Evaluation Criteria for the Suitability of Apple Cultivation in Kashmir Valley, India

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ABSTRACT

The study aims to provide viable criteria to assess land suitability for apple growing in Kashmir Valley, India. It used a Delphi survey and the analytical hierarchical process (AHP) approach to determine factors influencing apple production. The evaluation criteria were obtained through multiple rounds of the Delphi survey of stakeholders. The Delphi outcome was extended to enable prioritization of the criteria, using a pair-wise comparison process. Results show that experts value physical and economic considerations (accounting for 87% of the overall weight) more than social factors. Furthermore, location-specific factors (i.e., cost-benefit ratio and landholding size) have significant bearings on land suitability for apple in the study area. The Delphi-AHP method proved to be useful as it incorporated core issues of agricultural land use by creating a common framework for suitability evaluation and eliminated uncertainties in the decision-making process.

Keywords: land suitability, apple cultivation, evaluation criteria, Delphi survey, AHP

JEL codes: B55, C01, C52, D61, Q10

INTRODUCTION

Suitability is the natural ability of a given piece of land to support a specific use or purpose (FAO 1976). In the context of agriculture, suitability is defined as the function of crop requirements and soil/land characteristics in relation to the use of agricultural land on a sustainable basis (FAO 1983; Baniya 2008; Wali et al. 2016; Van Diepen et al. 1991). Land suitability analysis evaluates the factors responsible for crop suitability in a given area (Chozom and Nimasow 2021). It is a prerequisite condition for sustainable agriculture (Baniya 2008; Prakash 2003) and is used to identify the suitability of land for alternative, actual, or potential uses pertinent to the area under consideration (Dent and Yon 1981; Collins et al. 2001).

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Elevation, slope, aspect, soil, land cover, and several other climate factors make up the ideal environment for a crop to flourish (Chozom and Nimasow 2021). Land evaluation for suitability analysis is very critical for sustainability of land resources, especially when limited resources are at stake due to human interventions (Joshua et al. 2013; Gurmessa and Sileshi 2013; Chuong 2007; Stefanova et al. 2014). However, sustainability should consider all the factors deemed important while dealing with land use planning (Feizizadeh and Blaschke 2013; FAO 1995). Therefore, the selection of criteria and subcriteria forms the pillars of sustainability, ensuring maximum suitability and minimum vulnerability (Cengiz and Cengiz 2019; De La Rosa 2000) and, at the same time, maintaining balance between production and conservation (FAO 1995). The criteria should be carefully selected so that local needs and conditions are realized well in the final decision (Prakash 2003; Zhen and Routray 2003). In fact, socioeconomic factors are more easily manipulated by human interventions than biophysical and environmental factors (Zhang et al. 2015). Each criterion has its own relative importance, and its realization is vital to land suitability assessment for crop production (Memarbashi et al. 2017; Elsheikh et al. 2013). The factors are not equally important, however; some play critical roles more than others in determining the suitability of a crop (Kim and Kyomoon 2018). Thus, it is important to prioritize the criteria.

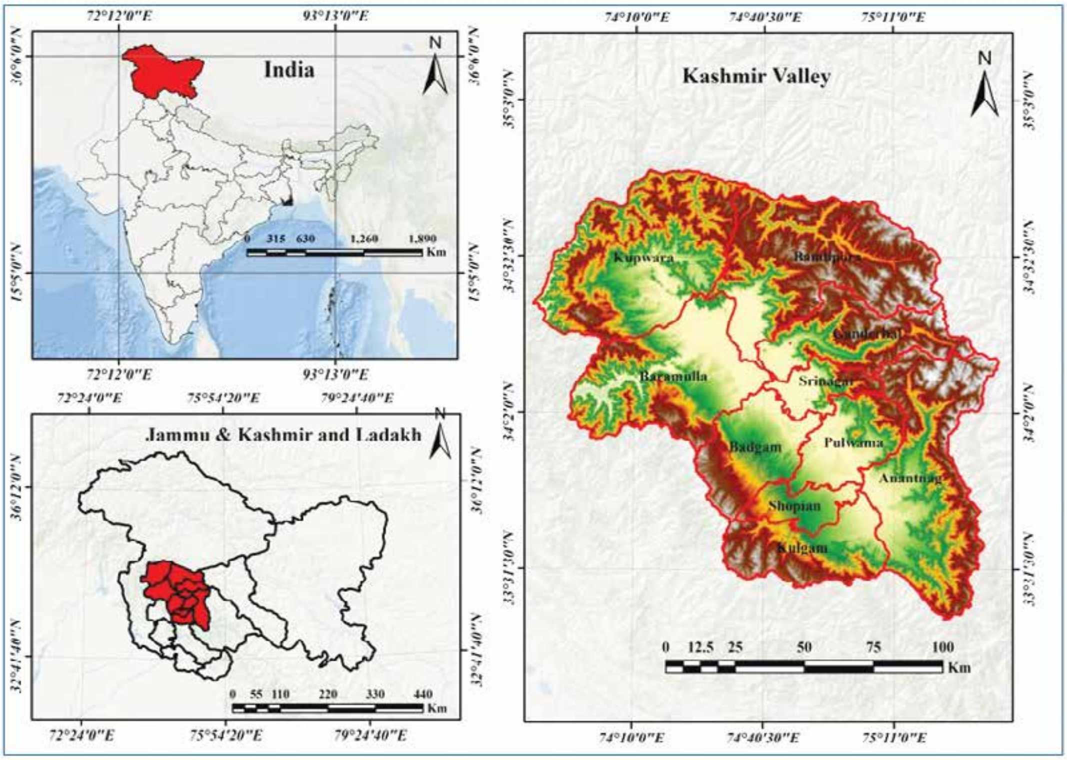
Furthermore, land suitability evaluation under a sustainable framework requires an interdisciplinary perspective that considers various aspects spanning biophysical factors such as nature of the soil and terrain, and socioeconomic factors, including market and infrastructure (Wali et al. 2016; Hu et al. 2012; Pramanik 2016). Each criterion has its functionality, from crop growth to economic viability and social acceptance. As such, the selection process of criteria would be inadequate if their roles and value in the final suitability are not considered and prioritized accordingly (Pramanik 2016; Akıncı et al. 2013).

