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What Determines Acceptance, Adoption and the Use of High-density Apple Plantation in India? A Hybrid Model Approach of PNTC and AUTAUT

Javid Majeed Pandith*[1] and Md Naushadul Haque Mullick[2]

[1-2] Department of Management Studies, Jamia Milia Islamia, New Delhi - 110 025

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Abstract

India is the fifth largest producer of apples in the world and Union territory of Jammu and Kashmir contributes about seventy five percent of total production. The area under apple production has been increasing but productivity has been stagnant or decreasing. Govt of erstwhile state of Jammu and Kashmir introduced high density apple plantation in 2015 This Study seeks to discover to which extent high-density apple plantation is adopted among the apple growers. Multiple stage sampling was used to collect data. A hybrid model of PNTC and AUTAUT was adopted and SPSS 26 and AMOS 21 were used for analysis of the collected data. The study establishes that need characteristics and technology characteristics can be considered as important factors for perceived need technology characteristics of farmers adopting HDAP technologies along with extended AUTAUT, it was found perceived benefits and facilitating condition has positive and significant impact on farmers intention to adopt HDAP technology, while as social influence and perceived risk doesn't influence farmers intention to adopt HDAP technologies in Kashmir. It is also recommended that factors like cost, subsidy, bank credit can be added as new factors in future works.

***Key words*:** UTAUT, TTF, Technology adoption, High-density, Apple plantation

Indian economy is dependent on agriculture, with about 50% of its population being engaged in agriculture and allied sectors. According to [1], this sector accounts for 15.87% of the GDP and 21% of gross value added. Furthermore, it contributes about 13% to the total value of exports in India. Besides its direct economic benefit, farming also provides provisions to non-farming activities and raw materials for many industries. It is important to note that for over 70% of rural population agriculture and associated activities are the main sources of livelihood. India is largest producer of milk, pulses, millet, jute as well as a leading producer of banana, mango and papaya horticultural crops in world [2]. In addition, wheat, rice and cotton are produced on large scale as per FAO's 2018 statistics by this country which ranks second globally. Thus, the output levels and productivity in agricultural crops heavily determine the overall state of the country's economy under these circumstances. Consequently, sustainable agriculture development coupled with growth is critical for Indian economic prosperity and food security.

Union Territory of Jammu and Kashmir continues to be an agrarian economy. Nearly 70 percent of the population is directly or indirectly involved in agriculture. According to the latest data agriculture in Jammu & Kashmir, contributes 17.2 percent to the total gross state domestic product (GSDP) and its growth rate of 9 percent is substantially higher than the national average of 2.9 percent [3]. Amongst the agricultural activities, horticulture is the most important driver of the growth rate and contributes 40 percent to the total output value from agriculture in Jammu and Kashmir [4-5].

Apples are the main fruit in Jammu and Kashmir, and they are grown on around 51% of the 2.72 lakh hectares that are used for all other temperate fruit growing in the state. Presently the state contributes 75 per cent of total Indian apple production with an average yield of commercially important apple cultivars per unit area is the highest in the country ranging between 10-13 t/ha, but compares poorly with yields of 20-40 t/ha in horticulturally advanced countries [6-7]. The temperature and other agro-ecological features of the Kashmir valley are ideal for cultivating a broad variety of apples, in addition to other temperate fruits. Over 30 lakh people, or roughly 5–6 lakh households, are said to be directly or indirectly engaged in the apple industry, which generates an annual revenue of Rs. 8000 crores for the state [5].

Apple is one of the high-value agricultural commodities [6], [8-9]. It is one of the major fruit crops of union territory of Jammu and Kashmir, India in terms of the potential growing area, production, and domestic consumption. Indian states viz; Himachal Pradesh, Uttarakhand, and Arunachal Pradesh including union territory of Jammu & Kashmir (J&K), provide niche for commercial apple cultivation [10]. The area under fruit crops has increased by 6978 Ha i.e. from 334719 Ha in the year 2020-21 to 341697 Ha in 2021-22 thereby recording a growth of 2.08 percent [1]. The overall fruit production has increased by 3.95 LMTs during 2021-22 i.e. from 20.36 LMTs

***Correspondence to:** Javid Majeed Pandith, E-mail: jmajid011@gmail.com; Tel: +91 7006039985

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in the year 2020-21 to 24.31 LMTs recording a growth of 19.39 Percent. An area of 6090.91 Ha has been covered under HDP in the financial year 21-22 registering a growth 591% over the previous year.

