toward climate-compatible niche crops.

Table 4. Shift from traditional agriculture toward horticulture

Response	Respondents	Percent
Yes	148	38.3
No	238	61.7
Total	386	100.0

Source: Author's field survey.

Interpretation. More than one-third of respondents have made an explicit structural shift toward horticulture. The remaining 61.7 per cent should not be interpreted as non-diversifiers; many continue cereal cultivation for food security while adding horticulture. Thus, the transition is often additive rather than complete crop substitution.

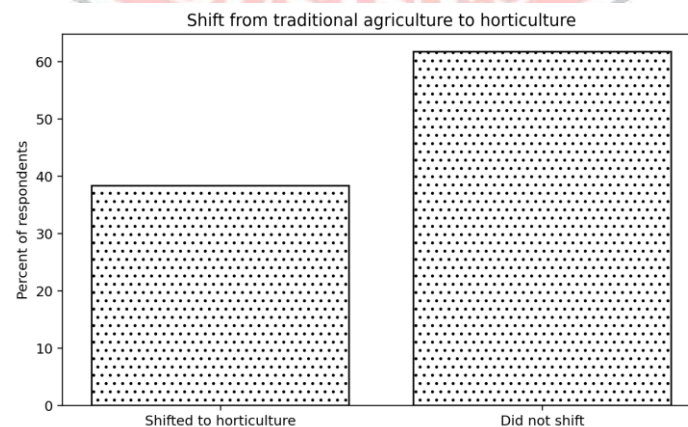


Figure 2. Reported shift from traditional agriculture to horticulture

Interpretation. The transition toward horticulture is significant but incomplete. This pattern is typical of risk-conscious smallholders: households preserve a subsistence cereal component while gradually expanding high-value crops.

Table 5. Beneficiary–non-beneficiary comparison of horticultural performance

Indicator	Beneficiaries	Non-beneficiaries	Difference reported (%)
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
Access to irrigation (%)	68	39	29
Use of improved varieties (%)	74	42	32

Source: Thesis Table 4.66; compiled from Economic Survey of Himachal Pradesh and Directorate of Horticulture sources.

Interpretation. The income gap is economically large: beneficiary farmers report about ₹1.75 lakh more annual horticultural income, alongside higher productivity, irrigation access and improved-variety use. The pattern supports a complementarity mechanism in which policy and infrastructure make high-value diversification more remunerative. Because the table does not provide group sample sizes or controls, the comparison is an association, not a causal treatment effect.

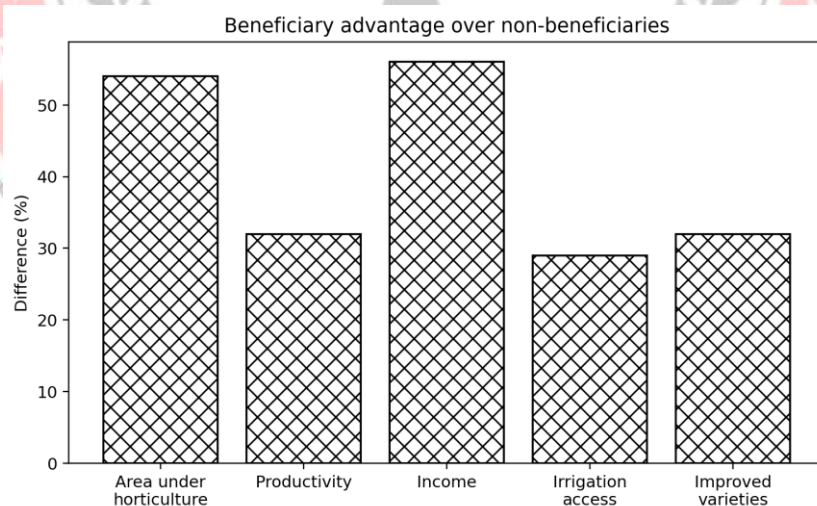


Figure 3. Relative advantage of beneficiaries over non-beneficiaries

Interpretation. The largest reported difference is in annual income, closely followed by the area placed under horticulture. The result is consistent with a commercialization pathway: support improves irrigation and technology adoption, which allows larger and more intensive participation in horticulture and is associated with higher earnings.