Agriculture plays a key role in strengthening the economic conditions of the large population in Kashmir Valley, India (Taufique and Khursheed 2018; Ganaie et al. 2017). However, the area's current land use development lacks a coherent sustainable policy. In the past three decades, land has been allocated to different crops without considering the potentials and constraints of the land. As a result, a large proportion of agricultural land has undergone land degradation (Zaz and Romshoo 2012), soil erosion (Altaf et al. 2014), flooding and water logging (Ahmad et al. 2018), fertility decline (Husaini et al. 2010), and other environmental problems (Dar and Khuroo 2020). Climate change has also become a serious and daunting challenge, affecting the land use dynamics in the region (Romshoo et al. 2015). The situation is further aggravated by the mountainous and fragile nature of the area. Around 31 percent of the total land is under various forms of soil degradation and 57 percent is unfit for cultivation due to the rugged terrain and environmental limitations (Mahapatra et al. 2000). The remaining 12 percent that is arable under natural conditions is under immense pressure to sustain a population of more than seven million people.

Given this, land evaluation for crop suitability analysis is the keystone to mitigate the current land use problems in the area and to realize the long-term goals of sustainable agriculture, food security, poverty alleviation, and environmental conservation, among others. Based on a review of existing literature, there has hardly been any analysis of selection and prioritization of criteria for crop suitability analysis in the area. Traditionally, land surveys have been carried out in the area based on agroecological zones, completely neglecting the socioeconomic dimension of land units. Further, while the Food and Agriculture Organization (FAO) has developed guidelines for land evaluation of most types of land, mountainous areas have not been part of them.

Kashmir Valley is situated in the northwestern folds of the Himalayas at an elevation of 1,585 meters above mean sea level (Figure 1). It is geologically an intermountain basin bounded by Pir-Panjal in the southwest and the Great Himalayan range in the north and east. The slope generally ranges from flat to moderate on the valley floor and *karewas* (elevated table

Figure 1. Location map of Kashmir Valley, India



land, also known as lacustrine deposits), becoming increasingly steep in the hilly regions (Singh 1982). The total geographical area is 15,948 km^2 and most of it is composed of mountains and foothills. The area has its geographical peculiarities in the form of the valley floor and somewhat flat *karewas* (Wadia 1979). These *karewas* are ideally suited for horticultural crops such as apple, almond, and saffron. The cropping land use is dominated by rice, apple, walnut, maize, and vegetables. There has been massive land conversion in the region toward horticultural crops during the past few decades because of their comparative advantage in terms of cost-benefit ratio and economic viability (Rasool et al. 2021; Lone et al. 2022; Lone et al. 2022a).

Against this backdrop, this study was undertaken to address the indicated gaps in knowledge linked to the evaluation criteria for the suitability of land to horticultural crops. The study mainly aims to formulate a set of feasible evaluation criteria for land suitability analysis for apple cultivation because of its large acreage, social acceptance, sustainability factors, and economic prospects. More broadly, the study intends to use the results of a modeling approach that integrates use of a geographic information system (GIS) and the analytical hierarchical process (AHP) in land/crop suitability analysis for major crops in Kashmir Valley.

