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RESEARCH NOTE

Technical Efficiency Analysis of Kiwi Growers: Evidence from Arunachal Pradesh in Eastern Himalaya

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ABSTRACT

Based on primary inputs collected from 241 kiwi cultivating households from Arunachal Pradesh, present paper examines the technical efficiency of kiwi growers. Stochastic Frontier Analysis depicts that the average level of technical efficiency of kiwi growers in Arunachal Pradesh is 53 per cent indicating an ample scope for improvement in it. Factors such as farming experience, access to government support and years of involvement in kiwi cultivation were found to be significantly increasing the technical efficiency of kiwi growers. Further, locational variation in technical efficiency of the kiwi growers was found. Based on the findings of the study, enhancing the coverage of government support services for kiwi farmers appears to be as an significant policy solution for efficient kiwi cultivation.

Keywords: Technical efficiency, Kiwi, Arunachal Pradesh, stochastic frontier analysis

JEL codes: D24, F14, I32, Q18, Q12

I

INTRODUCTION

With growing population pressure and presence of large scale hunger and malnourished people worldwide, ending hunger and achieving food security became very crucial for sustainable economic growth. Realizing the severity of the problem, achieving food security has been set as one of the broad targets of Sustainable Development Goals (SDGs). To be food secured, maintaining adequate availability of food grains is essential. In India, incidence of poverty is wide spread and despite agriculture is the main source of livelihood for large majority, a substantial section of its masses are not food secured. Thus, increase in food grain production is necessary for both achieving food security and reducing poverty. While enhancement of agricultural output is possible primarily through increase in area under cultivation and/or intensive utilization of available farm land, supply of land is inelastic in nature. In fact, agricultural land in India has been increasingly shifted for non-farm activities making it less available for farming. There is also decline in the size of agricultural holdings which has many adverse impacts on agricultural production. Therefore, agricultural output is to be increased mainly through improvement in efficiency of farm to meet the growing demand. Thus, efficiency analysis of important crops assumed importance in recent times.

The development of horticulture is one of the important strategic initiatives to secure the food as well as nutritional security for the countries (Achterbosch et al., 2014; Singh et al., 2015; Chadha, 2015 and Jha et al., 2019). Kiwi (Actinidia

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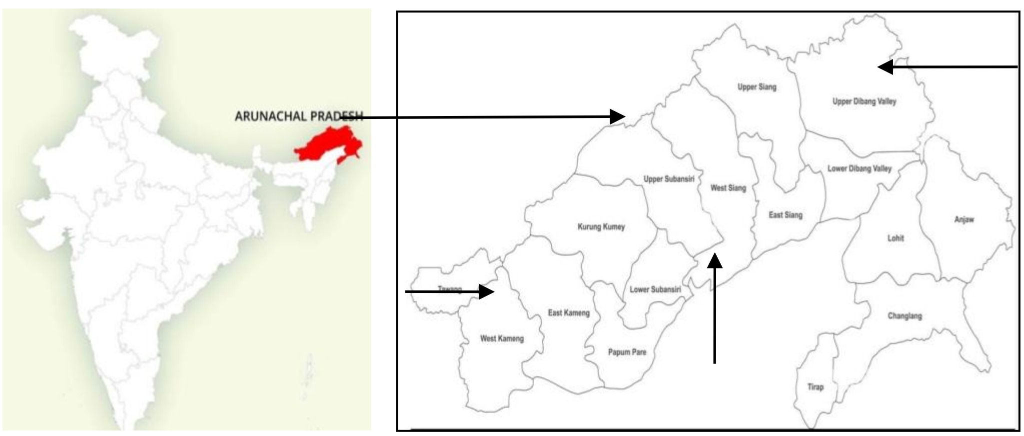
chinensis) is highly nutritious fruit. It is recommended for many health issues such as digestive, skin, heart, hair, eye, cardiovascular, blood clotting, depression, anemia, cancer and diabetes etc. It contains various kinds of vitamins and anti-oxidants and rich in vitamin C (Huang et al., 2004; Pandey and Tripathi, 2014; Guroo et al., 2017 and Xue et al., 2017). Due to its nutritional and health benefits, the demand for kiwi is increasing in recent times, especially in European and Asian countries (Laiopoulou and Haralabidis, 2002; Kalt, 2005; Bhist et al., 2012; Bano and Scrimgeour, 2012; Cruzat, 2014 and Tyagi et al., 2015). Indian market is also identified as the strongest emerging market for kiwi (Zespri, 2018). Apart from various health benefits, kiwi cultivation is a good source of livelihood. Chances of crops failure in case of kiwi is lower compared to other crops. Kiwi does not need sophisticated packaging and it is also easily transportable from one place to another without fruit damage (Pandey and Joshi, 1997). Such advantages make the cultivation of kiwi appealing and beneficial for rural farmers.

