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Sustainable Fruit Growing: An Analysis of Differences in Apple Productivity in the Indian State of Jammu and Kashmir

Zahoor Ahmad Shah [1,*], Mushtaq Ahmad Dar [2], Eajaz Ahmad Dar [3], Chukwujekwu A. Obianefo [4], Arif Hussain Bhat [5], Mohammed Tauseef Ali [6], Mohamed El-Sharnouby [7], Mustafa Shukry [8], Hosny Kesba [9] and Samy Sayed [10,*]

1 Department of Agri Extension and Communication, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir Shalimar, Jammu and Kashmir 190025, India
2 Division of Agricultural Extension and Communication, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir Shalimar, Jammu and Kashmir 190025, India
3 Krishi Vigyan Kendra, Ganderbal, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir Shalimar, Jammu and Kashmir 190025, India
4 Department of Agricultural Economics and Extension, Nnamdi Azikiwe University, Enugu-Onitsha Expressway, Awka P.M.B 5025, Nigeria
5 Division of Plant Pathology, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir Shalimar, Jammu and Kashmir 190025, India
6 Division of Fruit Sciences, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir Shalimar, Jammu and Kashmir 190025, India
7 Department of Biotechnology, College of Science, Taif University, P.O. Box 11099, Taif 21944, Saudi Arabia
8 Department of Physiology, Faculty of Veterinary Medicine, Kafrelsheikh University, Kafrelsheikh 33516, Egypt
9 Zoology and Agricultural Nematology Department, Faculty of Agriculture, Cairo University, Giza 12613, Egypt
10 Department of Science and Technology, University College-Ranyah, Taif University, P.O. Box 11099, Taif 21944, Saudi Arabia
* Correspondence: s.zahoor37@gmail.com (Z.A.S.); s.sayed@tu.edu.sa (S.S.)

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Abstract: Apple is considered as an important fruit crop in temperate regions of the world including India. It is one of the major fruit crops, with a considerable area under cultivation throughout the world and a large associated population. Despite this, the productivity of this important fruit is not up to the expected standard. To gain a practical understanding of the low productivity of apple fruit and its probable causes, a study was undertaken to analyze productivity differentials and their determinants to enable sustainable cultivation. A multistage sampling procedure was adopted to select districts, horticultural zones, and villages, and data were collected from randomly selected apple growers (300). The collected data were empirically analyzed with simple descriptive statistics, logistic regression, polynomial plots, and inferential statistics such as t-tests. The results indicated that apple yields followed a sigmoidal pattern, with the average yield per hectare for the current season as 9.43 t/ha, which depends on experience, education, annual income, and the adoption rate of apple growers. This yield average was significantly lower than the yield of the previous season at a probability level of 1%. To determine the root cause of low productivity, different constraints were studied, creating yield disparities in different quarters; hence, their percentage and value contributions (socioeconomic 11.1%, credit 4.2%, pests and diseases 0.05%, technology 0.9%, extension 2.0%, and market 3.5%) were also established in the study. The study will be of great interest to the relevant authorities in the study area, and the areas globally having similar congenial agro-climatic conditions, who are seeking to address the issues raised in this study through sustainable policy decisions. The different constraints that were the fundamental reasons for low productivity and that prevented the apple growers from adopting innovative techniques/improved practices to increase their yields need to be addressed as a matter of urgency.

Keywords: apple; constraints; differentials; growers; practices; productivity; yield gap

1. Introduction

Apple (*Malus domestica*) is one of the most popular fruits in the world [1]. Apples (*Malus domestica* Borkh.) represent one of the most produced fruits worldwide, along with citrus and bananas [2]. It is an important temperate fruit, grown in both developed as well as developing countries, including India. Apple is widely popular with both growers as well as consumers for its strong adaptability (ecological) and high nutritional value [3]. Globally it has an important economic impact and it has been estimated that almost 5 million hectares of apples is harvested worldwide. Approximately 17 million metric tons stem from European production, representing 20% of global production, which was approximately 90 million metric tons in 2019, becoming the fruit with the third-largest production, behind citrus and bananas [4].

According to the data (statistical) presented in the World Apple Review [5], this fruit accounted for 12.26% of the world's total fruit production from 2012 to 2014, which was second only to bananas and citrus. Similarly, the global apple production exceeded 80 million tons in 2015 [6]. In 2019, apples took third place in terms of popularity of fresh fruits (after bananas and watermelons) in the world [7] and nearly 87.24 million metric tons of apples were produced worldwide [8]. In 2020, it was reported that China, with ~40.5 million tons (47%) [9], was the leading producer of apples with 58% of total world production, followed by USA (6%), Turkey (3.61%), India (3%), and Iran (2%) [10]. It was estimated that average productivity of apple fruit in India was nearly 6–8 t/ha, much lower than that of other countries, viz. Belgium (46.22 t/ha), Denmark (41.87 t/ha), and the Netherlands (40.40 t/ha) [11].

Indian apple exports are worth ~USD 10 million annually, of which ~USD 5 million comes from the apples of Jammu and Kashmir State, which provides jobs to 1.2 million people directly or indirectly. Jammu and Kashmir has the highest average yield and accounts for 67% of total fruit (apple) production and 50% of exports in the country, hence it is a substantial foreign exchange earner and important for economic growth [12]. Kashmir is India's main apple producer, as almost 89% of the horticulture land in Kashmir is under apple cultivation. This is due to the suitable climate, awareness among the growers [13], and strong adaptability to the growing environment.

Despite suitable conditions for apple cultivation, the productivity of this important crop is still low, with the highest productivity achieved being only 13.0 t/ha [10] as compared to the productivity of 20–40 t/ha in horticulturally advanced countries of the world. Most of the state's income is from apple fruit, which provides a livelihood for 3.5 million people. Around 500,000–600,000 families in the state, comprising about 30 million people are directly or indirectly associated with apple cultivation [10].

It is obvious that the apple industry is strong and has established its credibility in improving growers' income, generating employment, and enhancing exports, besides providing a livelihood and financial security to the people associated with it. With growing consumer awareness about healthy eating and established perceptions about apples as a healthy and flavorful fruit, the Indian market for apples is expanding [14]. To meet this rapidly growing demand through domestic supply, there is scope in the Himalayan states for both horizontal as well as vertical expansion of apple cultivation. However, despite the huge return from the apple industry to the state and high consumer demand, apple growers are facing huge problems and constraints in areas ranging from establishment of apple orchards to the marketing of the fruit, resulting in not only production losses and income, but also loss of resources in the generation and development of innovative technologies. These constraints have drastically affected the apple productivity in India, resulting in financial insecurity of farmers.

In the state of Jammu and Kashmir, there is fluctuation in the yield of apple: the average yields of different cultivars are only 11–13 t/ha [10] compared to the yield of other countries, viz. China (17.96 t/ha), the United States (27.85 t/ha), Germany (25.40 t/ha), Italy (40.11 t/ha), France (43.98 t/ha), and the world average of 15.49 t/ha [1]. However, in such congenial agro-climatic conditions, the potential yield could be increased to 40–70 t/ha, which is the indication of enormous gap between actual production and the production capacity of apple crops in the state [15]. Research stations are developing different innovative technologies to increase the yield of apple fruit. However, such techniques/technologies have not been properly disseminated to farmers, and those who try to use them face several limitations, resulting in a yield gap in the apple sector [16].

It is believed that productivity is a difficult concept to interpret in the agricultural sector due to the diversity of capital utilized in production [17]. Other scholars have editorialized that productivity is the relationship of output to the related inputs [18]. Horticultural researchers from Bangladesh submitted that the productivity measure is divided into two, partial factor productivity (PFP) and total factor productivity (TFP); as indicated in [19], PFP relates to the ratio of output to a particular input, while TFP reflects the ratio of output to all productive inputs taken together.

Earlier studies outside Kashmir reported apple productivity of 24 t/ha [20] in a trend productivity analysis; the authors of [21] reported an apple productivity value of 75.4 t/ha in the 2000–01 farming season, dropping to 46.3 t/ha in the 2012–13 farming season. Gautam and Ahmed in [22] state that productivity trends are relative to farm size and modern technology adoption. In China, it was found that the average farmers' productivity was 29.9 t/ha [18]. This average productivity is yet to be attained by apple growers in Kashmir, and this productivity gap across different countries justifies the need for study, especially to establish what could cause such a drop in value.