MATERIALS AND METHODS

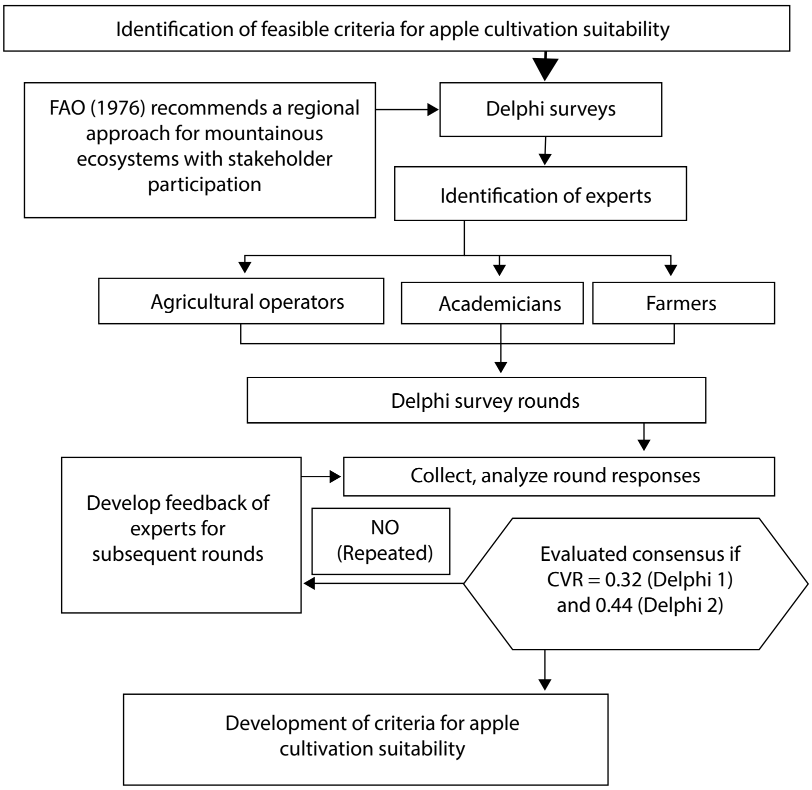
The study employed the Delphi method and AHP to select and prioritize feasible criteria and subcriteria for apple cultivation in Kashmir Valley (Hu et al. 2012). It mainly aimed to use the evaluation criteria to analyze the suitability of apple cultivation in view of efforts to promote sustainable horticulture in the region.

Delphi Method

The Delphi method is a special technique for gathering and enhancing collective opinion. It enables identification of the optimal application in circumstances when precise knowledge is not available (Hasson et al. 2000; Woudenberg 1991; Kaynak and Macauley 1984; Linstone and Turoff 1975). In addition to enabling experts to respond anonymously, this method can create expert views on a set of competing criteria and advance toward agreement on any problem (Miller 2001; Delbecq et al. 1975). The process of expert selection is the most crucial phase since the value of the Delphi method lies in the ideas produced (Gordon 1994), and the quality of the conclusion depends on the competence of the expert panel (Yousuf 2007). In this study, a two-round Delphi survey was undertaken. It involved 32 agricultural stakeholders, including agricultural operators and academics, who were interviewed face-to-face and via email (Figure 2).

Based on the recommendations of the experts panel, eight farmers with more than 15 years of farming experience qualified for inclusion in the first round of the Delphi survey. The balanced panel permitted the flow of local knowledge in the decision-making process. Coefficient of variation (CV) was used to check whether additional Delphi rounds were needed. In the study, when the CV value was less than 0.5, additional surveys were stopped (Dajani et al. 1979). Similarly, content validity ratio (CVR) was used to measure agreement among the respondents. CVR values ranged between -1 and +1. The experts were requested to specify their degree of agreement on various constructs reflected in the questionnaire using a five-point Likert scale. A higher CVR on any item/statement indicates better agreement among panel members. The CVR value depends on the number of experts involved and was determined using the Lawshe table. In the study, the value should be greater than 0.32 for Delphi round 1 and 0.44 for

Figure 2. Development of suitability criteria for apple cultivation using the Delphi method



Delphi round 2. Any construct/item scoring less than the said CVR values was eliminated. Using CVR makes it easy to compare overall precision of the data obtained, as shown in equation 1:

$$CVR = \frac{(Ne - N/2)}{(N/2)} \quad (1)$$

where N_e is the number of experts indicating "agree and strongly agree" and N is the total number of experts.

The content validity ratio translates well in the weighted average index (WAI) (Devkota et al. 2014; Ndamani and Watanabe 2015), derived using the following equation:

$$WAI = \frac{\sum FiWi}{\sum Fi} \quad (2)$$

where F is the frequency of response, W is the weight of each score, and i is the score (e.g., 1-strongly disagree, 2-disagree, 3-neutral, 4-agree, and 5-strongly agree).