Kiwi is a temperate fruit initially originated in China but commercialized in New Zealand (Jindal and Sharma, 2016). Arunachal Pradesh is one of kiwi cultivating states of India along with other states like Jammu and Kashmir, Himachal Pradesh, Sikkim, Nagaland and Mizoram (Bhist et al., 2012; Government of India, 2019). In fact, Arunachal Pradesh is the largest growers of kiwi in India in terms of area under cultivation (Government of India, 2025). Within the state, its position is fifth among the fruit crops cultivated (Government of India, 2025). Like any other crops such as cotton, rice, groundnut, potato and so on as evident from Shanmugam (2003), Rao et al. (2003), Shanmugam and Venkataramani (2006) Bhende and Kalirajan (2007), Bhatt and Bhat (2014) and Bordoloi and Lama (2022), Guha and Mandal (2021); presence of inefficiency in production of kiwi is quite possible. However, while studies by Pandey and Joshi, (1997); Jindal and Sharma, (2016) and Mani et al., (2018) have covered kiwi cultivation in Arunachal Pradesh, technical efficiency of kiwi growers has remained unexplored. This makes the technical efficiency analysis of kiwi cultivation in Arunachal Pradesh quite relevant. Hence, present paper attempts to fill this research gap by examining the technical efficiency of kiwi growers of Arunachal Pradesh and its determinants. Being the first attempt to examine the technical efficiency of kiwi in general and in Arunachal Pradesh in particular is the novelty of this study. Further, as exploitation of the potential of the existing technology is a major way for raising agricultural output (Mandal and Maity 2022), technical efficiency analysis of kiwi cultivation assumes significant policy implications. It will contribute to better understanding about the level of productive efficiency of kiwi growers and to identify the factors affecting it. Such micro level understanding will facilitate the policy makers to take adequate action for improving productive efficiency of kiwi growers apart from adding to the literature on technical efficiency of horticulture crops.

II

DATA SOURCE AND SAMPLING DESIGN

The study has been carried out utilizing farm level data collected from three non-contagious districts of Arunachal (Government of India, 2011). However, for the statistical background of the study, secondary data has been collected from various sources such as Ministry of Agriculture and Farmer Welfare, Government of India (2025); Arunachal Pradesh Horticulture Avenue for self-employment, Government of Arunachal Pradesh (2019). Data has also been collected from the Department of Horticulture and Department of Economics & Statistics of the Government of Arunachal Pradesh and from various government and non-government sources.



Source: https://www.freeworldmaps.net/asia/india/arunachalpradesh/ ; https://www.alamy.com/arunachal-pradesh-districts-map-with-name-labels-white-background-image424626569.html?imageid=55E8748F-1E82-4367-A5AE-55820DF8DA78&p=860624&pn=1&searchId=8af0d5bfa359a3ac202498855b6e4305&searchtype=0

FIGURE 1. MAP OF ARUNACHAL PRADESH

2.1 The Econometric Model

Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) were widely used non-parametric approach and parametric approach respectively for measuring the technical inefficiency among the producers across the different production setup as evident from available literature. Although both the approaches have own pros and cons, a major drawback of DEA approach was that it does not account for random shocks. It also fails to differentiate between the effects of noise and technical inefficiencies, attributing the whole deviation from the frontier to inefficiencies (Mandal and Maity, 2022). Whereas, SFA as proposed by Aigner *et al.* (1977) and Meeusen and Broeck (1977), included error term (e) composed of v_i and

u_i. The v_i represents random errors like measurement error, specification error and random shocks that were outside the control of the producer and assumed to be normally distributed, i.e., v_i ~ iid N (0, σ_v^2). The error component $u_i$represents inefficiency component of the farmers that arise due to the management and other problems that were under the control of the farmers and considered to follow one-sided distribution, i.e., u_i~ iid N^+(μ_i, σ_u^2) and it is non-negative.Thus, despite some limitations, SFA was usually preferred over DEA as the presence of random shock that were outside the control of producers and measurement error that accounts for inefficiency may affect the production process simultaneously. Moreover, in case of agriculture economics, SFA has been used widely (Mandal and Maity, 2022), SFA approach has adopted for the present analysis. In case of cross sectional analysis, both Cobb-Douglas and Translog forms are used under SFA. Considering the flexibility in the use of variables (Battese, 1998; Green, 2010), Translog form of stochastic frontier model was proposed to be used but owing to small sample size, Cobb-Douglas form of stochastic frontier model has been employed. Following the SFA model used by Islam et al., (2016); Ameachi et al., (2014); Jayasinghe and Toyada, (2004), basic stochastic frontier model was defined as follows:

Considering a Cobb-Douglas type production function and following Battese and Coelli (1995), the SFA model is outlined as below:

$$y_i = f(x_i, \beta)\exp(v_i)\exp(-u_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, $y_i =$ output of i[th]farm, x_i is (1xk) input vector, β is (kx1) vector of parameters, v_i is random term and distributed normally such that$v_i \sim iidN(0, \sigma_v^2)$ and u_i is one sided non-negative random variable associated with technical inefficiency in production and independently distributed such that u_i~ iid N^+ (μ_i, σ_u^2). u_i is obtained by truncation (at zero) of the normal distribution.

According to Battese and Coelli (1995) inefficiencies are assumed to be a function of a set of explanatory variables related to inefficient units and can be expressed as:

$$u_i = z_i\delta + \epsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, δ is a (mx1) vector of unknown parameters, z_i is a (1xm) vector of explanatory variables associated with technical inefficiencies of production unit and ϵ_i is defined by the truncation of the normal distribution with mean '0' and variance 'σ_u^2' such that . $\epsilon_i \geq -z_i\delta$. These assumptions are consistent with u_i being non-negative truncation of the N ($z_i\delta, \sigma_u^2$) distribution.

Thus, technical inefficiency of i[th] production unit is given by

$$TE_i = \exp(-u_i) = \exp\,(z_i\delta - \epsilon_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

TABLE 1. DESCRIPTIONS OF EXPLANATORY VARIABLES USED IN REGRESSION ANALYSIS

Variable	Description	Empirical Impact		Expected impact
		Positive	Negative	
Input variables				
Land	Total kiwi cultivated area (ha)	Debebe et al., (2015); Bhatt and Bhat (2014); Shanmugam (2003); Rao et al. (2003);		+
Family Labour	Number of family labour (mandays)	Debebe et al (2015)	Idumah & Okunmadewa (2013)	+/-
Hired Labour	Number of hired labour (mandays)	Idumah & Okunmadewa (2013); Shanmugam (2003)		+
Sapling	Number of saplings planted	Tegenie (2014); Bordoloi and Lama (2022);		+
Manure	Amount of manure applied (kg)	Tiruneh & Geta (2016); Torkashvand et al. (2016); Bordoloi and Lama (2022);		+
Pesticide	Amount of pesticide applied (litre)			+/-
Inefficiency determinants				
Age	Age of the head of the households (years).	Yegon et al. (2015); Rao et al. (2003);	Amaechi et al. (2014); Debebe et al. (2015); Tiruneh & Geta (2016); Tiruneh et al. (2017); Dube et al. (2018); Zannou et al. (2018); Coelli and Battese (1996);	+/-
Farming experience	Years of farmer spent on crop cultivation		Abbeam et al. (2012); Idumah & Okunmadewa (2013); Ameachi et al. (2014); Bhatt and Bhat (2014);	-
Educational attainment	Years of schooling of the head of the households		Abbeam et al., (2012); Amaechi et al. (2014); Debebe et al. (2015); Yegon et al. (2015); Tiruneh & Geta (2016); Dube et al. (2018); Zannou et al. (2018); Coelli and Battese (1996); Bhende and Kalirajan (2007); Rao et al.(2003);	-
Household size	Total number of household members	Abbeam et al. (2012); Dube et al. (2018)	Debebe et al., (2015); Bhatt and Bhat, (2014);	+/-
Access to agricultural training and extension services	Takes 1 if the farmers attended training/ availed extension services, 0 otherwise		Debebe et al. (2015); Bhattacharyya & Mandal (2016); Dube et al. (2018)	-
Access to credit	Takes 1 if the farmer accessed credit, 0 otherwise.		Amaechi et al. (2014); Bhattacharyya & Mandal (2016); Zannou et al. (2018).	-
Government Support	Takes 1 if the farmer received governments support, 0 otherwise.			-
Distance to the nearest market	Distance from the farm to nearest market (kilometres)		Lawal et al. (2014)	-
Sex of the head of the household	Takes 1 if the head of the household is female, 0 otherwise.	Tiruneh & Geta (2016)	Yegon et al. (2015); Zannou et al. (2018)	+/-
Membership of cooperative association	Takes 1 if the farmer is member of any farmers association, 0 otherwise		Idumah & Okunmadewa (2013); Amaechi et al. (2014); Debebe et al. (2015); Bhatt and Bhat (2014);	-
Income from sources other than agriculture	Takes 1 if farmer has an alternative source of income, 0 otherwise		Yegon et al. (2015)	-
Landholdings size	Area allocated for kiwi cultivation (ha)	Debebe et al. (2015)	Yegon et al. (2015); Tiruneh & Geta (2016); Bhatt and Bhat (2014);	+/-
Years of involvement in kiwi cultivation	Years involved in kiwi cultivation (from fruiting stage)			-
Dibang Valley	1 for Dibang Valley, 0 otherwise			+/-
Lower Subansiri	1 for Lower Subansiri, 0 otherwise. reference location is West Kameng			+/-