The authors in [18] opined that the yield gap is the difference between potential yield and actual or observed average yield. This productivity gap can be closed through integrated crop management practice, timely input supply, early planting, credit support to farmers, research and extension collaboration, and technology transfer through the adoption process. Some studies have compared the yield gap from the expected output, as well as its causes [23], but none to the best of the researchers' knowledge has compared productivity trends with recent production due to the COVID-19 outbreak, which has altered production patterns and resultant output expectation. Therefore, the annual productivity pattern in Kashmir from 2007–08 to 2019–20 farm seasons, as obtained from the Department of Horticulture, Government of Jammu and Kashmir, India were compared to the 2020–21 farm season figures from a field survey to identify those constraints responsible for creating an output gap. This approach will help to influence the judgment regarding the need to intensify apple production to attain the frontier output. The introduction of these variables (integrated crop management practice, timely input supply, early planting, credit support to farmers, etc.) to control and reduce the yield gap remains one of the best technologies to improve apple production in the study area. This approach differentiates the present study from the approaches of other scholars [24] who have submitted that technological intervention is needed to improve apple productivity, but could not list the technological interventions that should be advocated to support the annual 9.15% increase in apple productivity. A shortcoming in the study of Bhat presented in [25] assumed that farmers' perceptions of possible higher returns (63%), climate change (27%), and others (10%) are the drivers for increased production of apple in the Himalayan states. The study was not able to decipher the variable other factors that constituted 10% of farmers' drive. This study points to the statistics on the value of apple productivity in the study area, which is an improvement to the study of Sahu [26], who alleged that Himachal Pradesh State is the highest producer of apple in India without statistical backing. A similar shortcoming was observed in the study by Kumar [27], who used remote sensing to map out areas of apple production but gave no value as to the volume of apple produced in the area. Several authors [24] who have similar work in the study area have not paid close attention to the personal and economic status of the farmers, which could be determinants of apple productivity. Haven established the novelty; the research was undertaken to analyze productivity differentials in order to point out the root cause of yield gap and make better recommendations to address the situation. The study specifically tried to ascertain the trend of apple production, understand its productivity pattern, and estimate the determinants of apple productivity in the study area.

2. Materials and Methods

2.1. Data

The data used in the present paper were obtained from field study of major apple growing regions of the Kashmir Valley, which is the northernmost region of India (Figure 1). The design for the study was extensively derived from different combinations of methodologies of both quantitative and qualitative approaches. Different variables (dependent and independent), indicators, and numerous items of excerpted questionnaires were obtained from the in-depth available literature, mostly from package of practices, recommended by the State Agricultural University, farm science centers (KVKs), and extension functionaries of line departments (horticultural departments).

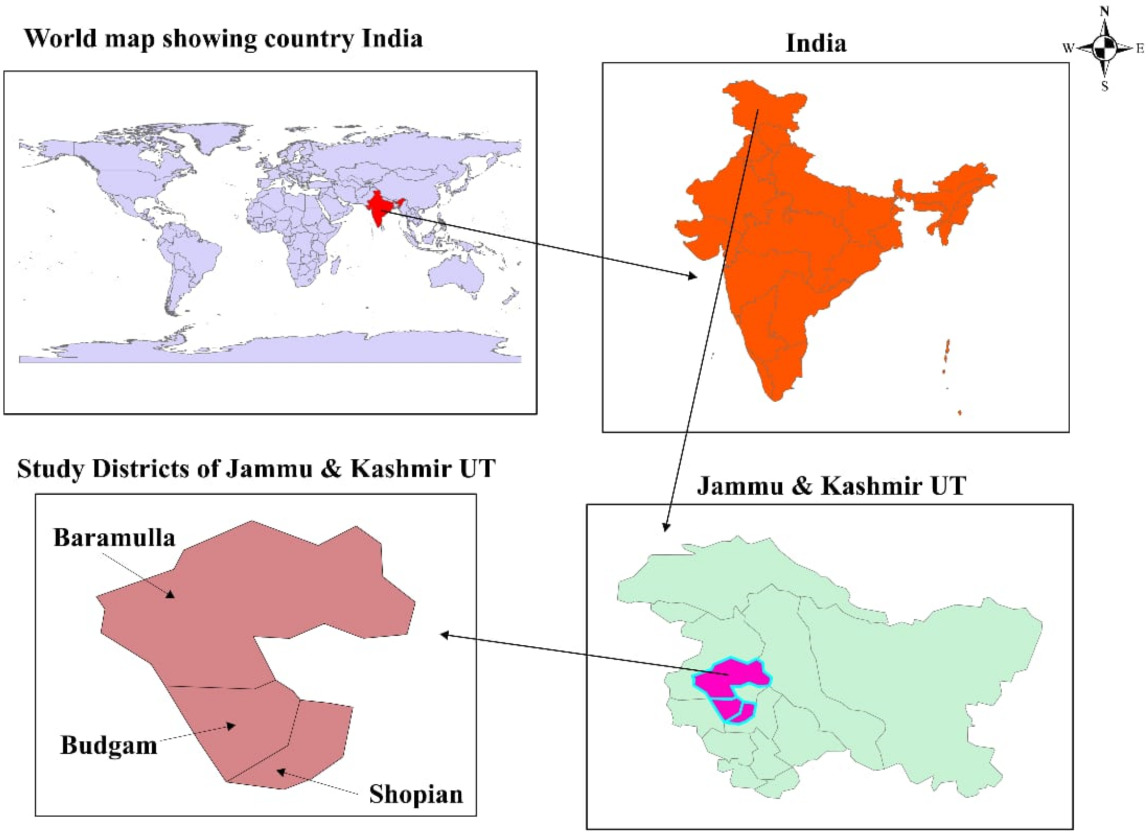

Figure 1. Map showing the selected areas.

A multistage sampling procedure was adopted for the selection of different districts, horticultural zones, villages, and apple growers. A list of apple growers from purposively selected districts was obtained from concerned line departments (horticultural) and a total of 3380 apple growers were counted in the study area. Three horticultural zones (one from each district) having a maximum area under apple cultivation were selected and from each horticultural zone, one village was selected purposively having maximum area under apple cultivation. A list of apple growers (orchardists) of selected villages was obtained from concerned horticultural development offices and a sample of different apple growers having marginal, small, medium, and large landholdings were selected for the study. Thus, a total of 300 apple growers (orchardists) were selected purposively from nine (9) villages using the formula adopted from the literature presented in [28].

$$n_i = \frac{N_i}{N} n$$

where:

n_i = Number of sampled apple growers in each village;
n = Total number of apple growers selected for the present study (300);
N = Total number of apple growers in sampled villages;
N_1 = Total number of apple growers in ith village.

The structured interview schedule was prepared, which included relevant questions seeking information about different aspects of the study objectives. The interview schedule was pretested before its finalization in a non-sampled area for its practicability and relevancy. It was pretested by interviewing thirty (30) apple growers from different areas that were not included in the sampling unit to determine whether the apple growers gave the required information. The pretesting of the interview schedule helped the researcher to make modifications and alternations (additions and deletions) in order to obtain spontaneous responses from the apple growers. The validity of the research tool was confirmed by several extension specialists in the region and the reliability was measured by employing the test–retest method. The correlation coefficient (r = 0.82) was found to be highly significant at 0.01 level of probability, indicating a high degree of dependability of the instrument, as confirmed by Shah et al. in [29]. The data were collected by administering the pretested interview schedule to the apple growers in the study area.

The apple growers were personally interviewed (face-to-face interview) by the investigator(s), which enabled them to obtain first-hand information and was an opportunity to observe the apple growers' responses. It was made sure that the questions that were not correctly understood by the apple growers were repeated whenever necessary. It was attempted to contact the apple growers at home as well as at their farms (apple orchards) at a convenient time to obtain the information. The data collected were treated and different statistical tools were employed to obtain different results.

The study adopted a three-step methodology prior to final collection of data in order to maintain validity of the model and content as suggested by May et al. [30] and Dang et al. [31]. Step one: different variables and indicators were composed from the available literature review; step two: a pilot test (pretest) was done by interviewing apple growers from different areas to find any conceptual inconsistency or bias content. Step three: the study eliminated all the latent variables as per the coefficient alphas after the questionnaire was adjusted. Once validity was achieved, the reliability of the measurement was identified by securing internal consistency and indicators' reliability as performed by Wang et al. in [32]. The seasonal apple productivity obtained from 2009–10 to 2019–20 production years is presented in Table 1. These outputs formed the basis for comparing current production with past performance in the sector to track whether the study area is living up to expectations regarding apple production.

Table 1. Seasonal yield of apple in the study area.

Year	**Apple Productivity (t/ha)**		
	Southern Region (*Shopian*)	**Central Region (*Budgam*)**	**Northern Region (*Baramulla*)**
2009–2010	9.63	4.76	19.49
2010–2011	12.75	6.29	25.79
2011–2012	10.92	5.86	25.53
2012–2013	8.85	5.85	13.3
2013–2014	11.14	4.75	19.49
2014–2015	8.49	2.11	16.98
2015–2016	11.48	12.16	21
2016–2017	10.94	10.16	15.07
2017–2018	13.33	9.39	16
2018–2019	12.58	10.76	16.01
2019–2020	12.74	10.9	18.95
Average yield/ha	11.17	7.54	18.87

Source: Department of Horticulture, Government of Jammu and Kashmir, India, 2021.