High density planting is normally understood as a system wherein a higher number of plants are accommodated in a unit area as compared to the conventional planting [7]. The various HDP agricultures technologies available today strengthen managerial decision-making abilities, thereby allowing farm operations to use resources more efficiently and reduce risk. Compared to traditional orchards, high-density planting has a far shorter payback period due to its early maturity, yielding fruit in the second year of planting and reaching peak output in the fourth. Apart from this, high-density plantations produce the highest ratio of A-Grade fruits (>80%) which are qualitatively and price wise better [11].

High density planting (HDP) is the practice of increasing plant population per unit area of land in order to raise fruit output, overcoming low productivity and a long gestation time for early returns. This is accomplished by utilizing appropriate scion cultivars grafted on dwarfing/semi dwarfing rootstocks. High density orchards began to be planted in Europe at the end of the 19th century, and conventional low-density orchards have declined since then [12]. The main idea of HDP is to make the optimal use of vertical and horizontal space per unit time while achieving the highest potential return per unit of output. Standard apple plants produced on seedling rootstocks are planted at a spacing of 6×6 m to 7×7 m, with a planting density of 204-278 trees/ha. Spur varieties on seedling rootstocks are planted at a spacing of 5.0×5.0 m, with a planting density of 400 plants/ha. The average production of these orchards is 10 to 12 MT/ha, which is much lower than the productivity of high-density orchards (60-80 MT/ha). High-density planting of apple types grafted on dwarf/semi-dwarf clonal rootstocks may support roughly 3,333 plants per hectare, increasing output without compromising yield quality.

The aims of the research paper are to demonstrate application of a hybrid model of task technology fit with the addition of other factors adopted from AUTAUT to determine acceptance and adoption decision making of farmers. The study will try to fill the gap by looking into factors embedded in TTF and AUTUAT to provide an understanding of farmers behavioral intention to use HDAP technology. These factors can better comprehend how farmers behavioral intensions and adoption of HDAP are influenced.

MATERIALS AND METHODS

Perceived need for technological characteristics (PNTC)

Enhanced production and productivity can indeed be achieved through two primary approaches: improving the efficiency of existing production practices and adopting higher-yielding technologies. Task-Technology Fit theories generally focus on how well a technology fits or aligns with a specific task or set of tasks within an organization [13]. The Task-Technology Fit (TTF) model, is a theoretical framework used in information systems research to understand the relationship between task characteristics, technology characteristics, and their combined effect on task performance or outcomes [14]. Tasks are broadly defined as the actions carried out in turning inputs into outputs to satisfy information needs [15]. The term "technology" encompasses a broad spectrum of components and systems, and it goes beyond just hardware and software. The perceived need technology characteristics (PNTC) is not solely determined by the technology itself; it's a complex interplay of the technology's perceived capabilities, the task requirements, and the users' competence [16]. Contrary to many information technologies, such as mobile banking, which are free for the end user, expenses must be taken into account when evaluating agricultural technology adoption [17]. Thus, in order to ascertain farmers' perceptions of cost, risk incorporated into the TAM. To evaluate the match between a farmer's (perceived) requirements and HDAP technologies and ascertain their relevance in forecasting HDAP adoption, perceived need for technology characteristics, or PNTC, was presented as an alternative to the TTF model.