Table 6. Selected perception and correlation evidence relevant to farm income

Relationship / indicator	Statistic	Interpretation
Horticulture is more profitable	Mean 3.55	Moderately strong agreement
Income improved	Mean 3.22	Positive but less uniform experience
Marketing facilities	Mean 3.56	Highly valued enabling factor
Irrigation facilities	Mean 3.53	Important production support
Training programmes	Mean 3.52	Strong perceived value
Income improved vs living standard	$r = 0.76$	Strong positive association
Marketing facilities vs profitability	$r = 0.69$	Positive association

Source: Author's survey; thesis Tables 4.62–4.63.

Interpretation. The perception evidence helps explain why the diversification-income relationship varies across households. Farmers associate profitability with marketing and improved living standards with income gains. This supports a value-chain interpretation: crop diversification creates income opportunities only when output can be produced reliably and sold remuneratively.

Table 7. Reported regression coefficients for intention to continue horticulture

Independent variable	Coefficient (β)	Reported significance
Profitability	0.41	Significant
Government support	0.29	Significant
Marketing facilities	0.24	Significant
Irrigation facilities	0.2	Moderate
Training programmes	0.17	Moderate

Source: Author's survey; thesis Table 4.64. Dependent variable: intention to continue horticulture.

Interpretation. Profitability is the largest reported coefficient, followed by government support and marketing. This model does not estimate farm income directly; its role in the present paper is behavioural. It shows that the same factors expected to make diversification income-enhancing also influence farmers' willingness to remain in horticulture.

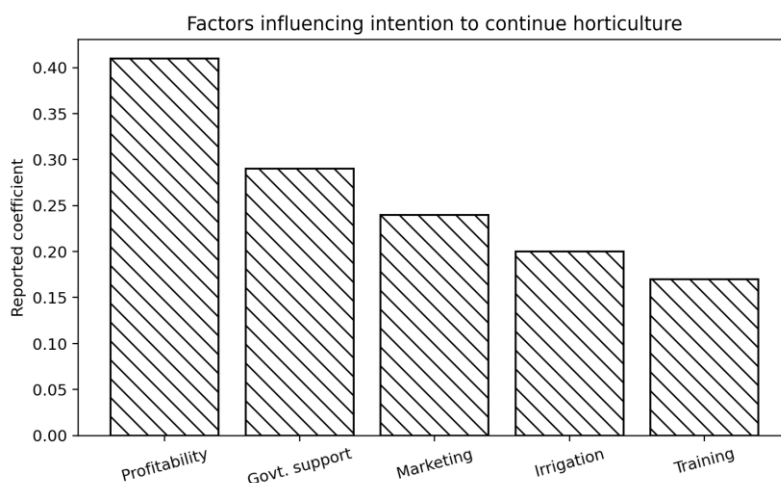


Figure 4. Reported determinants of willingness to continue horticulture

Interpretation. The ranking of coefficients places economic return first, followed by institutional and market support. This reinforces the argument that diversification policy must be commercially viable and cannot rely on agronomic recommendations alone.

5. Discussion: How Diversification Can Raise Farm Income

The results point to a conditional positive relationship rather than a mechanical one. The Mid and High Hill zones combine relatively high diversification with more developed commercial horticulture, while the Cold Dry Zone combines lower diversification with severe ecological and logistical constraints. The comparison suggests that farmers diversify most successfully where the opportunity set includes multiple high-value crops and where transport, irrigation and institutions lower the cost of entering those crops.

The beneficiary comparison offers a second piece of evidence. Higher income among beneficiaries is accompanied by better irrigation and improved varieties. This clustering of outcomes matters: it implies that policy support may affect income partly by altering the crop and technology portfolio. A farmer with assured water and improved planting material can allocate land to vegetables or higher-yielding fruit varieties that would otherwise be too risky. Diversification is therefore a mediated process, not an isolated land-allocation decision.

Market access is equally central because horticultural crops are perishable and quality-sensitive. A diversified portfolio of tomatoes, peas, stone fruits and flowers can become a liability if roads, pack houses, storage or market intelligence are weak. The positive relationship between marketing facilities and perceived profitability is therefore economically plausible. In the hill context, commercialization and diversification are jointly produced by production infrastructure and market infrastructure.

The results also reveal why the same policy should not be applied uniformly. In the Cold Dry Zone, a lower SID can be an efficient response to environmental constraints. Policy should focus on water-efficient niche crops, protected cultivation, short-duration vegetables, quality seed production and storage rather than forcing a broad crop basket. In the High Hill Zone, diversification around apple can reduce climate and price concentration. In the Mid Hill Zone,

the policy opportunity is to strengthen already expanding mixed fruit–vegetable systems. In the Low Hill Zone, citrus, mango, guava and vegetables can be linked more strongly with irrigation and nearby markets.