2.2. Analytical Framework

The logistic model (LM) was used to establish the relationship between a dichotomous response variable and a set of regression variables. A LM is quite applicable when an individual chooses between two alternatives and in each case, it was assumed that the alternatives were mutually exclusive [33]. A LM also has the advantage of not treating categories in any continuous form; this is what differentiates LMs from ordered or sequential probit models. Logit models estimate the effects of the explanatory variables on a dependent variable with unordered response categories. The advantage of the ordinary least squares (OLS) model is that it eliminates heteroskedasticity in the error term; in a LM, the error term is normally distributed and the predicted probabilities range between 0 and 1. An additional advantage of the logit model is its computational ease and it is also relatively robust, as measured by goodness of fit or prediction accuracy [30]. Suffice to note that the LM uses the maximum likelihood estimate (MLE) approach to produce the best fit result from its analysis. The model adopted from [33] is defined as:

$$P_r(\mathrm{Y} = 1) = \frac{e^{\beta x}}{1 + e^{\beta x}}$$

with the cumulative distribution function given by:

$$\mathrm{F}(\beta \mathrm{x}) = \frac{1}{1 + e^{\beta x}}$$

where β represents the vector of parameters associated with the factor x, assuming the probability that n apple growers are productive or not productive. This productivity of the farmers is assigned a value of 1 for those whose productivity value is from the mean output and above, while those below the mean value take the value of 0. Thus, the individual empirical models to be estimated are specified as:

$$P_1{}^{*} = \beta_0 + \beta_1 X_1 + \ldots\ldots\ldots\ \beta_n X_n + \varepsilon_i$$
$$P_2{}^{*} = \gamma_0 + \gamma_1 X_1 + \ldots\ldots\ldots\ldots \gamma_n X_n + \varepsilon_i$$

where

$P_1{}^{*}$ = not productive apple growers;
$P_2{}^{*}$ = productive apple growers;
β and γ are vectors of respective parameters to be estimated;
X_i = vectors of explanatory variables (determinants);
ε_i = error terms.

3. Results

3.1. Trend Analysis of Apple Productivity from 2009–10 to 2019–20

The trend movement of apple productivity in temperate regions of the Indian state of Jammu and Kashmir from the 2009–10 to the 2019–20 farming season is presented in Figure 2. The researcher(s) used a trend-line movement, plotted on a histogram, to illustrate the status of apple productivity over the eleven (11) years. The trend curve depicts that 2009–2010 farming season recorded a productivity value of 10.91 t/ha; similarly, the 2010–2011 season recorded 14.44 t/ha. After the 2010–2011 farming season, which recorded the highest value, apple productivity has continued in an uneven pattern. It was found that the 2011–2012 season recorded declining productivity of 12.51 t/ha; likewise, the 2012–2013 farming season showed a declining (9.47 t/ha) trend. In 2013–14, apple productivity rose by 18.60% to stand at 11.23 t/ha, but then had the lowest yield of 7.87 t/ha in the 2014–15 farming season. The 2015–16 season brought a sharp (70.7%) productivity rise to 13.36 t/ha, while the 2016–17 season could not continue the trend, but rather recorded a productivity decline of 12.8% to yield 11.65 t/ha. In the 2017–18 farming season, there was another 09.30% productivity rise (12.74 t/ha), and a slight decline of 0.7% to a record

12.65 t/ha in the 2018–19 farming season. Again, the 2019–20 farming season recorded a 7.2% productivity increase to yield 13.56 t/ha. The study further revealed that 41.0% of the apple growers are producing below average, whereas the remaining 59.0% have a productivity value greater than or equal to 09.43 t/ha.

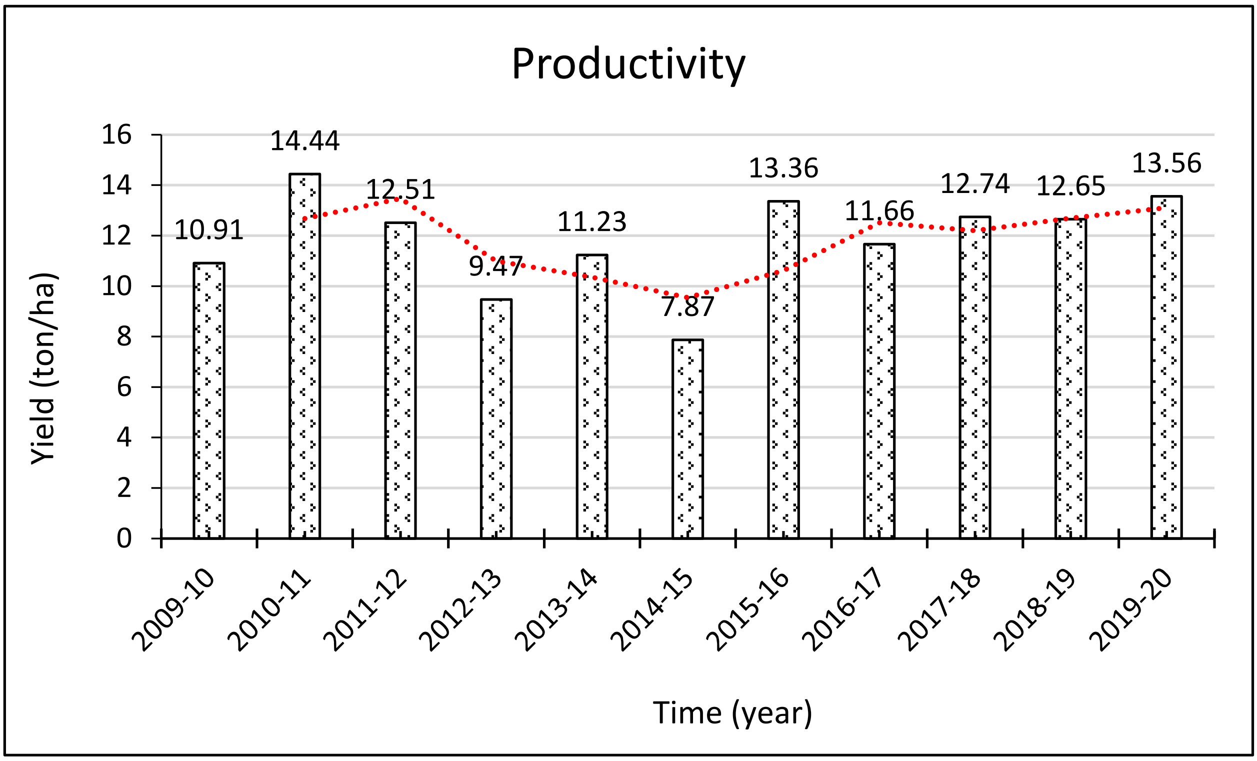

Figure 2. Trend analysis of apple productivity from 2009–2010 to 2019–2020.

3.2. Apple Growers' Productivity in 2020–2021

The productivity status of apple growers (orchardists) in the 2020–21 farming season presented in Table 2 reveals that the majority (67%) of farmers in the Kashmir region recorded a productivity value between 5.0 and 10.0 t/ha, while the remaining 33% produced above 10.0 t/ha. We found that farmers in Budgam had the least output (0.48 t/ha), whereas those from Shopian (75.0 t/ha) produced the highest yields in the 2020–21 season. The maximum productivity figure from Shopian agrees with the 75.4 t/ha reported by Sanaullah et al. [21]. On average, farmers in Baramulla reported average productivity of 11.07 t/ha, which agrees with the work of Wani et al. [10], who reported a 11–13 t/ha level of productivity. Orchardists in the Kashmir division of India had a 2.00 t/ha output deviation from the average productivity of 9.43 t/ha in the area. The average yield of 9.43 t/ha was 39% lower than the world average of 15.49 t/ha reported by Na et al. [15]. Further, the study found that 41% of the orchardists were producing below the divisional average, while 59% were producing either at the average point or above average productivity in the area. The fact the farmers were producing below the world average output of 15.49 t/ha suggested the need to disseminate and intensify technology adoption among apple orchardists in Kashmir. The fact that all three regions recorded productivity value below the world average [1] has economic implications for the gross domestic product (GDP) of India. It either means that the extension officers are not putting in extra effort to disseminate the available technology or that the farmers have refused to adopt the needed technology.

Table 2. Apple growers' productivity in 2020–2021 production year.

Current Range of Productivity per Hectare	Shopian	Budgam	Baramulla	Kashmir Division (Pooled)
0–4.9 t/ha	9 (9)	37 (33)	13 (15)	3 (0)
5.0–10.0 t/ha	72 (71)	62 (55)	40 (47)	200 (67)
above 10.0 t/ha	20 (20)	14 (12)	33 (38)	97 (33)
Total	101 (100.0)	113 (100.0)	86 (100.0)	300 (100.0)
Min.	0.5	0.48	1.00	0.50
Max.	75.0	24.20	40.00	13.00
Mean	9.14	6.94	11.07	9.43
Std. Dev.	7.75	4.00	6.80	2.00
Below average productivity	73 (72)	61 (54)	53 (62)	123 (41)
Greater than equal to average productivity	28 (28)	52 (46)	33 (38)	177 (59)

Source: field survey 2021. The figures in parenthesis are percentages.

3.3. Productivity Differentials across Different Farming Seasons

A productivity comparison among apple growers from 2009–10 to 2019–20 against current (2020–21) production is presented in Table 3. The Table shows that 2009–10 (12.83) ***, 2010–11 (43.40) ***, 2011–12 (26.69) ***, 2013–14 (15.60) ***, 2015–16 (34.05) ***, 2016–17 (19.32) ***, 2017–18 (28.68) ***, 2018–19 (27.90) ***, and 2019–20 (35.78) *** are negatively significant at a 1% level of probability. This significant and negative t-statistics value is an indication that apple orchardists are experiencing a decline in production from previous seasons, which calls for concern regarding the agronomic practices the farmers have been implementing in recent seasons.