Analytical Hierarchal Process (AHP)

The AHP basically breaks down an issue into a series of manageable chunks (Saaty 1980; Saaty and Vargas 2001; Frei and Harker 1999). These steps show a goal, a criterion, a subcriterion, and possible solutions on a numerical scale that is easy to understand and evaluate (Saaty 1980). Agricultural researchers worldwide have used the AHP method as it unifies the multidimensionality of land suitability evaluation. Several land suitability evaluation studies have employed AHP as a multicriteria evaluation tool for land suitability evaluation (Chozom and Nimasow 2021; Wali et al. 2016; Stefanova et al. 2014; Akinci et al. 2013; Prakash 2003; Baniya 2008; Perveen et al. 2008; Ceballos-Silva and Lopez-Blanco 2003). Using AHP in combination with GIS, comprehensive land suitability models can be generated for sustainable agricultural land use (Baniya 2008; Wali et al. 2015). The use of socioeconomic factors through AHP reflects the real situation in an area (Stefanova et al. 2014).

Since land evaluation and crop suitability analysis are confronted with three basic problems, namely, choice, priority, and precision of decision-making, all these are addressed by AHP in the most proper expressions (Forman and Gass 2001). The Eigenvalue method proposed by Saaty (1980) was used to estimate weights and relative importance of the determining factors. The expert panel, consisting of agricultural operators and academicians, were asked to fill the matrix based on the Saaty scale (1–9) for pair-wise comparison. The Eigen value method for weight evaluation formula can be expressed mathematically as:

$$A \, . W = \lambda \max . W \quad (3)$$

where A is the square matrix resulting from pair-wise comparison, max is the maximum eigen value, and W is the eigenvector.

To measure the consistency of the decision-making process and precision of the data obtained, the consistency index (CI) and consistency ratio (CR) were calculated to derive the level of deviation at each hierarchy. CI and CR were computed using equations 4 and 5, respectively (Saaty and Kearns 1985).

$$\mathrm{CI} = \frac{(\lambda\mathrm{max} - \mathrm{n})}{(n-1)} \quad (4)$$

where λmax is the maximum Eigen value and n is the number of criteria or subcriteria in the matrix of pair-wise comparison.

CR is the ratio of CI to the average random inconsistency index (RI) for the same order matrix and can be expressed as:

$$\mathrm{CR} = \frac{CI}{RI} \quad (5)$$

where CI is the consistency index and RI is the random index.

RI is derived from the Saaty table and depends on the number of criteria or subcriteria involved (Golden and Wang 1989). Both CI and

CR must be ≤ 0.10 for a matrix to be considered as consistent; AHP can be continued only under this assumption, otherwise, the assessment needs to be revised as the matrix is taken to be inconsistent.

RESULTS AND DISCUSSION

Evaluation Criteria of Land Suitability for Apple Cultivation by Delphi Method

Figure 3 shows the results of Delphi survey round 1, which aimed to frame land evaluation regulatory guidelines for suitability of horticulture in the study area. Each evaluation criterion met the required levels of CV (< 0.5), which meant no further Delphi survey rounds were needed. However, two constructs (nos. 3 and 10) were eliminated from the evaluation criteria due to low CVR values. From the results, it can be concluded that Delphi survey experts fully agreed that land suitability for horticultural crops must incorporate both biophysical and socioeconomic parameters so that potential land units are identified on sustainable lines. The regional approach should be the basis for conducting land evaluation surveys. The rejection of the last construct clearly indicates that the criteria differ in importance based on their functionality with respect to a given crop. This suggests that prioritization of criteria is indispensable in land suitability analysis and should be promoted on scientific lines, involving expert opinion or a sound methodological framework.

Based on the results of Delphi survey round 1, the questionnaire was revised for the final identification and selection of criteria and subcriteria. It must be noted that a good number of the Delphi survey respondents did not take part in the second round, reducing participation rate to around 57 percent. In this round, the experts not only recorded their opinions on a five-point Likert scale, but also recommended criteria they deemed important for evaluating crop suitability. A detailed list of criteria and subcriteria was prepared and presented before the panelists to induce agreement on the essential parameters for apple cultivation.