For small and marginal farmers, the relevant welfare metric is return per unit of land and stability of household cash flow. High-value diversification can raise land productivity, but it also increases working-capital needs and transaction costs. Farmer-producer organisations, cooperative marketing, shared grading and cold storage, and timely institutional credit can reduce these fixed costs and make the gains from diversification more inclusive.

6. Robustness, Limitations and Scopus-Submission Requirements

The present paper is deliberately conservative in its statistical claims. The compiled thesis provides verified zone-level diversification indices, respondent counts, perception statistics and a beneficiary income comparison, but it does not expose the full respondent-level cross-tabulation of crop shares and exact income. A publication-quality causal coefficient between SID and income cannot therefore be reconstructed honestly from the grouped tables.

Before journal submission, the original 386-household dataset should be used to estimate the income model directly. If exact annual income is available, a log-linear OLS model with heteroskedasticity-robust standard errors can be estimated first, followed by instrumental-variable tests if SID is endogenous. If income is only observed in the questionnaire's four ordered categories, ordered logit or ordered probit is the correct primary estimator. Zone fixed effects, farm-size controls, irrigation, training, market access, policy participation and education should be included.

Robustness checks should use both SID and HI, test the high-value-crop share separately from overall diversity, examine interactions between diversification and infrastructure, and report variance-inflation factors, heteroskedasticity tests and sensitivity to alternative functional forms. This final micro-econometric step is what will elevate the manuscript from a descriptive paper to a strong Scopus-targeted empirical contribution.

7. Conclusions and Policy Implications

Crop diversification in Himachal Pradesh is strongly differentiated by agro-climatic conditions and by the enabling environment for commercial horticulture. The Mid Hill Zone records the highest survey-based diversification, followed by the High and Low Hill zones, while the Cold Dry Zone remains relatively concentrated. The direction of change is toward fruits, vegetables and other high-value crops rather than merely toward a larger number of traditional crops. A substantial 38.3 per cent of respondents report shifting from traditional cereal cultivation toward horticulture.

The income-related evidence is consistent with a positive diversification pathway, but the relationship is conditional. Beneficiary farmers report higher annual horticultural income, productivity, irrigation access and adoption of improved varieties. Farmer perceptions similarly emphasise profitability, marketing, irrigation and training. These results imply that diversification should be promoted through an integrated strategy combining crop choice with

water security, technology, extension, roads, storage, grading, collective marketing and price information.

The strongest policy recommendation is therefore zone-specific diversification rather than a uniform state-wide prescription. The Mid Hills can deepen fruit–vegetable diversification; the High Hills should diversify around the apple economy while investing in climate resilience; the Low Hills can expand subtropical fruit and vegetable systems; and the Cold Dry Zone requires niche, water-efficient and climate-compatible enterprises. The final microdata regression should quantify the independent effect of diversification on income and test whether infrastructure and policy support strengthen that effect.

6A. Detailed Agro-Climatic Interpretation of Diversification

The Low Hill Zone occupies an important transitional position in the diversification process. Its survey SID of 0.69 indicates that the crop portfolio is already broad, but the structure is different from the temperate horticulture of higher altitudes. Mango, citrus/kinnow and guava coexist with tomato, capsicum and cauliflower. Such a portfolio can generate cash income over different seasons and reduce dependence on cereals, yet it is also exposed to monsoon variability, heat stress and market congestion in vegetables. The economic advantage of diversification in this zone therefore depends strongly on reliable irrigation and the ability to reach nearby markets before quality deteriorates. Since holdings are fragmented, small-scale irrigation systems, collection centres and shared transport can have a disproportionate effect on realised farm income.

The Mid Hill Zone emerges as the most diversified survey region with SID 0.74 and HI 0.26. This is consistent with a wide agro-climatic opportunity set in which lower-elevation fruits, temperate fruits and off-season vegetables overlap. The zone can therefore exploit both biological and market seasonality. Off-season vegetables are particularly relevant because they allow small farmers to capture higher prices when plains production is seasonally constrained. Fruit crops provide a longer-term asset and income stream, while vegetables generate shorter-cycle cash flow. The combination is economically attractive because it reduces the liquidity problem associated with orchard gestation. At the same time, the larger number of enterprises can increase labour and management demands. The income-maximising portfolio is therefore likely to be diversified but not unlimited.