Table 3. Productivity comparison across different farming seasons.

Year	Yield Diff.	t-Text Value
2009–2010	−1.48	−12.83 ***
2010–2011	−5.01	−43.40 ***
2011–2012	−3.08	−26.69 ***
2012–2013	−0.04	−0.36
2013–2014	−1.80	−15.60 ***
2014–2015	1.56	13.50 ***
2015–2016	−3.93	−34.05 ***
2016–2017	−2.23	−19.32 ***
2017–2018	−3.31	−28.68 ***
2018–2019	−3.22	−27.90 ***
2019–2020	−4.13	−35.78 ***

Source: Department of Horticulture, Government of Jammu and Kashmir, India, 2021.

3.4. Estimation of the Determinants of Apple Growers' Productivity

The study presents its productivity determinants in Table 4. The marginal effect size estimation was used to predict the linear function of the logit model (LM). The choice of LM takes care of the heteroskedasticity of the sample variants [34]. This is because apple growers with a productivity value below the average yield of the 2020–21 farming season (Table 3) take the dummy value of 0, while those with a productivity score equaling the average yield or more take a dummy value of 1. However, the model is not without its limitations, as it cannot explain the linear relationship between the dependent and independent variables in the study. The researcher(s), therefore, employed a post-estimation approach in understanding the marginal effect size of the productivity increase.

Table 4. Estimation of the determinants of apple growers' productivity in the study area.

Productivity	Kashmir Region Marginal Effect	Shopian Marginal Effect	Budgam Marginal Effect	Baramulla Marginal Effect
Age	0.001 (0.65)	0.008 (2.91) **	−0.003 (−0.95)	0.002 (0.44)
Farming experience	0.015 (7.23) ***	0.005 (1.16)	−0.001 (−0.25)	0.012 (1.93) *
Level of education	−0.052 (−2.57) **	0.004 (0.09)	0.006 (0.14)	0.006 (0.13)
Annual income	0.000 (4.58) ***	0.000 (1.79) *	0.000 (−1.28)	0.000 (1.31)
Extension contact	−0.011 (−1.21)	0.025 (1.48)	−0.008 (−0.45)	0.015 (0.84)
Adoption rate	0.005 (2.64) **	−0.005 (−1.31)	0.002 (0.60)	−0.002 (−0.51)
LR-test	109.65 ***	12.42 ***	2.53 **	5.65 ***
Pseudo R^2	0.270	0.104	0.016	0.050
Log-likelihood	−148.232	−53.411	−76.703	−53.472
Obs.	300	101	113	86

Source: field survey 2021. The figures in parentheses are the Z-scores significant at a 10% (*), 5% (**), and 1% (***) level.

The table reveals a log-likelihood value of −148.232 for the Kashmir division, −53.411 for Shopian, −76.703 for Budgam, and −53.472 for Baramulla. The higher the negative value of the log-likelihood, the better the result of the LM. The likelihood ratio scores of 109.56 *** (Kashmir), 12.42 *** (Shopian), and 5.65 *** (Baramulla) are all significant at a 1% level of probability, whereas that of Budgam (2.53) ** was significant at a 5% level of probability. These significance values are indications that the chosen models are properly fitted to explain the relationship between apple productivity and farmers' socioeconomic variables. The Pseudo R-square values of 0.270 (Kashmir), 0.104 (Shopian), 0.016 (Budgam), and 0.050 (Baramulla) are an indication that only 27.0% (Kashmir), 10.4% (Shopian), 1.6% (Budgam), and 5.0% (Baramulla) were explained by the joint action of the farmers' managerial potentials. Improving apple growers' (orchardists') productivity requires us to pay critical attention to farmers' economic profiles, which will aid in the adoption of recommended/improved practices.

The study reported that a marginal increase in farmers' age in Shopian region increased productivity by 0.8%. Thus, older farmers in this region seem to pay more attention to improved/recommended techniques and technologies, resulting in increased apple productivity and hence yield. Progressively, experience also comes with age; therefore, a marginal increase in experience in Kashmir region (1%) and Baramulla (5%) resulted in a 1.5% and 1.2% increase in apple productivity, respectively. Since empirical evidence suggested that experience comes with age, it therefore means that older farmers are more productive in the study area.

Again, the level of education is negatively significant at 5% level of probability. This implies that more entrant farmers with lower educational status will reduce apple productivity by 5.2%. Most of the agricultural programs organized by public sector agencies are targeted at the rural poor, whose educational background is comparatively very low. In agreement with empirical studies, this explains why apple production in Kashmir region has declined below the world average of 15.49 t/ha [1]. Though annual income was positively significant at 1% (Kashmir) and 5% (Shopian) levels of probability, this marginal increase in income does not transcend any increase in productivity. The implication is that the majority of the apple growers might have engaged in the enterprise to raise funds for other ventures they consider more profitable. So it is high time that extension functionaries worked more with those farmers who are involved in apple production and considered it as their primary occupation.

Furthermore, the adoption rate of improved/recommended practices was positive and significant at a 5% level of probability. These results reflected the researchers' a priori expectation, since they revealed a 0.5% increase in apple productivity in the Kashmir region. Most studies have found that adoption increases the productivity of crops [35], which this study validated. The study predicts and considers that age, farming experience, level of education, annual income, and adoption rate are the determinants of productivity in the study area. Human resources are one of the most important productive assets to which policymakers should pay keen attention to improve the production ingenuity of the growers, as this will enable them to identify and strategize on how to improve apple production in the study area and other parts of the world.

3.5. Causes of Apple Yield Gap

Just suggested in [36] that the causes of the yield gap should be empirically investigated to inform logical recommendations for the study area. The variables that cause this yield gap as proposed by the researcher(s) are socioeconomic, credit, pest and disease, technological, extension, and market-related constraints. In a good study on the yield gap, Schnug in [35] recommends that the first step in achieving a good polynomial plot for yield gap analysis is the identification of outliers.

These outliers are data that separate themselves from the group of data to be used for the analysis. Singh and Bhattacherjee in [37] noted that if these outliers are not treated, it invalidates the results of the quadratic estimation. Thus, it was suggested in [36] that a box plot act as a tool to remove the outliers. Figure 3 shows the box of productivity constraints that are free from outliers that could have led to a misleading result. Later on, yield gaps were predicted from the polynomial curve using a scatter plot chart-builder.

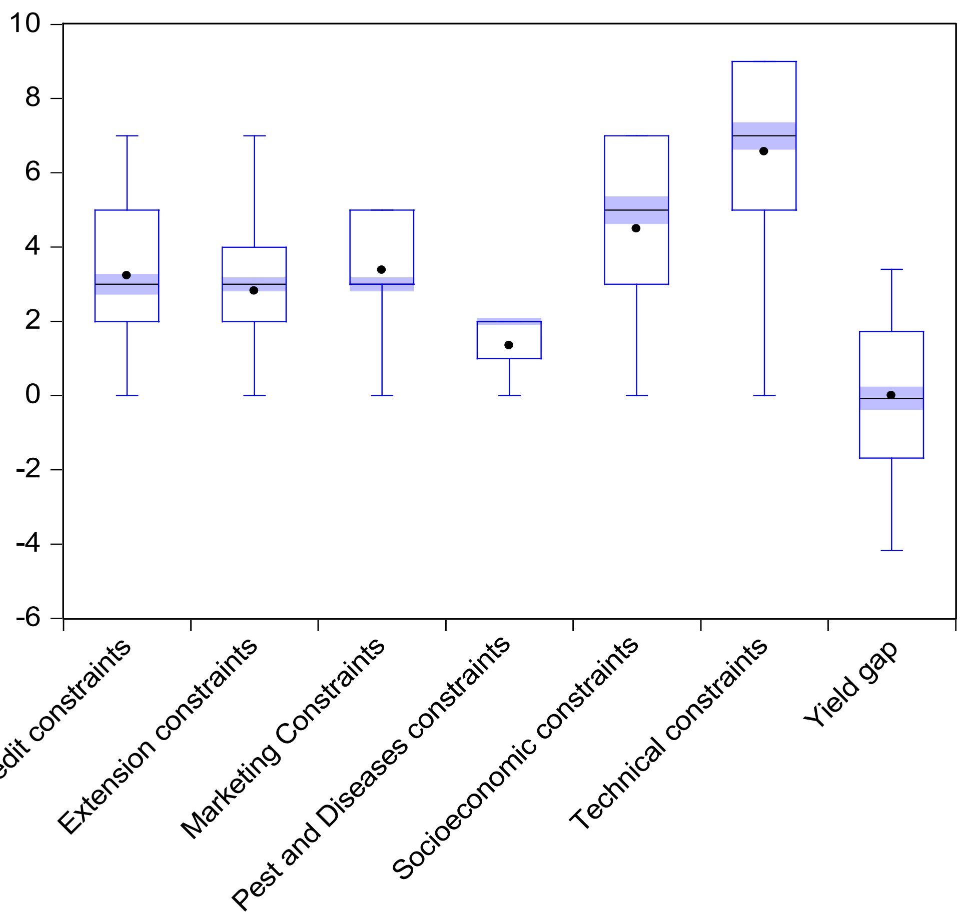

Figure 3. Box plot/outlier treatment of factors causing the yield gap.