Figure 3. Results for various constructs used in round 1 of the Delphi survey

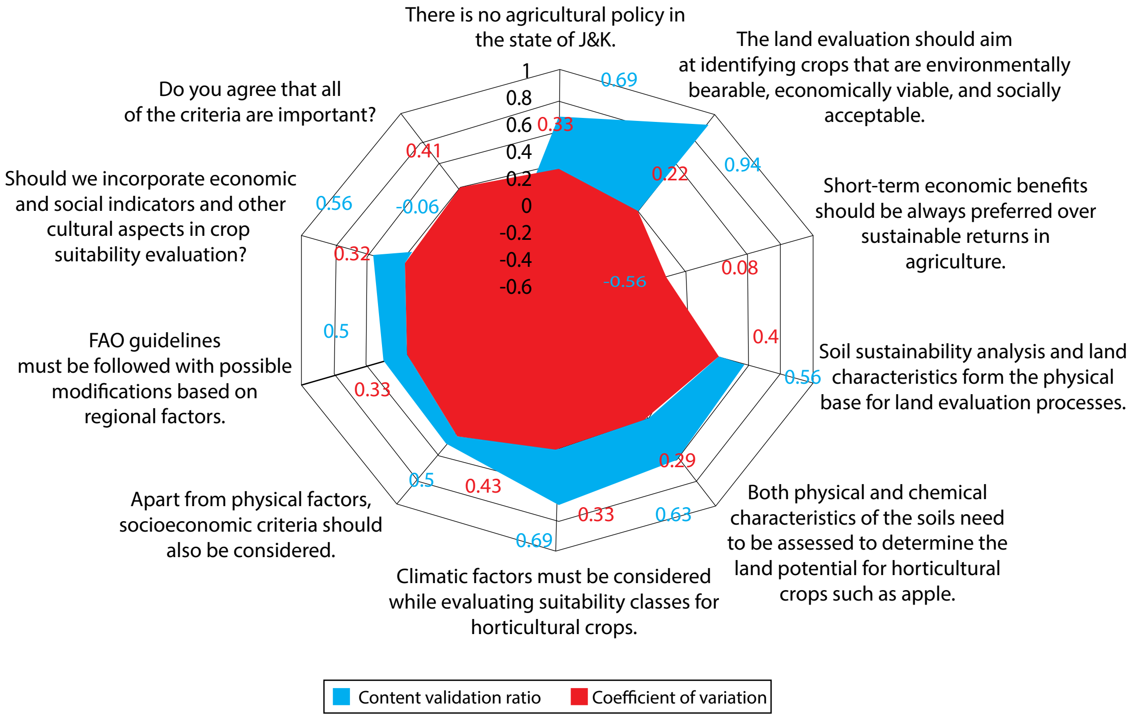


Table 1. Delphi survey results for the physical criteria in the study area

Indicator	Subcriterion	WAI	CVR	CV	Decision
Soil	Soil pH	3.72	1	0.18	Retained
	Soil depth	3.27	0.78	0.25	Retained
	Soil texture	3.83	1	0.27	Retained
	Water holding capacity *				Eliminated*
	Soil type	1.72	1	0.13	Retained
	Organic matter	1.65	1	0.1	Retained
	Soil fertility	1.55	0.89	0.11	Retained
	Porosity*				Eliminated*
Climate	Temperature	1.77	1	0.15	Retained
	Rainfall	1.72	1	0.12	Retained
	Wind*				Eliminated*
	Relative humidity	1.32	0.56	0.16	Retained
	Evapo-transpiration	1.27	0.22	0.48	Eliminated
	Sunshine hours/crop growing days	1.32	0.56	0.16	Eliminated
Land	Aspect	1.42	0.78	0.18	Retained
	Slope	1.62	1	0.1	Retained
	Altitude	1.47	1	0.27	Retained
	Potential for mechanization	1.32	0.56	0.38	Retained
	Physiography	1.4	0.56	0.45	Retained
	Geology	1.07	0	0.41	Eliminated

* Directly rejected by the experts
Source: Delphi survey (2019)

The data were statistically tested to check whether the individual parameters met the required cut-off or not. Tables 1 and 2 present the subcriteria with their respective CVs, CVRs, and WAIs, which would influence the land suitability evaluation for apple in the study area. The subcriteria related to physical environment are classified under three broad factors: soil, climate, and land characteristics (Table 1). Of the eight subcriteria, six were found to be in high agreement as indicated by higher CVRs and WAIs. Both physical and chemical characteristics of the soil—soil pH, organic matter, fertility, soil texture, soil depth and soil type—were found significant in the land suitability evaluation for apple (Sys et al. 1993). The respondents recommended the exclusion of water holding capacity and porosity because these parameters are largely governed by soil texture. Similarly, three subcriteria were eliminated in the climate category due to either direct recommendation or required cutoffs.