The effective utilization of technology is closely tied to the alignment between the features of the technology and the specific requirements of the task at hand [13]. Aligning technology with user requirements enhances the likelihood of successful adoption, while a mismatch can lead to reluctance and decreased intention to adopt Previous studies have found the influence of task and technology characteristics on PNTC [13]. The two key factors need characteristics and technology characteristics influence PNTC in the context of information systems [13]. PNTC is crucial for promoting user adoption. In contrast, a poor task, in turn, can lead to a decrease in users' adoption intention. Thus, as per the discussion, we propose the following hypothesis as:

H1: Need Characteristics have a positive impact on perceived need technology characteristics

H2: Technology characteristics have a positive impact on perceived need technology characteristics

H3: Perceived need technology characteristics have positive impact on intention to adopt HDAP technology

UTAUT model

Unified Theory of Acceptance and Use of Technology (UTAUT), which was developed by [18] is a theoretical framework that emphasizes on individual-level elements, such as performance expectation, effort expectancy, social influence, enabling circumstances, and demographic factors, that affect behavioural intention and use behaviour. In order to address this, the Adapted Unified Theory of Acceptance and Use of Technology (AUT2) model was created to analyze farmer HDAP adoption. The UTAUT was modified in this study by include perceived risks in the theory.

Perceived benefits (PB)

Perceived benefits are the convictions people have about the advantages of engaging in a certain behaviour [19-20]. Benefits that are perceived have a significant impact on people's decisions to accept new technology. These are the arbitrary advantages that people think they will get by using a specific piece of technology. Perceived benefits have been found to be the main element that increases farmers' adoption of new technologies [21]. We can propose the following hypothesis as:

H4: Perceived Benefits have a positive impact on intention to adopt HDAP technology

Perceived risk (PR)

Perceived risk is, in fact, a key topic in the study of consumer behaviour and innovation uptake. The term "perceived risk" describes a consumer's subjective belief or impression of the uncertainty and possible unfavorable consequences connected to a certain purchase or choice [22-23]. Precision agriculture methods may not be widely adopted in agriculture due to farmers' attitudes towards the industry and their perceptions of risk [24]. However, users' perceptions of risk and levels of trust may influence their behavioural intention when it comes to agri-technology, a complicated example [15]. There are always risks associated with agriculture because of the weather, the state of the market, and other variables. Farmers could be risk-averse and hesitant to embrace new technology that might upset their customs and endanger their means of subsistence [25]. From the above discussion we propose the following hypothesis as:

H5: Perceived Risk has a positive impact on intention to adopt HDAP technology

Social influence (SI)

The extent to which individuals perceive the opinions or beliefs of important people in their social circles regarding the use of a particular technology is called as social influence. A farm's operational development is somewhat influenced by the social environment, including friends and family [26]. Furthermore, it has been found that a farmer's experiences with new technology now have a major impact on how they utilize them in the future [27]. The discussion allows us to formulate the following hypothesis as:

H6: Social Influence have a positive impact on intention to adopt HDAP technology

Facilitating condition (FC)

The degree to which a person feels that the technological and organizational infrastructure is in place to assist and make it easier for them to utilize a certain system is known as the facilitating condition [18]. FC will therefore directly and favorably influence users' behavioral intention in reaction to agriculture. The concept of enabling circumstances encompasses all of the necessary operational prerequisites that enable the initial use of new technology. The supportive atmosphere affects both the adoption process and the way that it is used [28-29]. From the above discussion we can propose the following hypothesis as:

H7: Facilitating Conditions have a positive impact on use behavior of HDAP technology

Behavioral intention (BI)

H8: Behavioral intention has a positive impact on use behavior of HDAP technology