However, the percentage contribution to the yield gap by each constraint is presented in Figures 4–9. Figure 4 proves that socioeconomic-related problems as encountered by the apple growers in the study area contributed to 10.7% yield gap in apple productivity. Figure 5 indicates that credit-related constraints as encountered by the apple growers in the study area contributed to a 4.1% yield gap in apple productivity. Due to the non-parabolic functionality of the relationship between pests and diseases and apple yield gap, the linear prediction of the constraints in Figure 6 did not add-up to any significant yield reduction in the study area, so this empirical finding confirms that pest and diseases are least concerns for farmers since it can be managed through recommended spray schedule or by integrated pest management system (IPMS). Equally, Figure 7 reveals that technological constraints contributed a 0.8% yield gap in apple productivity in the study area. Further, Figure 8 indicates that extension-related constraints approximately contributed to a 2.0% yield gap, and Figure 9 shows that marketing-related constraints contributed to a 3.2% yield gap in apple productivity in the study area.

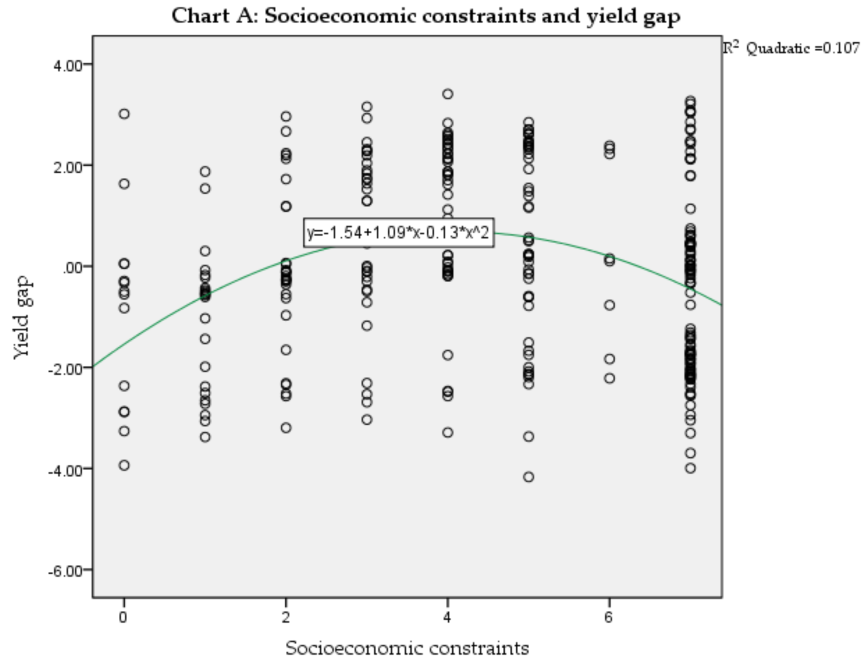

Figure 4. Scatter plot/quadratic prediction of socioeconomic constraints contributing to apple productivity yield gap.

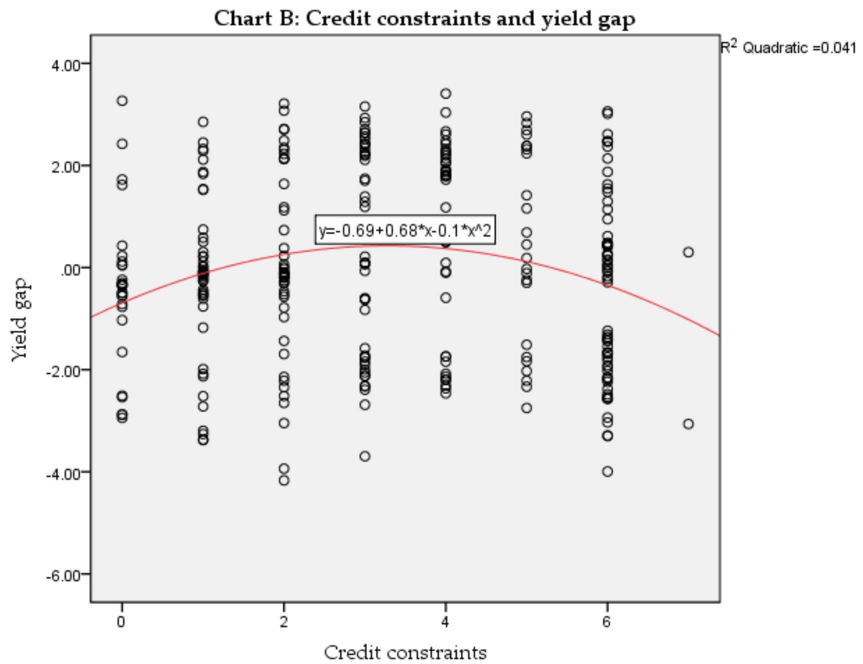

Figure 5. Scatter plot/quadratic prediction of credit constraints contributiing to apple productivity yield gap.

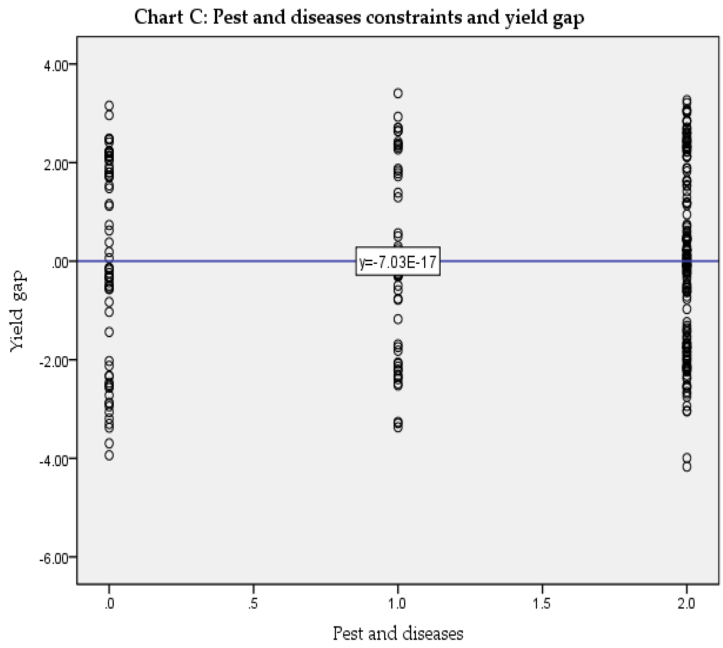

Figure 6. Scatter plot/quadratic prediction of pest and diseases, contributing to apple productivity yield gap.

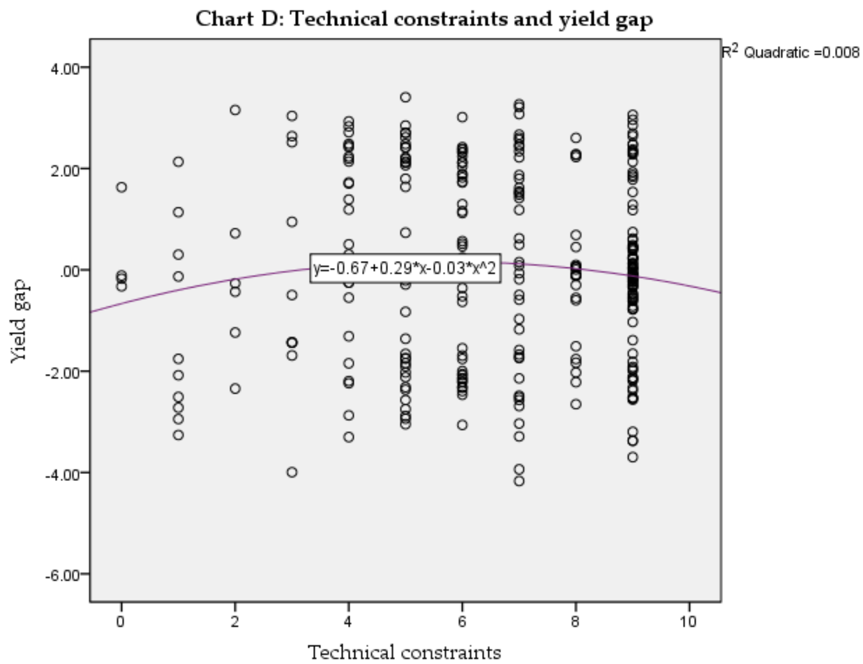

Figure 7. Scatter plot/quadratic prediction of Technological constraints contributing to apple productivity yield gap.