The High Hill Zone records SID 0.72 and retains a strong apple orientation. This should not be misread as a contradiction. A region can remain specialised in a leading commercial crop while diversifying around it through plum, peach, cherry, pear, peas and selected vegetables. The economic role of such diversification is especially important when the dominant crop is exposed to climate-sensitive chilling requirements, hail, frost, pest outbreaks or volatile market arrivals. Diversification around an apple core can reduce the covariance of household returns and spread harvest periods. It can also create opportunities to use labour and market infrastructure more fully throughout the season. However, the high fixed investment in orchards means that diversification decisions in this zone are path-dependent and require long planning horizons.

The Cold Dry Zone records the lowest survey SID at 0.58 and the highest HI at 0.42. In a conventional interpretation this appears to indicate insufficient diversification, but a mountain-economy interpretation is more nuanced. Very low temperatures, short growing seasons, moisture scarcity and long transport distances limit the feasible crop set. Consequently, concentration may reflect ecological comparative advantage rather than an information failure. Policy should not attempt to replicate the Mid Hill crop basket. A more suitable strategy is selective diversification into water-efficient niche crops, seed production, protected vegetables and high-quality temperate products that can command price premiums sufficient to cover transport costs. In this zone, the quality and profitability of diversification matter more than the sheer number of crops.

6B. Diversification, Farm Size and Household Risk

The predominance of marginal and small holdings in the survey has major implications for the diversification-income relationship. Small farms usually cannot increase income through area expansion, so they must improve value per hectare, increase cropping intensity or combine enterprises with different cash-flow patterns. High-value horticulture is therefore potentially attractive. Yet smallholders also face higher transaction costs per unit of output, weaker bargaining power and less capacity to absorb a failed crop. Diversification can partly compensate by spreading risk, but it can also increase the number of input and marketing decisions that must be financed and managed. For this reason, cooperative input purchase, shared grading, collective transport and farmer-producer organisations should be viewed as part of the diversification technology.

Risk reduction is an important benefit that is not captured fully by mean annual income. Fruit and vegetable prices can fluctuate sharply, and climate-related shocks do not affect all crops in the same way. A portfolio containing orchard crops, vegetables and limited subsistence cereals can therefore stabilise consumption and cash flow even when the expected mean return is only modestly higher. A future version of the paper should estimate not only the income level effect of SID but also the relationship between diversification and income variance, probability of severe income shortfall, or subjective income stability. Such analysis would be especially valuable for a mountain state where weather shocks are spatially concentrated and transport disruptions can occur during peak marketing periods.

Farm size may also generate a non-linear relationship. Very small farms may be diversified for subsistence and risk reasons, medium farms may be able to exploit commercial diversification most effectively, and large farms may obtain economies of specialisation. This possibility is well established in the diversification literature and should be tested in the respondent-level dataset by including farm-size categories and an interaction between farm size and SID. A statistically significant interaction would show whether diversification has different income effects for marginal, small and medium farms. Such heterogeneity would materially strengthen the policy relevance of the paper.

6C. Interpretation of Income Evidence

The available income evidence should be interpreted carefully. The beneficiary mean of ₹4.85 lakh compared with ₹3.10 lakh among non-beneficiaries indicates an annual difference of

₹1.75 lakh, or roughly 56 per cent relative to the non-beneficiary mean. At the same time, beneficiaries cultivate more horticultural area, achieve higher productivity, have greater irrigation access and use improved varieties more frequently. These differences are not statistical nuisances; they are part of the economic mechanism through which institutional support may enable diversification. But they also mean that a simple comparison cannot isolate the independent contribution of crop diversity. The final econometric model must control for these factors and, if possible, address selection into programme participation.

The survey perception 'income improved' has a mean of 3.22, which is positive but weaker than the mean score for horticulture being more profitable (3.55). This gap is informative. Farmers may recognise that horticulture offers higher gross or potential returns while still experiencing uneven realised income because of price volatility, rising input costs, crop loss or marketing margins. A strong Scopus paper should exploit this distinction rather than treating profitability and income as identical concepts. Profitability is a production-business outcome, whereas household income is affected by area, crop failure, debt service, non-farm earnings and the share of produce actually marketed.