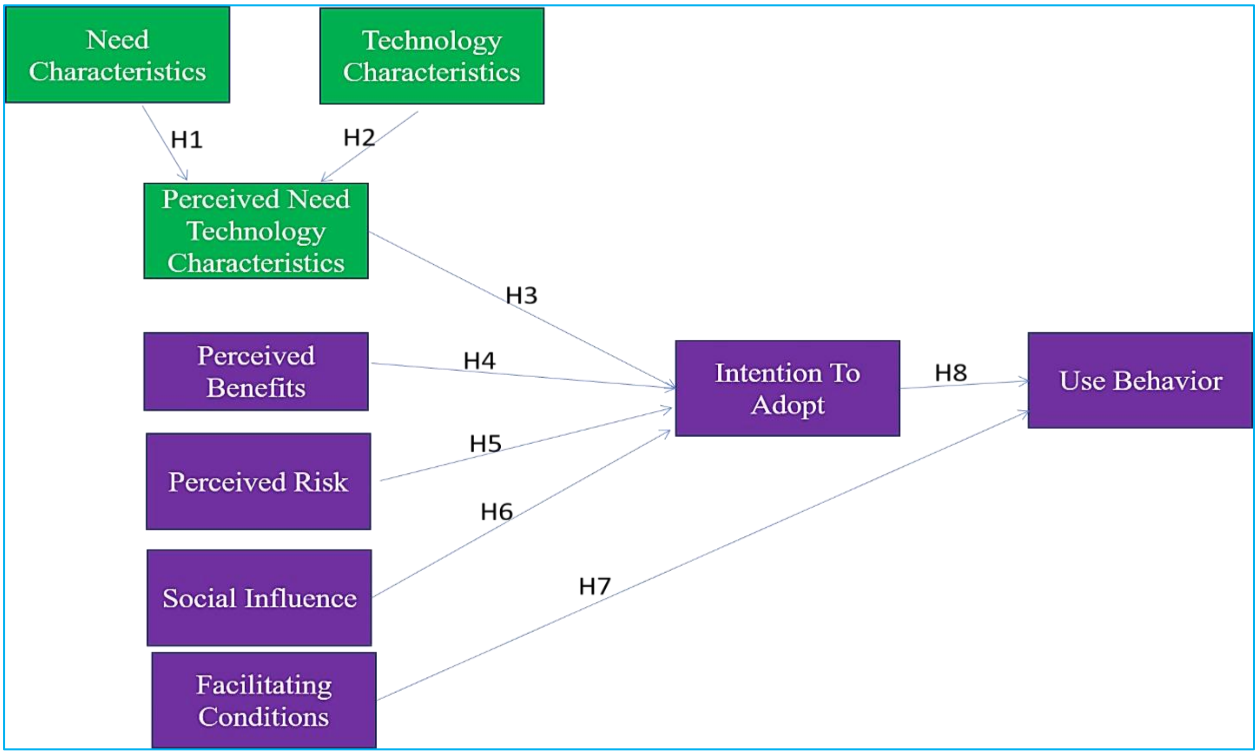


Fig 1 Proposed conceptual model

Variable measurement and data collection

The survey questions were derived from previous studies on the adoption of new technology [17], [30-31]. In order to collect data, a survey questionnaire was created in English and examined by few professors from Jamia Millia Islamia University in New Delhi, India, as well as specialists in the field of agriculture. The views of the experts ensured that the survey questions could be understood from the farmers' point of view on the deployment of high-density plantation technologies. Data were collected with the help of questionnaires and interview methods. The indicators in the survey were measured using a five-point Likert scale, representing from strongly agree = "5" to strongly disagree = "1" except for demographic variables. The survey questionnaire was tested by conducting a pilot study with the help of 45 farmers belonging to five different districts of Jammu and Kashmir.

Data analysis and results

Four steps were taken in the data analysis process for this research. In the first phase, descriptive statistics were done to understand the structure of the sample. A total of 353 out of 400 responses were received from five major apple-producing districts of Union Territory of Jammu & Kashmir (Baramulla, Budam, Ganderbal Shopian, and Anantnag), 47 responses were discarded due to missing data points Therefore, this research study examined 353 valid responses, 78% from male participants and 22% female participants, ensuring the results to be free from gender bias. In addition, most of the participants 38% were from the age group 45-55 years followed by 23% above 55 years 22% between 35-45 years 10% below 25-35 years and 7% below 25 years. In this survey the income of farmers ranged from (<less than 1 lac=1%, 1lac to 3 lac =9%, 3lac to 5lac=16%,5lac to 10 lac=40%, and above 10 lac=4%)

furthermore landholding of farmers lies between 1Hectare =12%, 1-2 hectares=27%, 2-4 hectares=32 and 4-24 hectares 29%). Data in (Table 1) summarizes demographic variables related to the collected and analyzed sample.