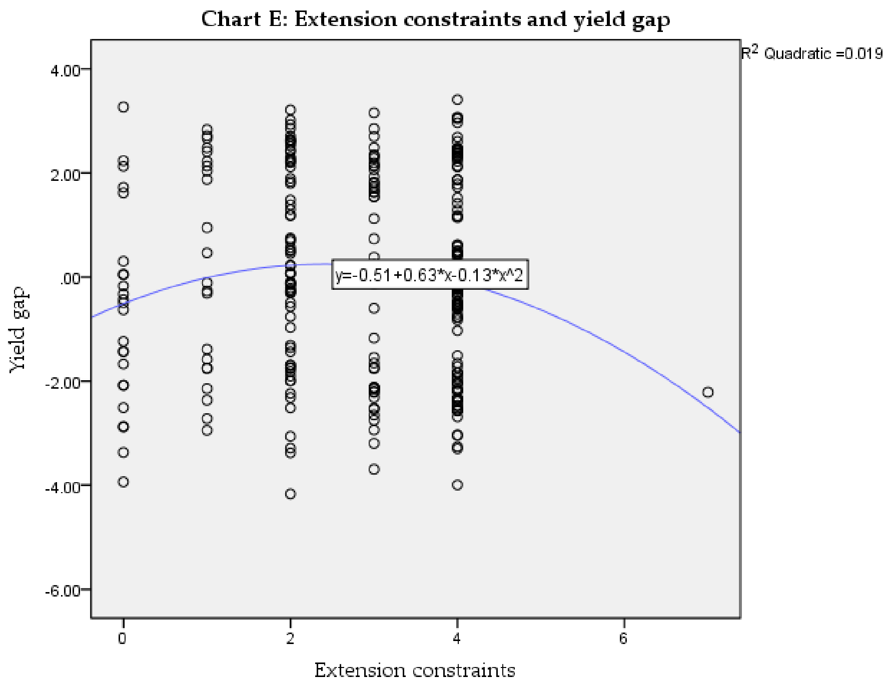

Figure 8. Scatter plot/quadratic prediction of extension-related constraints contributing to apple productivity yield gap.

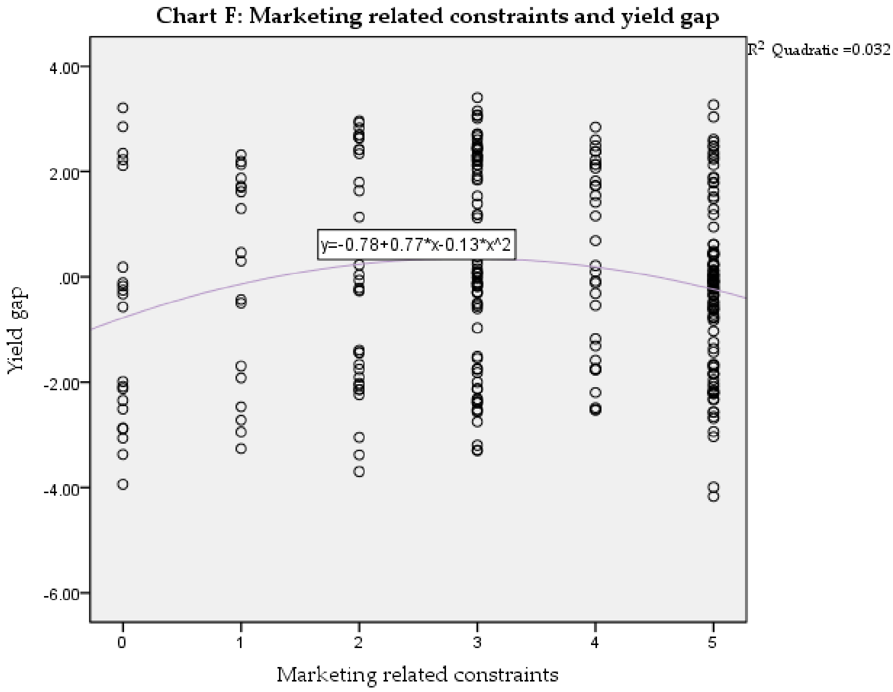

Figure 9. Scatter plot/quadratic prediction of Market related constraints contributing to apple productivity yield gap.

4. Discussion

4.1. Trend Analysis of Apple Productivity from 2009–10 to 2019–20

Back in 1997, it was noted in [38] that trend analysis is a graph that shows the movement or performance of a firm's achievement over time. This technique is used in technical analysis that attempts to predict future productivity movements based on recently observed data. From the chart and trend line, it is evident that for the studied eleven (11) years, productivity rose in one season and dropped in the next production year. This is an indication that apple productivity follows a sigmoidal movement pattern. This trend analysis chart established that the 2010–2011 farming season remained the most productive year for apple growers in Kashmir Valley, while 2014–2015 was the worst productive year for apple growers. In that 2014–15 farming season, productivity fell below 8.79 t/ha, as reported in [24]. It must be noted that in 2014 there were devastating floods that hit the apple growing regions badly, resulting in a low yield. Based on the pattern movement as observed by the chart, there may be a productivity decline in 2020–2021 farming season. This will be addressed in the latter part of the study. Another reason to believe or expect a decline in yield for the 2020–2021 season is the COVID-19 outbreak, which disrupted production patterns in 2020–21. Despite the favorable environmental conditions for apple cultivation in the study area [13], one can assume that innovative approaches (technological adoption) for apple production are not fully practicable. This confirms the suggestions of Uchemba [39], who editorialized that one-time use of technology does not guarantee its continued use among farmers without continued extension intensification.

4.2. Apple Grower Productivity in the 2020–2021 Farming Season

Productivity measures the ratio of total output to input use as a result of improvements in technological adoption or knowledge [40]. The average productivity value of 09.4 t/ha as recorded in the study is far below those found in other world-leading apple growing regions such as Turkey (productivity value of 24 t/ha) [20], and China (29.9 t/ha) [18]. This finding is an indication that policymakers vis-a-vis other stakeholders in the region need to promote innovative technological dissemination and ensure its adoption in farmers' fields through intensive extension of information dissemination. Despite the production potential of apple growers in the region, farmers are yet to attain maximum or recommended productivity, as is evident by 41.0% of the apple growers producing below the average in the 2020–21 season (Table 3). These arguments underline the need for this study; in latter parts of the study, the problems (constraints) causing this production deviation from optimal levels are examined to help researcher(s) make informed policy recommendations.

4.3. Productivity Differentials across Different Farming Seasons

The productivity comparison was possible because the eleven years of trend production data made available by the Department of Horticulture, Government of Jammu and Kashmir, India in 2021 were used as a baseline data or reference category for the t-test comparison using an unequal variance approach. The study revealed that excluding the 2012–13 farming season, the yields from 2009–10 to 2011–12 farming seasons were significantly higher than the 2020–21 yield at a 1% level of probability. The 2020–21 yield (9.43 t/ha) was significantly higher than the 2014–15 yield at a 1% level of probability. From 2015–16 to the 2019–20 farming season, apple productivity was significantly higher than the current yield at 1% level of probability. These findings show the need to intensify extension in the study area. The improved varieties need to be introduced and subsidized to encourage affordability. This means the supposition that there has been no difference in productivity across different years is rejected.

4.4. Estimation of the Determinants of Apple Growers' Productivity

The significant likelihood ratio test (Table 4) indicates that the overall model was a good fit model and the explanatory variables were adequate to determine productivity in the study area. The 0.270 value of the R^2 implies that 27.0% of variation in apple growers' productivity is explained by the joint action of their socioeconomic characteristics, while the remaining 73.0% is unexplained as a result of external factors beyond the growers' control. The value of the pseudo R^2 is low but falls within the weak effect size of 0.25 recommended for behavioral study in [41,42]. However, this value of R^2 is not accepted for experimental study.

The study revealed that experience, level of education, annual income, and adoption rate are the determinants of apple productivity in the study area. Based on their significance levels, the marginal effect size (β = 0.015) for farming experience implies that a 1% increase in the number of years the respondents are employed in apple production will increase their productivity by 1.5%. So, the results suggest that productivity is experience-dependent in the study area. It is no wonder the apple growers have not been able to break even in their productivity because they seem to rely more on indigenous/traditional practices rather than modern innovative technologies that are being disseminated to improve their productivity/yield. This finding is in agreement with Ogbonna et al. [43], who reported a positive and significant relationship between farming experience and technological adoption that suggested an increase in productivity in their study. The marginal effect size (β = 0.052) for the level of education implies that 5% advancement in apple growers' educational level will cause 5.2% reduction in productivity in the study area. This could be attributed to the fact that more educated farmers are engaged in other paid or white-collar jobs which they perceive as more rewarding than apple production. This divided attention will not permit them to try their best to achieve optimal productivity. Policymakers and stakeholders need to engage and retain educated youth in apple cultivation by providing subsidized planting material and other farm inputs and technologies to enhance the productivity of apple fruit.

Again, the marginal effect size (β = 0.000) of annual income is an indication that a marginal increase in an apple grower's income will have a positive effect on productivity. Though increasing income opportunity of farmers is seen to increase apple production, it does not guarantee even a 1% increase in production value. This is because farmers may lean towards economic diversification when their income access increases rather than investing in better and improved apple varieties for optimal growth. Furthermore, the marginal effect size (β = 0.005) of the adoption rate shows that a 5% increase in technological adoption will increase apple productivity by 0.5%. Shah et al. in their study presented in [44] suggested that adoption of innovative techniques and technologies developed at different research stations and experimental stations can boost the productivity of crops in different regions. So, the adoption of technical vis-a-vis market information will facilitate the effective use of available technologies to improve crop production (apple). This result also corroborates the results presented in [39], where the author(s) suggested that technological adoption is a key to increased agricultural productivity.