The positive correlation between income improvement and living standard ($r=0.76$) also has a clear welfare interpretation. Where horticultural income rises, households report better living standards. This association supports the broader relevance of diversification beyond farm accounts, but it remains a perception-based relationship. The preferred final model should use actual rupee income as the dependent variable and use perception indicators as complementary evidence. Combining objective and subjective measures in this way would make the empirical argument more convincing and reduce common-method bias.

6D. Comparison with the Odisha Empirical Model

The Odisha specimen classifies districts into highly, moderately and least diversified groups using the Herfindahl Index and then compares average net returns. The present Himachal analysis follows the same logic but replaces district-wide crop concentration with agro-climatic zone comparisons because ecological heterogeneity is more fundamental to crop choice in a mountain state. Both studies therefore ask whether a broader crop portfolio is associated with better farm returns, but the spatial unit and the crop opportunity set differ substantially.

A second difference concerns irrigation. In the Odisha study, higher irrigated area was associated with greater crop concentration because irrigation was strongly tied to paddy. In Himachal Pradesh, irrigation is more likely to broaden the feasible set of horticultural crops, especially vegetables and new fruit systems. This reversal is theoretically important: infrastructure does not have a universal sign in a diversification equation; its effect depends on the crop that the infrastructure favours. The Himachal paper can therefore make a genuine contribution by showing that mountain irrigation may be diversification-enhancing rather than concentration-enhancing.

A third difference is the role of perishability. Odisha crop diversification in the specimen includes foodgrains, oilseeds, pulses and vegetables, whereas Himachal's commercial diversification is heavily weighted toward fruits and vegetables. The income effect is therefore more dependent on grading, packing, cold storage and transport. This strengthens the case for

including market and infrastructure variables directly in the Himachal model rather than treating diversification as a purely production-side decision.

Finally, the Himachal study has the opportunity to move beyond a simple diversified-versus-concentrated comparison by exploiting respondent-level farm data. Once the original microdata are linked, it can estimate the marginal effect of SID on income while controlling for farm size, irrigation, education, training, policy participation and zone. This would preserve the intuitive accessibility of the Odisha paper while adding a more rigorous micro-econometric contribution.

6E. Hypotheses and Expected Signs for Final Econometric Estimation

The principal hypothesis is H1: greater crop diversification is associated with higher farm income after controlling for farm and household characteristics. The expected coefficient on SID is positive if diversification is primarily toward remunerative horticultural crops. H2 states that the income effect of diversification is stronger where irrigation and market access are better. This can be tested through SID×Irrigation and SID×Market interaction terms. H3 states that high-value-crop share has an independent positive effect on income even after controlling for overall SID, allowing the analysis to separate portfolio breadth from portfolio quality.

H4 concerns institutional support: training, extension and policy participation are expected to increase the probability and profitability of diversification. H5 concerns agro-climatic heterogeneity: the marginal income return to SID differs across zones. Zone interactions are preferable to a single pooled coefficient if the data support them. H6 concerns farm-size heterogeneity: commercial diversification is expected to have the strongest income effect among small and medium farmers, while extremely small farms may diversify mainly for subsistence and very large farms may benefit from specialisation.

Testing these hypotheses would create a coherent empirical sequence: descriptive SID and HI values establish the spatial pattern; crop profiles establish the direction of diversification; income comparisons establish economic relevance; and the household regression isolates the conditional association or causal effect. This sequence closely follows the logic of high-quality applied agricultural-economics papers and would address the main weakness of a purely descriptive manuscript.

6F. Policy Matrix for Income-Enhancing Diversification

Zone	Priority diversification pathway	Critical constraint	Priority intervention
Low Hill	Subtropical fruits + commercial vegetables	Irrigation gaps; marketing	Micro-irrigation, collection centres, local processing

Mid Hill	Off-season vegetables + mixed fruits	Post-harvest handling; price risk	Pack houses, cold chain, market intelligence
High Hill	Apple-centred diversification into stone fruits/vegetables	Climate risk; ageing orchards	Orchard renewal, climate-resilient varieties, insurance
Cold Dry	Niche fruits, peas, seed crops, protected cultivation	Water scarcity; isolation	Water harvesting, protected cultivation, specialised logistics

Table 8. Zone-specific policy matrix for income-enhancing diversification

Source: Synthesis of the author's survey findings and agro-climatic analysis.