In the land characteristic category, geology was revealed to be the least important. The other factors were found within the scope of land suitability evaluation, given the mountainous and fragile nature of the study area. In fact, land characteristics such as slope, altitude, and aspect determine the availability of crop requirements, thus, acting as agronomic limitations to a given crop. Overall, the different aspects linked to soil, climate, and land were retained based on expert opinion. These factors are important in mountainous landscapes and have a paramount impact on the suitability of crops (Geitner et al. 2017).

As indicated earlier, suitability evaluation is a multidimensional approach that considers factors biophysical and socioeconomic criteria.

Table 2. Delphi survey results for the economic and social subcriteria

	Subcriterion	WAI	CVR	CV	Decision
Economic	Cost-benefit ratio	3.83	1	0.1	Retained
	Agricultural input availability	3.72	0.89	0.15	Retained
	Capital investment capacity*				Eliminated
	Irrigational facilities	2.66	0.44	0.25	Retained
	Value addition process	2.83	0.56	0.22	Retained
	Market accessibility	3	0.22	0.32	Retained
	Road accessibility	2.28	2.56	0.25	Retained
	Farm Income*	3.5	0.89		Retained
Social/cultural	Labor force (family)	2.35	0.56	0.12	Retained
	Landholding size	3.33	2.11	0.15	Retained
	Managerial skill index **(farmers)	3.38	1.56	0.25	Retained
	Information score/extension services	2.54	0.44	0.2	Retained
	Food habits	1.56	−0.33	0.18	Eliminated
	Cultivation pattern*	0	−1	0.15	Eliminated

Note: ** and * indicate directly included and rejected sub-criteria, respectively, by the experts.

The socioeconomic milieu in any geographical region determines the crop combination and diversification, especially the social and economic conditions governing the cultivation of cash crops in any territory (Olofsson 2020). Likewise, in the present study, all the socioeconomic factors, except food habits and cultivation pattern, were included for suitability analysis, as shown in Table 2, to clearly depict the reality in the area.

Cultivation pattern was excluded as a parameter as fruit crops in the study area are mainly grown as cash crops, and this led to the rejection of local food habits as a criterion. Cultivation pattern was not given much importance owing to the widespread distribution of orchards in the study area, where horticulture is commonly practiced. It also had a low CVR value. It must also be pointed out that managerial skill index (pertaining to agricultural management) was proposed in place of farmers' motivation (which includes various critical dimensions such as farming experience, education level, and training). Given their higher WAI and CVR values, economic factors in the study area seem to be the yardstick in achieving economic sustainability with respect to agricultural land use. The economic strength of the people has a direct bearing on the suitability of horticulture. Such land use demands huge initial investments until the gestation period is over and orchards start bearing fruits.

AHP Results

It is very difficult to prioritize criteria or subcriteria using only the Delphi approach or the brainstorming technique. However, by using pair-wise comparison method, it is possible to quantify the relative importance of the criteria or subcriteria involved and to determine the alternatives. The main criteria were prioritized in terms of their relative importance; the results are shown in Tables 3 to 7.

The results indicate that the biophysical and economic criteria were equally prioritized through expert opinion, with each having a weighted percentage of 43.5 (Table 3). This is partly justified since the economic condition in the study area is largely governed by apple cultivation. Social criteria, on the other hand, were found to be the least determining factors. This is explained by the fact that apple cultivation mainly needs capital and land suitability so that social factors like religion,

Table 3. Computation of weights for the main criteria of crop suitability

Factor	Economic	Physical	Social	Relative Weight (%)
Physical	1	1	5	43.5
Economic		1	5	43.5
Social			1	13.0
Consistency Index = 0.055	*Consistency Ratio = 0.0948*		*Lamda Max = 3.11*	
Computation of factor weights, consistency index, and consistency ratio				

Factor	Land characteristics	Climate	Soil	Relative Weight (%)	Overall weight (%)
Land characteristics	1	2	1/2	32.0	13.9
Climate		1	1/2	22.7	9.9
Soil			1	45.3	19.7
Lamda max.= 3.012		*CI = 0.006*		*CR = 0.009*	

Source: Author's calculation from the data collected

race, culture, taboos, and literacy have a much lesser impact on the suitability of land for such cultivation. Both CI and CR of the main criteria are less than 0.1, suggesting consistency of the results. Soil characteristics are obviously the most important determinants of apple suitability in the Kashmir Valley, with a relative importance of 45.3 percent, followed by land characteristics (32%) and climatic conditions (22.7%).

It was necessary to subdivide the biophysical criteria into three broad indicators: soil characteristics, climatic condition, and land characteristics. Thereafter, the pair-wise comparison matrix was developed using the answers of 18 experts who filled in the matrix. Table 4 shows the results for both relative importance and overall weight of soil parameters for apple suitability analysis. In the soil category, soil texture, which had an overall weight of 6.7 percent, accounted for 34.1 percent in relative importance, followed by soil pH (20.5%), soil fertility (20.5%), organic matter (12.7%), soil type (10.2%), and soil depth (4.8%). Both CI and CR have values way below 0.1, indicating precision and consistency of the decision-making process through expert opinion.