Table 1 Demographic profile

Characteristics	Category	Frequency	Percentage
Gender	Male	274	78
	Female	79	22
	Total	353	100
Age	Below 25	23	7
	25-35	37	10
	35-45	77	22
	45-55	133	38
	Above 55	83	23
	Total	353	100
District	Baramulla	115	33
	Budgam	53	15
	Shopian	81	23
	Ganderbal	25	7
	Anantnag	79	22
	Total	353	100
Income	Less than 1,00,000	5	1
	1,00,000 – 3 00,000	31	9
	3,00,000 – 5,00,000	56	16
	5 00,000 - 10, 00,000	140	40
	10, 00,000 or above	121	34
	Total	353	100
Land Holding	Marginal (up to 1 Hectare/8 Kanals)	42	12
	Small (1-2 hectare/ 8- 16 Kanals)	96	27
	Medium (2-4 hectare/ 16-24 Kanals)	109	32
	Large (4 and above/ 24 Kanals and above	103	29
	Total	353	100

Reliability and validity analysis

The validity and reliability of the constructs were evaluated in the second round of data analysis. The statistical software programs SPSS 26.0 and AMOS 21.0 were utilized to analyze suggestions for the assessment of reliability and validity components. All retained items were also subjected to tests for construct reliability and validity. Both composite reliability (CR) and average variance extracted (AVE) were considered as suggested by [32]. As seen in (Table 2), the CR values for all constructs were noticed to be above 0.70 (33).The largest CR value was recorded for social influence while the lowest value was for perceived benefit. As for the AVE values, all constructs have an acceptable value of AVE higher than 0.50 as suggested by [34]. The highest value of AVE was for social influence while the lowest value was found in the case of perceived benefits.

Table 2 Reliability and validity statistics

	CR	AVE	MSV	MaxR(H)	SI	FC	NC	PR	PNTC	UB	PB	TC	BI
SI	0.946	0.855	0.149	0.955	0.925								
FC	0.944	0.808	0.245	0.957	0.116	0.899							
NC	0.942	0.803	0.106	0.958	0.146	0.178	0.896						
PR	0.945	0.812	0.002	0.966	0.020	0.028	-0.026	0.901					
PNTC	0.940	0.796	0.149	0.948	0.386	0.233	0.255	-0.010	0.892				
UB	0.926	0.758	0.401	0.927	0.251	0.495	0.322	0.018	0.302	0.871			
PB	0.920	0.743	0.018	0.950	0.108	-0.135	-0.012	0.048	0.055	-0.020	0.862		
TC	0.894	0.678	0.017	0.902	0.035	0.096	-0.034	-0.038	0.130	0.110	-0.080	0.824	
BI	0.908	0.767	0.401	0.910	0.177	0.439	0.325	0.017	0.278	0.633	-0.010	0.126	0.876

Note: "CR=Composite Reliability; AVE= Average variance extracted; MSV=Maximum Shared Variance"; MaxR(H)= Maximum reliability

Table 3 Results of measurement model

Fit indices	Cut off point	Model Fit (Measurement model)	Result
CMIN/DF	≤3.000	1.332	Accepted
GFI	≥0.90	0.914	Accepted
AGFI	≥0.80	0.893	Accepted
NFI	≥0.90	0.949	Accepted
CFI	≥0.90	0.987	Accepted
RMSEA	≤0.08	0.031	Accepted