Interpretation. The policy matrix converts the statistical results into region-specific action. It recognises that a single diversification target would be inappropriate in a state where ecological opportunity sets differ sharply by altitude. The common principle is to combine high-value crop choice with the particular infrastructure bottleneck that constrains income realisation in each zone.

6G. Determinants of Diversification in the Himachal Context

Irrigation is likely to have a different structural role in Himachal Pradesh from that observed in rice-dominant regions. In a paddy system, expansion of assured irrigation can reinforce concentration because the subsidised and technically familiar crop absorbs the additional water. In hill horticulture, by contrast, reliable irrigation often enlarges the feasible crop set. Drip and sprinkler systems can make tomato, capsicum, cauliflower, peas, flowers and newly planted orchards less dependent on rainfall timing. The expected sign of irrigation in a diversification equation is therefore positive for SID, although the effect may vary by zone. This context dependence should be highlighted because it is one of the clearest ways in which the Himachal evidence can extend the Odisha literature rather than merely reproduce it.

Market distance and transport quality are also expected to shape diversification strongly. High-value crops generally have a greater price per kilogram but also a shorter marketing window and higher quality sensitivity. A farmer far from an all-weather road may face an implicit transport tax that erodes the profitability of diversification. The household may therefore concentrate on crops that are storable, locally consumed or less sensitive to delays. In the final microdata analysis, distance to market should be entered in kilometres and, if possible, interacted with the share of perishable crops. A negative interaction would provide direct evidence that remoteness reduces the income return from diversification.

Extension and training can affect both the probability and the quality of diversification. New crops require information on varieties, sowing or planting time, pest management, grading and market standards. The survey's relatively high mean score for training programmes indicates that farmers value this support. A binary training variable alone may, however, be too crude. If the questionnaire records frequency, type or source of training, the final paper should

distinguish exposure to government extension, Krishi Vigyan Kendra advice, private input dealers and farmer networks. Different sources may have different implications for crop choice and profitability.

Credit is similarly ambiguous. Formal credit can enable investment in irrigation, protected cultivation, planting material and orchard rejuvenation, thereby supporting high-value diversification. But debt can also encourage concentration in a familiar commercial crop if lenders prefer established enterprises with predictable marketing channels. The sign of credit in a diversification equation is therefore an empirical question. The preferred specification should distinguish access to credit from the amount borrowed and, if data permit, separate productive horticultural credit from consumption or distress borrowing.

Education can reduce information barriers and improve the ability to interpret market signals, but its effect on diversification may not be linear. More educated households may adopt new horticultural technologies, while they may also have better non-farm employment options and therefore devote less managerial time to a complex farm portfolio. The model should therefore include education categories or years of schooling and, ideally, non-farm income. This separation prevents the education coefficient from capturing the opportunity cost of farm labour.

Government policy variables should be treated as both determinants and possible moderators. A subsidy for planting material may directly increase the adoption of a new fruit crop, while irrigation or market infrastructure may strengthen the profitability of an already diversified portfolio. In econometric terms, a policy dummy can enter the diversification equation, while interactions such as $SID \times Policy$ or $SID \times Irrigation$ can enter the income equation. This design would test whether public support changes the return to diversification rather than simply whether beneficiaries have higher income.

6H. Net Returns, Opportunity Cost and the Meaning of Farm Income

A high-quality farm-income paper must define income precisely. Gross receipts are not equivalent to farm income because horticulture often involves substantial expenditure on planting material, fertiliser, plant protection, hired labour, transport, packaging and commission charges. Orchard crops also require treatment of establishment costs and depreciation over the productive life of the orchard. The Odisha specimen uses gross returns, cultivation cost and net returns per hectare, which provides a transparent accounting framework. The Himachal paper should follow the same principle wherever crop-wise cost data are available.

If the respondent dataset contains only annual horticultural income categories, the paper should describe that variable as reported net or gross income according to the questionnaire wording and avoid switching terminology. If crop-wise costs are available separately, a second outcome—net return per hectare—would materially improve the paper. This would allow a direct comparison of returns from apple, stone fruits, citrus and vegetables and would reveal whether higher SID reflects movement toward crops with greater margins or merely a more even allocation of area.