For the climate category, temperature occupies the top priority with 55.5 percent weight in relation to rainfall and relative humidity, making it a critical agronomic condition for apple cultivation in Kashmir Valley (Table 5). However,

Table 4. Standardized matrix for apple suitability using soil parameters

Subcriterion	C_1	C_2	C_3	C_4	C_5	C_6	Relative Weight (%)	Overall Weight (%)
Soil pH (C_1)	0.19	0.18	0.19	0.227	0.22	0.21	20.5	4.1
Soil texture (C_2)	0.39	0.35	0.39	0.34	0.29	0.26	34.1	6.7
Soil fertility (C_3)	0.19	0.18	0.19	0.22	0.22	0.21	20.5	4.0
Organic matter (C_4)	0.09	0.12	0.09	0.11	0.14	0.18	12.7	2.3
Soil type (C_5)	0.06	0.09	0.06	0.22	0.07	0.09	10.2	1.8
Soil depth (C_6)	0.04	0.07	0.04	0.03	0.03	0.04	4.8	0.8
λ max. = 6.449				*CI = 0.075*			*CR = 0.06*	

Table 5. Computation of weights for the climate category

Subcriterion	C_1	C_2	C_3	Relative Weight (%)	Overall Weight (%)
Temperature (C_1)	1	2	6	55.5	5.5
Rainfall (C_2)		1	7	37.3	3.7
Relative Humidity (C_3)			1	7.2	0.7
λmax.=3.109		*CR=0.062*		*CI=0.036*	

Computation of weights for the land category

Subcriterion	C_1	C_2	C_3	C_4	C_5	Relative Weight (%)	Overall Weight (%)
Aspect (C_1)	1	1/3	2	3	1	18.8	2.6
Slope (C_2)		1	4	5	2	42.8	6.0
Altitude (C_3)			1	2	1/2	10.8	1.5
Potential for mechanization (C_4)				1	1/2	7.4	1.0
Physiography (C_5)					1	20.1	2.8
λmax.= 5.151		*CI = 0.03*			*CR = 0.027*		

Source: Compiled by the author from the data collected

due to the low significance of the climate variables in the preceding hierarchy, the climate category reflected a low rank as indicated by the overall weight values of temperature (5.5%), rainfall (3.7), and relative humidity (0.7%).

As regards land characteristics, slope is the most important factor, accounting for 42.8 percent of total relative weight (Table 5). It is followed by physiography (20.1%) and aspect (18.8%). These results are well reflected in the geographical distribution of apple orchards in certain physiographic divisions such as flat *karewas* and on the southern slope of Kashmir Valley.

It was noted that socioeconomic factors play a vital role in determining the economic viability of a given crop. Unlike biophysical factors, economic factors are region specific and influence the sustainable use of agriculture. As such, seven economic subcriteria were brought into pair-wise comparison to calculate both partial and overall weights. Tables 6 and 7 provide the detailed pair-wise comparison matrices of the economic subcriteria.

Cost-benefit ratio is shown to be the most important criterion, with a final weight of 16.2 percent, followed by farm income (5.7%) and

Table 6. Pair-wise comparison matrix using the economic subcriteria

Criterion	C_1	C_2	C_3	C_4	C_5	C_6	C_7	Relative Weight (%)	Overall Weight (%)
Agricultural input availability (C_1)	1	1/2	1	1/5	1/6	2	1/3	6.2	2.9
Irrigational facilities (C_2)		1	2	1/3	3	4	1/2	13.2	5.7
Market accessibility (C_3)			1	1/6	1/2	2	1/3	6.4	2.9
Cost-benefit ratio (C_4)				1	5	8	2	37.4	16.3
Road connectivity (C_5)					1	2	1/2	12.1	5.3
Value addition process (C_6)						1	1/4	4.0	2.0
Farm income (C_7)							1	19.4	8.5
***λ**max.= 7.41*			*CR = 0.052*				*CI = 0.068*		