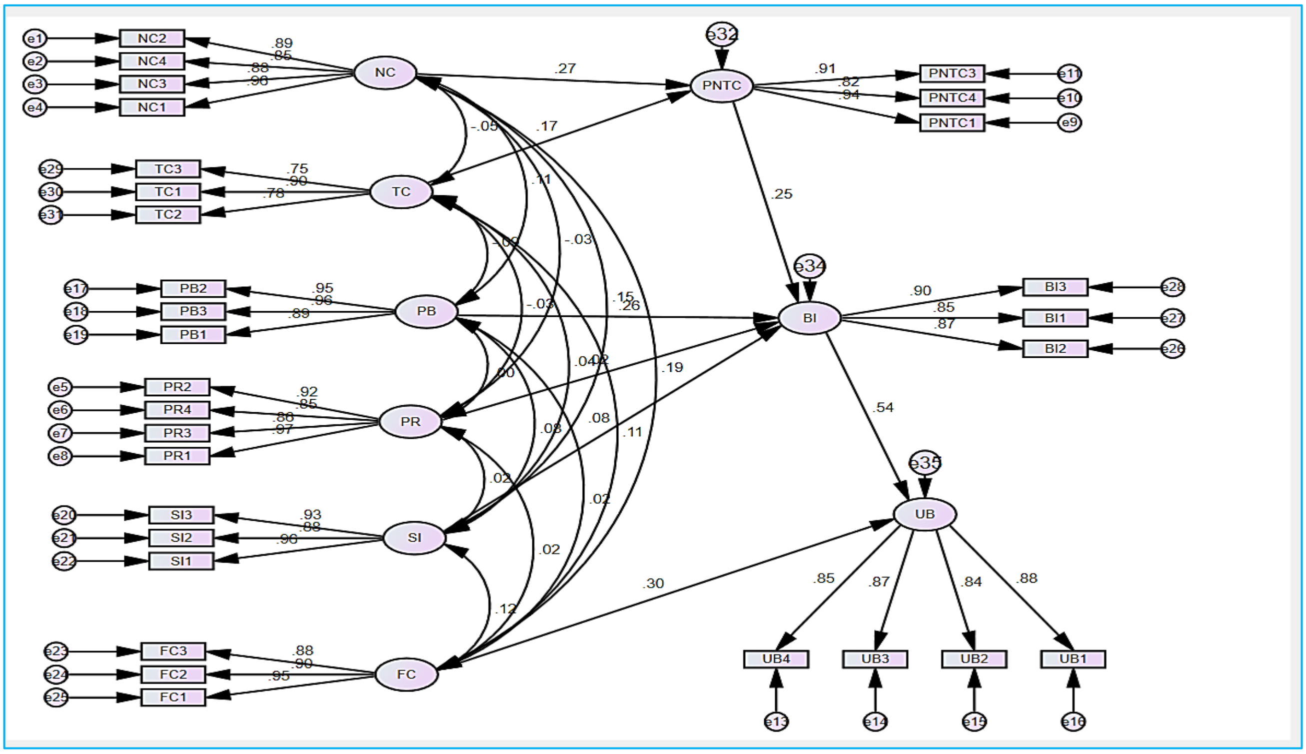
Measurement model

In the third step, confirmatory factor analyses, were evaluated to make sure there was a suitable level of model fitness along with construct validity and reliability. Then, the main research hypotheses were tested at the second stage (structural model). As seen in (Table 2), a number of the fit indices of the measurement model were found to be within their acceptable level (GFI: Goodness-of-Fit Index=.916; AGFI: Adjusted Goodness-of-Fit Index=.935; CFI: Comparative Fit Index=.984; CMIN/DF: Normed Chi-Square= 1.392; NFI: Normed-Fit Index=.945; and RMSEA: Root Mean Square Error of Approximation=.033). Therefore, the model has adequate level of model fitness as all fit indices [18], [29].

Structural model

To prevent any issues related to the common method bias, Harman's single-factor test (1976) has to be used before moving ahead with the structural model analysis. Consequently, SPSS 26 was used to retrieve nine latent constructs together with their unremoved items for Harman's single-factor test. This value was less than the recommended one (< 0.50) [34-35]. Therefore, it seems that there was no problem regarding the issue of common method bias. To ensure that multicollinearity problem does not exist between main dependent and independent constructs, variance inflation factors (VIF) were tested and all values extracted in this respect were noticed within their recommended level (< 10).

In the last stage, the structural model of SEM was tested to verify the conceptual model and its associated hypotheses. Similar to the measurement model, all fit indices of the structural model were observed to be within their acceptable levels as follows: GFI=0.900; AGFI=0.881; NFI=0.940; CFI=0.975; and RMSEA=0.039 [34]. As seen in (Fig 2), the conceptual model was also able to predict a large portion of variance on farmers adoption of High-density Plantation Technologies with R2 value of 0.63. This, in turn, supports the predictive validity of the current study model.