4.5. Critical Analysis of the Causes of Apple Yield Gap

Socioeconomic constraints reduce the prosperity of apple growers in the study area and growers in other regions of the world. It is believed that the socioeconomic status of any grower (globally) is important in achieving goals in the shortest possible time, being successful, and thriving in his/her profession. Worldwide, socioeconomic challenges are major concerns of the majority of the people associated with the agricultural and allied sectors and these challenges are affecting the participation of young and energetic youth in the cultivation of crops including apple. Engagement of youth in apple cultivation could create employment opportunities and raise the income levels of apple-growing households [45]. One socioeconomic variable often complained about by farmers is the "high cost of inputs" related to apple cultivation. Apart from the high cost of inputs (seeds, fertilizers, pesticides, and farm machinery), the quality standard of inputs cannot avoid exploiting the poor and marginalized fruit growers in both ways. Due to the high cost and unavailability of inputs at peak periods, growers seldom utilize recommended doses of inputs including fertilizers, pesticides, seeds, healthy and robust planting material, etc., thereby following traditional methods of cultivation, resulting in low production and productivity of this important fruit and at the same time threatening the food security and sustainability of the crop not just in the study area, but globally.

Poor infrastructure and the shortage of skilled laborers are among farmers' socioeconomic constraints as modern-day cultivation is not subsistence-focused, but a basis for commerce and industry. For the world apple industry to improve, the enabling conditions and facilities of growers need to be strengthened and updated. The most prominent of these required conditions are largely in the realm of infrastructural development of growers [46].

If the farmers (apple growers) in the world in general, and India in particular, are to produce enough food to feed a growing population and increase their production as well as productivity to earn adequate returns while also sustaining a living from agriculture, there is enormous need for infrastructural development. The development of infrastructural facilities can connect growers with global markets, linking them to the inputs needed for the industry to survive. The infrastructure deficit is one of the most significant barriers to sustainable agricultural growth [47]. To develop the infrastructure of growers in the study area and similar regions of the world, different services, schemes, and subsidies need to be put in place for the better development of the apple industry. Besides, apple cultivation requires complex and scientific cultivation practices such as training and pruning, fertilizer and pesticide application (timing and dosage), irrigation management, harvesting, picking, grading, marketing, etc., where apple growers need skills and competencies to maintain their orchards and produce robust and good quality fruits. Special training online as well as offline needs to be done in a timely way on different practices and for that purpose, both public as well as private agencies need to be used through public–private partnerships. The extension agencies can play an important role in improving the skills and competencies of growers through demonstrations, field days, workshops, seminars, etc.

Credit constraint is defined as the failure of policies and little or inadequate access to formal credit loans. It hinders growers from enhancing their living standards and well-being and increasing farm production [48]. Apple growers face hardships such as low productivity due to labor force issues, minimum profits, and credit constraints that have adverse effects on their output (farm produce). Agricultural credits widely improve growers' income vis-a-vis welfare and promote their (apple growers') welfare; the majority of the agrarian countries of the world have targeted the potential gains of growers through credit-related programs [49]. In modern technology, credit related to agriculture is considered as an essential factor for farm productivity [50]. Small-scale growers use agricultural credit for their survival while large-scale growers use it to improve their income streams [51]. In the study area, financial crises in the family, high rates of interest on loans, and complicated procedures for obtaining loans were the main credit-related constraints of apple growers. Despite government schemes for obtaining loans at low-interest rates, such as Kisan Credit Cards (KCC), apple growers were not benefiting from such schemes due to complicated procedures for receiving such services. The KCC scheme was introduced in India in 1998–99 and has since become a flagship program for providing access to short-term credit in the agricultural sector [52]. However, the apple growers in the study area were limited in using KCCs because the grower has to repay the loan within a year with a 4% interest rate and if they fail, the lending agencies will charge 7% in interest. It is worth mentioning that credit constraints are having devastating impacts on Indian farmers, and as it was pointed out by Bhukuth in [53], credit constraints are one of the main constraints that are forcing farmers to commit suicide in India, including uncertainty related to technology, higher input prices, and loss of expected utility.

As Baiyegunhi found in [54], credit constraints are hurting farmers' welfare, and the researcher(s) believe that the farmers released from such constraints have relatively higher monthly spending as compared to credit-constrained farmers. These constraints limit the consumption expenses of farmers while unconstrained farmers' consumption expenses were unlimited [55]. It was also observed that such constraints decreased the income of farmers by 13.2% in China, and the elimination of credit constraints can add about 23.2% in income [56]. Similar results were found in the United States (US): as reported by Griffin in [57], credit constraints account for a 3% loss in total value of production for farmers. So, the need of the hour is that interest-free (fixed) credit be made available to growers to help them at least buy necessary (critical) agricultural inputs during the year.

Pest and disease management constraints: Apple fruits are subjected to numerous plant diseases [58], and the pests cause devastating effects on fruits including branches, leaves, and roots. Apple growers need to spray their orchards with at least 13–15 different pesticides/insecticides in a year. Spraying of different pesticides/insecticides is cumbersome, laborious, uneconomical in terms of money, and hazardous for animals and water bodies, besides degrading the environment. There was a high infestation of pests and diseases in almost all the regions of the study area, which was a major cause for low production. High infestation of pests and diseases causes yield losses; as reported by Cerda in [59], pests and diseases lead to high primary yield losses (26%) and even higher secondary yield losses (38%). Similar results were reported in China by Tudi in [60], wherein it was found that the loss of fruits due to pests and diseases was 78% in absence of pesticides.

High infestation of pests and diseases limits farmers (apple growers) in obtaining better crop yields and ensuring food as well as nutritional security [61]. Farmers (apple growers) use different chemicals to manage insect pests and diseases; however, there is a huge challenge in that insect resistance is increasingly building up and is becoming a worse constraint to crop management and obtaining good crop yields [62]. In many cases, apple growers are being exploited by the private dealers (unauthorized pesticide/fungicide dealers) who charge hefty amounts, besides selling substandard pesticides/insecticides and verbally abusing the marginalized growers. So, insects and pests need to be managed by using sustainable measures that will not alter the balances in the environment, and use of integrated pest and disease management (IPM), resistant varieties, and other biological controls that are less hazardous need to be promoted, as well as a focus on organic farming. Extension programs such as on-farm training need to be conducted using different agencies to create awareness among apple growers about the negative impacts of chemicals on the food ecosystem. Apple growers in the study area and for that matter, growers throughout the world, need to be advised frequently through different media (radio and television, posters, pamphlets, etc.) to minimize the usage of such hazardous chemicals, thereby maintaining sustainable fruit cultivation.

Technological constraints: To increase the production as well as the productivity of any crop in the study area or in other parts of the world, the generation of innovative techniques and technologies, as well as dissemination of such technologies to farmers (apple growers) is important. Different technologies are being developed by scientists at different research institutes, experimental stations and farm science centers; however, such technologies or improved practices either are not disseminated or not being adopted by the growers in their fields [29]. Increased use of recommended technologies in apple cultivation (and other crops) leads to higher production as well as productivity of fruits/crops thereby improving the socioeconomic status as well as standard of living of the apple growers. It was reported that an increase in agricultural production leads to enhanced annual income of any grower(s) and has a positive impact on access to the food supply in the domestic market, thereby contributing to sustainability of agriculture by improving agricultural practices [63]. Adoption of scientific practices is expected to increase the yield of apple fruit, estimated to be 50–60 t/ha. A study conducted in Pakistan revealed that there was a huge gap between the actual yield and potential yield of different crops [64], thus clearly indicating that the available innovative technologies, if properly adopted by the growers at their farms, not only in the study area but throughout the world, can boost agricultural production manifold times [65]. Similarly, in India, much of the focus remains on the generation and development of the technologies, but the same are not adopted by farmers in general and apple growers in particular.

Dissemination of information related to innovative technologies among farmers (apple growers) is as important as the development of modern technologies in research stations and incubation centers. Farmers (apple growers) need modern and scientific information not only to practice farming (new seeds, fertilizers, pesticides, equipment) but also for selling their output at the right place and remunerative prices, and on demand patterns, government schemes, weather information, and so on [66]. Today the extension agents can use different methods for the dissemination of scientific information to apple growers, and one of the methods could be information and communication technology. ICT is an electronic and interactive bridge between farmers (apple growers) and extension agents [67]. It assists the growers to plan their markets in order to obtain better prices for their produce and prevents them from being exploited by the middlemen, who use the prevailing information gap [68]. Among the modern ICTs, mobile phones in today's world serve as a best means for effective dissemination of knowledge as well as information about different agricultural markets and innovative technologies to farmers (apple growers), enabling them to apply such knowledge directly to improve their output (farming) and giving growers easy access to different markets both online as well as offline [69]. In addition to this, motivating different categories of farmers to adopt innovative agricultural technologies as well as techniques remains a focal point of the change agencies [70]. The use of smartphones and electronic mail has had a profound (positive) impact on the farm production of small growers [71]. Electronic communication such as radio and TV can play a vital role in transfer of information to apple growers in timely situations of urgency and emergency. By using such technologies, growers can be informed promptly about various aspects of diseases and pests and their control, and floods and changing weather [72].