Source: Compiled by author from the data collected

Table 7. Pair-wise comparison matrix using the social subcriteria

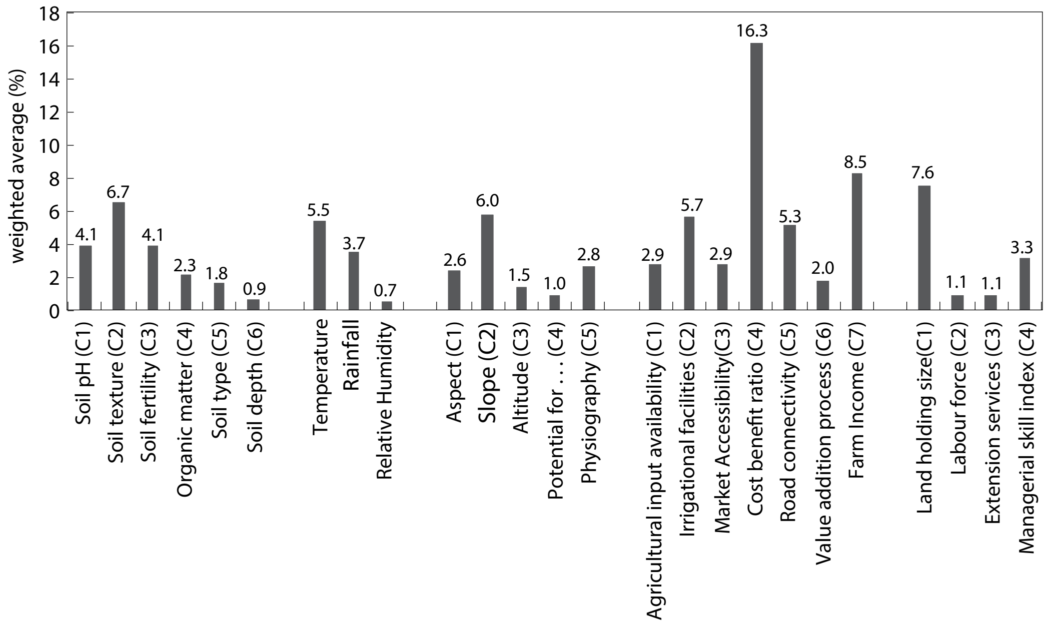
Criterion	C_1	C_2	C_3	C_4	Relative Weight (%)	Overall Weight (%)
Landholding size (C_1)	1	7	6	3	58.7	7.6
Labor force (C_2)		1	1	1/3	8.2	1.1
Extension services/information score (C_3)			1	1/4	8.1	1.1
Managerial skill index (C_4)				1	25.1	3.3
λmax *= 4.06*		*CI = 0.020667*			*CR = 0.023*	

Source: Compiled by author from the data collected

irrigational facilities (8.5%). It should be pointed out that the economy of the study area in general, and farmers in particular, highly depends on cash crops such as apple. As such, prioritizing the cost-benefit ratio seems to address the local needs and conditions of the study area. The other associated economic parameters were found to be moderate to less significant determinants of apple suitability. The other economic parameters such as farm income, market accessibility, and road connectivity were also rightly prioritized as they are essential to maximize the utilization of horticultural resources for sustainable development.

From the social perspective, experts ranked landholding size as the most important subcriterion, which also has a significant role in making horticulture economically prospective. From the farming perspective, managerial skill index of farmers was the most significant subcriterion. The preference for this subcriterion shows that farmers' level of knowledge and experience are important to assure economic efficiency of resource use. The other social parameters such as labor force and extension services were least prioritized by the experts. Figure 4 depicts the impact of all the factors and their cross comparisons. Input-output, farm income, landholding size, soil texture, among others, influence more the cultivation of horticultural crops.

Figure 4. Factors affecting the suitability of apple cultivation in Kashmir Valley



CONCLUSION

The selection of appropriate criteria and their prioritization is important for land suitability analysis in northwestern Himalayas as the region lacks coherent evaluation criteria within the framework of agricultural sustainability. This study was conducted to identify and prioritize feasible criteria and subcriteria for land suitability evaluation. The investigation focused on apple cultivation in Kashmir Valley, India, using the Delphi-AHP approach. Multiple expert surveys were performed to determine the evaluation criteria and subsequently expand the subcriteria list. The primary Delphi survey resulted in the selection of biophysical and socioeconomic factors. The secondary survey generated an array of subcriteria for the suitability analysis. The AHP method was used to prioritize selected criteria and subcriteria based on their importance. A significant outcome of the study points to the high priority given to certain socioeconomic factors that are region specific, such as cost-benefit ratio, landholding size, and managerial skill index of farmers.

The present methodology offers multiple options in land use planning and future agricultural development. First, the results could be modeled to assess land suitability evaluation of other horticultural crops in the study area. Second, with some flexibility, the methodology can be replicated for other crops in regions with similar ecological and socioeconomic characteristics. Third, the methodology augments the introduction of parameters through stakeholder participation so that local needs and conditions of a region are considered in the final decisions. And fourth, the application of the Delphi-AHP approach has proven to be a superior multicriteria decision-making tool as it integrates quantitative methods into the evaluation criteria and supplements the results by checking the precision of the data obtained.

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