PNTC=Perceived Need Technology Characteristics, TC=Technology Characteristics, NC= Need Characteristics, FC= Facilitating Conditions, SI= Social Influence, PB= Perceived Benefits, INT=Intention to Use, UB=Use Behavior

Fig 2 Structure model

RESULTS AND DISCUSSION

The main causal paths were tested using path coefficient analyses as seen in (Table 4). The main factors of PNTC namely NC (C. R= 4.886 P < 0.001), TC (C. R= 2.937, P < 0.05), PNTC (C. R= 4.646 P < 0.001) were found to have a significant impact on farmers intention to adopt HDAP technologies. And for UTAUT mode constructs namely FC (CR=6.248 P<0.001) PB (CR=4.773 P<0.001), and BI (C. R= 10.203 P < 0.001), were found to have a significant impact on the farmers intention and use behavior of HDAP technologies. However, PR (CR =0.391 P>0.05) and SI (C.R = 1.44 P>0.05) and was not proved to have any statistical significance with farmers intention to adopt HDAP technologies. Therefore, except for H5 and H6, all other research hypotheses (H1, H2, H3, H4, and H8) were supported.

Table 4 Regression weights: (Group number 1 - Default model)

Hypothesized Path			Estimate	S.E.	C.R.	P
PNTC	<---	NC	0.289	0.059	4.886	***
PNTC	<---	TC	0.227	0.077	2.937	0.003
BI	<---	PR	0.019	0.048	0.391	0.696
BI	<---	SI	0.067	0.047	1.44	0.15
BI	<---	PB	0.308	0.064	4.773	***
BI	<---	PNTC	0.232	0.05	4.646	***
UB	<---	BI	0.574	0.056	10.203	***
UB	<---	FC	0.349	0.056	6.248	***

Note: ***=0.001

This study endeavors to determine the key factors that influence farmers intention to adopt HDAP technologies in agricultural sectors. One striking finding of this study is that farmer's need characteristics (NC) and technology characteristics (TC) were observed to have a significant positive impact on perceived need for technology characteristics (PNTC). These results are consistent with the findings of [13]. These development and improvement of high-density apple technologies, aligning them more closely with farmers needs and expectations. Furthermore, perceived need for technology characteristics positively impacts farmers' intention to HDAP technologies the results are similar to previous research works of [13] specific technology characteristics can contribute to a positive attitude and intention to adopt HDAP technologies among farmers, fostering the advancement of agriculture practices.

Furthermore, the study demonstrated that facilitating conditions has a positive impact on user behaviors to adopt HDAP technology which is consistent with previous studies done by [15], [36]. It was also studied that perceived benefit has a significant impact on intention to adopt new technology which was evident in earlier studies of [32-33], [37]. This study also demonstrates that perceived risk has not significant influence on farmers' intention to HDAP technologies. This result is consistent with the findings of [13], [38]. It implies that farmers do consider perceived risks as significant barriers or concerns when deciding whether to adopt these technologies. Perceived risk in this context might include concerns about the financial investment, uncertainties about technology performance, potential for crop failure, or other factors that farmers might view as risky. Additionally social influence has no significant impacts farmers' intention to HDAP technologies. This result is consistent to previous research [39-40]. Further intention to use technology is positively associated with use behavior. It can be concluded that the farmer's intention will have a substantial favorable impact on how people use technology, thus confirming H9. These findings are in line with the findings reported in past studies [41].

CONCLUSION

The HDAP has immense potential to enhance food security, environmental preservation, and agricultural productivity. Although HDAP technology is widely used in other cropping systems, it is not widely accepted in Jammu & Kashmir. HDAP adoption in Jammu and Kashmir has been studied from a socioeconomic perspective in the past. Other factors affecting technology adoption have been overlooked. This study developed and tested a hybrid model that combined the perceived need for technology characteristics (PNTC) with adopted unified theory of acceptance and use of technology (AUTAUT). HDAP adoption can be predicted more accurately with this model by identifying the factors that will encourage or hinder farmers from adopting it. Farmers' perceptions of their own needs and how well HDAP technology characteristics align with these also had a significant impact on their intention to adopt HDAP. Therefore, throughout the HDAP technology innovation process, providers and regulators must take into account the relationship between technological features and farmers' demands. To accomplish efficient coproduction of HDAP technologies, end users and other interested stakeholders must be contacted early enough in the invention process to ensure that HDAP technologies meet with end-user expectations. It is also recommended that factors like cost, subsidy, bank credit and extension contacts can be added as new factors in extended technology acceptance models to understand and expand the technology adoption in farming community of India.

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