Apple growers can make use of different sources to obtain knowledge and awareness regarding different management practices (pests, fertilizers, planting material, logistics, and market awareness); moreover, it was observed from the data that the majority of apple growers from almost all the regions thought that there should be greater availability of technical knowledge from line departments and state agricultural university. However, both the agencies use different sources (print and electronic media) to disseminate the right information to the apple growers at right time. State agricultural universities use farm science centers located at the district level to keep farmers, including apple growers, aware of the recommended technologies and practices used in apple cultivation. Farm science centers make use of front-line demonstrations to show apple growers different innovative methods in apple cultivation. The Agriculture Technology Information Centre (ATIC) works under the state agricultural universities to help the apple growers with possible solutions to their queries. It is important to mention that ATIC contains a pool of scientists from different subjects (plant pathology, entomology, agronomy, extension, floriculture, fruit sciences, vegetable sciences) who provide solutions to grower problems, besides making available different agricultural inputs to the growers. Farmers need to benefit from such services in order to enhance productivity without much losses of their produce.

Extension-related constraints: Different constraints were identified that were the main cause of diminishing production and low productivity of apple fruit in the northernmost Himalayan state of India. There is a huge potential that the yield of apple fruit can be increased to 40–79 t/ha, as the agro-ecological conditions in the region are most favorable for the cultivation of horticultural crops in general and apple cultivation in particular. However, due to different constraints and problems in the cultivation of apple fruit, productivity is stagnant at 11 t/ha compared to the yield of other countries viz. China 17.96 t/ha (world average 15.49 t/ha), France (43.98 t/ha) [1], and certain other countries yield of 70–80 t/ha was also registered [25]. Farmers all over the world have complained of inadequate contact with extension agents and other stakeholders. There is a scarcity of extension officers, who can deliver the right and recommended scientific information to the growers. As per the literature cited in [73], of the 143,863 positions in the agricultural department in the country, only 91,288 posts are filled. This huge gap in change agents is paramount: on average, scientific technology reaches only 6.80% of apple growers. Further, one extension officer served 1162 operational holdings; i.e., the ratio of extension worker to growers is 1:1162 at the national level, which is too low against the recommended 1:750. However, China, which produces food for 21% of the world population, has a strong extension system, wherein one extension officer serves 0.81 villages or 283 farm households [74]. So, in order to enhance productivity in the study area and other regions of the world with similar situations, this gap needs to be minimized by involving private extension service providers in the field of delivery and dissemination of scientific technology to the growers/farmers.

The promotion of farmer and producer organizations (FPOs) is important and will play a key role in strengthening extension activities, like that of farmer cooperatives in China in the application and dissemination of modern technologies. Various cooperatives collaborate with different research institutes, experimental stations, extension organizations and provide timely information to their clients [75]. In China, cooperative organizations not only disseminate information but also provide other agricultural inputs such as seeds, pesticides, fertilizers, and farm machinery to farmers through group buying and direct purchase, thereby reducing input costs by 10% and increasing the margin of profit by 20–30% [76].

Market-related constraints: The marketing and supply chain of agricultural produce is one of the serious concerns of farmers worldwide, including in India. The efficiency of marketing for agricultural produce in India has been a noteworthy concern in recent years. Inadequate marketing infrastructure and poor efficiency of marketing channels are believed to be the root cause of high and fluctuating consumer prices, besides a lesser share of consumer rupees reaching growers [77]. Typically, farmers in India depend heavily on middlemen, particularly in fruit and vegetable marketing. The producers as well as consumers often obtain a poor deal and the middlemen control the markets but do not add much value [78]. Most farmers usually sell their products through traditional spot markets, and a majority of them are not/little regulated. Apple growers in the study area and other growers in many parts of the world are charged hefty margins on their produce in these traditional markets. These predominantly unorganized markets with limited infrastructure cannot meet the quality requirements and specifications of changing demand and this has increased the importance of organized retail for agricultural products [79]. Infrastructure is the necessity that can facilitate production as well as marketing activities and its shortage can lead to different multiplier effects on other sectors [80]. It was reported that due to a lack of basic infrastructural facilities that can bridge the gap between rural and urban areas, the growth of the agro-industry has not reached its required level of development [81].

Fluctuation of the prevailing market price for agricultural produce in general and apple fruit in particular is worrisome for farmers. Many farmers are unaware of the prevailing market prices for their produce and uncertainty about future market prices is a great concern for apple producers. Lack of knowledge of growers about the prevailing market price for apple fruit remains the reason for the low profit of their produce. It was reported that accurate information about prices in the near future would facilitate the producer's rational market decisions (regarding the choice of markets and quantum of produce (output) to be dispatched) for maximization of profit [82]. Integration of markets and forecasting of price would help in stabilizing prices by removing market imperfections such as monopolies and monopsonies and attaining market efficiency [83].

To remove bottlenecks in the marketing of apple fruit in India and other related regions of the world, government agencies need to update farmers in a timely way and make them aware of best options available for the procurement of their produce. Credible agencies could make use of Kisan Call Centres (a well-known ICT-based initiative in India) to cater to all the market-related information needs of apple growers [84]. The main application of ICT in the agricultural sector in Indian scenario/other related regions is providing relevant information on prices and other market-related awareness to farming communities [85]. Similarly, apple growers can take advantage of different ICT-based applications (m-Kisan initiative) through which they can receive daily information related to prices from the agricultural produce markets (APMCs) through short message services (SMSs) in local language [86]. Apple growers can make use of the eNAM (National Agriculture Market) initiative that aims at creating a pan-India electronic trading platform and providing single-window facilities for APMC-related information [87].

5. Conclusions, Recommendations, and Limitations

As large number of people are directly or indirectly associated with apple cultivation in the world, including in India. There is a need to study different aspects of apple cultivation to analyze the root cause of low productivity of this important crop. During the present study, different constraints encountered by farmers were found to be the main cause of low productivity (9.43 t/ha) and the yield gap in apple fruit. Socioeconomic constraints, lack of technical knowledge, low extension contacts, credit related constraints, pests and disease infestation, and market-related constraints were the prime reasons for non-adoption of recommended/improved cultivation practices by apple growers; these were statistically proven to affect the apple production in the study area. This poses a real challenge for different stakeholders seeking to improve the socioeconomic conditions of resource-poor farmers. Extension functionaries need to gear up to disseminate and increase the technical knowledge of apple growers through effective capacity-building programs that need to concentrate on those variables (farming experience, level of education, and annual income) which were found to significantly determine apple productivity. Agencies tasked with updating the skills of farmers need to adopt a pragmatic/holistic approach in demonstration of potentially improved practices/technologies in farmers' fields. Farm and home visits by these agencies need to be increased to advise and assist in solving specific problems, besides sustaining interest of growers in apple cultivation. In order to mitigate the constraints that came to the fore during the study, more emphasis need to be given to practical training instead of lectures and apple growers need to be encouraged to learn by doing as seeing is believing.

It was found that apple productivity followed a sigmoidal movement pattern over the eleven-year trend, so it was evident that these growers were not consistent in using the available technologies in apple cultivation, resulting in an adoption gap which determined that their productivity growth was not constant over time. The study, therefore, recommends that extension/research technologies need to be disseminated, and diffused until innovative/improved technologies are completely adopted. Policymakers need to understand that short-term subsidies/services are not sufficient for full adoption of innovative technologies; thus, these should not be immediately withdrawn from farmers, as this will help to ameliorate the challenges identified in the study. However, there are numerous parameters which are limiting the enhancement of productivity of different crops throughout the world. In the study area, and likewise other areas of the world, it is important to study the environmental factors causing yield loss in apple as well as in other crops. Similarly, it is important to study the adoption and impact of climate-smart technologies (CST) on yield.

During the course of the study, a number of challenges were encountered by the researcher(s) as the majority of the apple growers were not free to provide relevant information as requested in the questionnaire. As the study was conducted in rural areas, lack of transportation was a major hindrance to reaching the farmers in time. Besides, the apple growers had a low level of education, so were not able to answer the questions in the interview schedule.

Social, Political, and Environmental Implications

Furthermore, it has been found that apple production is significant among literate people in the study area, it could serve as a good source of employment to women and youth in the area. Apple growers need to adopt recommended/improved practices so that their socioeconomic status will be enhanced. Political will needs to be demonstrated among policymakers to initiate different programs targeted at empowering people through apple orchards. The income from the enterprise will help to grow the economy of the state, as it is the industry in which a majority of people are engaged. When people are actively and enthusiastically engaged with apple production, the revenue from the enterprise could be used to improve the livelihood of farmers so that their living standards will rise. They could then afford basic amenities of life, such as shelter, gas, etc., and this will help to reduce deforestation in the search for fuel and building materials.

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