Family labour creates another measurement issue. Small farms often rely heavily on unpaid household labour. A business-income concept may treat family labour as part of the household return, while an economic-profit concept imputes its opportunity cost. Both measures are legitimate but answer different questions. For comparison with the Odisha paper and with farmer welfare, business income or net cash return may be the more intuitive primary measure, with an imputed-cost measure reported as a robustness check. The manuscript should state the chosen accounting concept explicitly.

The gestation period of orchards also means that current-year income may not align perfectly with current diversification. A household that has recently planted a new orchard may appear highly diversified but may not yet receive income from the new enterprise. If the survey records year of shift or orchard age, the analysis should control for gestation or distinguish mature and immature orchards. This is particularly important in high-value fruit systems where establishment decisions precede revenue by several years.

6I. Statistical Presentation for the Final Journal Version

The final results section should report a full descriptive-statistics table for all variables used in the regression: mean, standard deviation, minimum, maximum and number of observations. A correlation matrix should then be used primarily as a diagnostic rather than as proof of causality. Regression tables should report coefficients, robust standard errors, test statistics, exact p-values, goodness-of-fit measures and the number of observations. Stars may be used for conventional significance levels, but exact p-values are preferable when space permits.

For the diversification measure, the distribution of SID should be shown at household level, not only as four zonal means. A histogram or kernel density plot would reveal whether the index is concentrated near particular values and whether transformation is necessary. A box plot by zone would show within-zone heterogeneity. The present paper includes zonal bars because those are the verified statistics available in the thesis; the final microdata version should add the household distribution and report the median and interquartile range.

Model robustness should include at least three specifications: a parsimonious model with SID and zone controls; an extended model adding farm and household characteristics; and a full model adding infrastructure and institutional variables. Stability of the SID coefficient across specifications would strengthen the argument. If the coefficient changes substantially, the paper should interpret which omitted variables were confounding the simple relationship. This transparent sequence is more informative than presenting only one 'best' equation.

Finally, the discussion should compare the magnitude and sign of the Himachal coefficients with the Odisha and Bihar studies without forcing identical conclusions. The value of a regional study lies precisely in showing where relationships differ because of crop systems, agro-climatic conditions and institutions. A finding that irrigation promotes diversification in Himachal while reducing it in paddy-dominant Odisha would be a substantive result, not a problem to be reconciled away.

6J. Research Implications and Future Extensions

The paper also has implications for how agricultural diversification should be measured in a horticulture-dominant state. Area shares are intuitive and comparable with the Odisha study, but they may understate the importance of enterprises that generate high value from small areas. Flowers, protected vegetables and nursery activities are obvious examples. A value-of-output diversification index should therefore be calculated as a robustness measure. If the income coefficient is stronger for value-based SID than for area-based SID, the result would indicate that the economic composition of the portfolio matters more than physical land allocation. If the two indices produce similar conclusions, confidence in the general diversification effect would increase.

Another useful extension is to distinguish planned diversification from distress diversification. Households may add crops because they perceive profitable market opportunities, but they may also diversify after a climate shock, crop failure or inadequate income from the dominant crop. The questionnaire's reasons for shifting toward horticulture already identify income, market demand, government support and climate suitability as motives. These motives can be converted into categorical variables and related to income outcomes. Opportunity-led diversification should, in principle, be associated with higher expected returns than distress-led diversification, although the latter may still improve resilience.

Temporal sequencing is also important. The current cross-sectional survey provides a strong snapshot, but it cannot fully establish whether higher income follows diversification or whether higher-income farmers diversify more readily. A panel follow-up of the same households would be particularly valuable. Re-interviewing respondents after two or three seasons would allow fixed-effects estimation, control for time-invariant household characteristics and provide direct evidence on whether changes in SID precede changes in income. Even a smaller panel subsample could materially strengthen causal inference.

The role of prices deserves more attention in subsequent research. High-value diversification can appear profitable in a favourable market year and much less attractive when many farmers harvest simultaneously. Farm-gate price series for apple, tomato, peas, citrus and stone fruits could be linked to household crop portfolios to construct expected revenue and price-risk measures. This would allow the paper to distinguish productivity-driven income growth from price-driven income growth and to evaluate whether diversification reduces exposure to commodity-specific price shocks.

Finally, gender and generational dimensions could enrich the analysis. Diversified horticulture often changes labour requirements, marketing responsibilities and the timing of farm work. Younger and more educated household members may be more willing to adopt protected cultivation, digital marketing or new varieties, while women may play major roles in labour-intensive crop management. If the dataset records gender and age of the principal decision-maker, interaction terms can test whether the income return to diversification differs across demographic groups. Such results would widen the policy relevance of the study beyond aggregate farm income.

6K. Synthesis of Empirical Evidence

Taken together, the empirical evidence supports a layered interpretation of the diversification-income nexus. The first layer is structural: the survey indices demonstrate that crop portfolios differ substantially across agro-climatic zones. The second layer is behavioural: more than one-third of respondents report a conscious movement from traditional agriculture toward horticulture, and profitability is the strongest reported factor in the decision to continue horticulture. The third layer is institutional: programme beneficiaries display better irrigation, improved-variety adoption, productivity and annual income. The fourth layer is welfare-related: higher perceived income improvement is strongly associated with a better living standard. None of these pieces alone proves causality, but together they form a coherent empirical pattern that is consistent with income-enhancing diversification under supportive conditions.

This layered evidence also explains why a single bivariate correlation between SID and income would be insufficient. The observed effect of diversification is likely to pass through several mediating variables. Irrigation changes the set of feasible crops; training changes the farmer's ability to manage them; roads and markets determine the realised price; policy support affects investment capacity; and agro-climatic conditions determine biological suitability. A multivariate model that ignores these channels may overstate the direct effect of SID, while a model that controls for variables that are themselves consequences of diversification may understate it. The final specification should therefore be guided by a clear causal diagram distinguishing predetermined household characteristics, enabling factors, diversification decisions and income outcomes.

The Himachal setting can also contribute to the debate on specialisation versus diversification. Commercial agriculture is often associated with greater specialisation because producers concentrate resources in the crop in which they hold comparative advantage. Yet the survey suggests that advanced horticultural regions can remain commercially specialised at a broad level while becoming diversified within horticulture. The High Hill Zone is the clearest example: apple remains the anchor crop, but additional fruits and vegetables widen the revenue portfolio. Thus, commercialisation and diversification need not be opposites; diversification can occur within a specialised high-value sector.

From a policy-evaluation perspective, the results suggest that infrastructure and programme participation should be examined not merely as controls but as potential effect modifiers. The income gain from adding a vegetable enterprise is likely to be much larger for a household with reliable irrigation and rapid market access than for an otherwise similar household without those facilities. Estimating marginal effects at different infrastructure levels would therefore provide more informative policy evidence than a single average SID coefficient. Such an approach would directly answer where public investment generates the largest return from diversification.

The broader development implication is that diversification policy should be integrated with regional planning. Roads, storage and irrigation have long economic lives and shape production choices for many years. Crop promotion undertaken without corresponding infrastructure can



create temporary expansion followed by price collapse or post-harvest loss. Conversely, infrastructure investment that is aligned with suitable high-value crops can crowd in private orchard investment, protected cultivation and marketing activity. The combined strategy is particularly important in remote hill areas where individual farmers cannot overcome fixed logistics costs on their own.

References

- Basantaray, A.K. and Nancharaiah, G. (2017). Relationship between Crop Diversification and Farm Income in Odisha—An Empirical Analysis. *Agricultural Economics Research Review*, 30 (Conference Number), 45–58.
- Birthal, P.S., Negi, D.S., Jha, A.K. and Singh, D. (2014). Income sources of farm households in India: determinants, distributional consequences and policy implications. *Agricultural Economics Research Review*, 27(2), 37–48.
- Chand, R., Saxena, R. and Rana, S. (2015). Estimates and analysis of farm income in India: 1983–84 to 2011–12. *Economic & Political Weekly*, 50(22), 139–145.
- Government of Himachal Pradesh. *Economic Survey of Himachal Pradesh*, various issues.
- Directorate of Horticulture, Government of Himachal Pradesh. *Horticulture statistics and programme reports*, various issues.
- Joshi, P.K., Gulati, A., Birthal, P.S. and Tewari, L. (2004). Agriculture diversification in South Asia: patterns, determinants and policy implications. *Economic & Political Weekly*, 39(24), 2457–2467.
- Pingali, P.L. and Rosegrant, M.W. (1995). Agricultural commercialization and diversification: processes and policies. *Food Policy*, 20(3), 171–185.
- Sen, B., Venkatesh, P., Jha, G.K., Singh, D.R. and Suresh, A. (2017). Agricultural Diversification and its Impact on Farm Income: A Case Study of Bihar. *Agricultural Economics Research Review*, 30 (Conference Number), 77–88.