2.2 Model Specification

The explanatory variables used in the SFA analysis are identified based on available literature as well as theoretical justification. Table 1 presents the definition, description and anticipated impact of the explanatory variables.

Following Aigner et al. (1977), corresponding to equation (1), the empirical SFA model is specified as:

$$LnY_i = \beta_0 + \beta_1 Ln\mathit{Land}_i + \beta_2 Ln\mathit{Familylabour}_i + \beta_3 Ln\mathit{Hiredlabour}_i + \beta_4 Ln\mathit{Sapling}_i + \beta_5 Ln\mathit{Manure}_i + \beta_6 Ln\mathit{Pesticide}_i + v_i - u_i \ldots\ldots (4)$$

All the sample farmers have not used all the input variables specified in the model due to which the explanatory variables such as *Familylabour, Hiredlabour, Manure* and *Pesticide* have zero values for some observations. In order to eliminate the problem of zero value of explanatory variables, following Battese (1998) and as used by Bhattacharya & Mandal (2016), four dummy variables have created corresponding to *Familylabour, Hiredlabour, Manure and Pesticide* as follows:

Where,

$D_{Familylabour}$ =1, if Familylabour =0 (Family labour is not used)

=0, if Familylabour>0 (Family labour is used)

$D_{Hiredlabour}$ =1, if Hiredlabour =0 (Hired labour is not used)

=0, if Hiredlabour>0 (Hired labour is used)

D_{Manure} =1, if Manure = 0 (Manure is not used)

=0, if Manure >0 (Manure is used)

$D_{Pesticide}$=1, if Pesticide =0 (Pesticide is not applied)

=0, if Pesticide >0 (Pesticide is applied)

Now, the variables *Familylabour, Hiredlabour, Manure* and *Pesticide* were replaced respectively by $\mathit{Familylabour}^*$, $\mathit{Hiredlabour}^*$, Manure^* and $\mathit{Pesticide}^*$.

Where,

$\mathit{Familylabour}^*$=Max (Familylabour, $D_{Familylabour}$)

$\mathit{Hiredlabour}^*$= Max (Hiredlabour, $D_{Hiredlabour}$)

Manure^* = Max (Manure, D_{Manure})

$\mathit{Pesticide}^*$= Max (Pesticide, $D_{Pesticide}$)

Thus, the final SFA model to be estimated is:

$$\text{Ln}Y_i = \beta_0 + \beta_1 \text{Ln}\textit{Land}_i + \beta_2 \text{Ln}\textit{Familylabour}_i^* + \beta_3 \text{Ln}\textit{Hiredlabour}_i^* + \beta_4 \text{Ln}\textit{Sapling}_i + \beta_5 \text{Ln}\textit{Manure}_i^* + \beta_6 \text{Ln}\textit{Pesticide}_i^* + \beta_7 D_{\textit{Familylabour}} + \beta_8 D_{\textit{Hiredlabour}} + \beta_9 D_{\textit{Manure}} + \beta_{10} D_{\textit{Pesticide}} + v_i - u_i \quad ......(5)$$

Corresponding to equation (3), the empirical inefficiency model to be estimated as follows:-

$$u_i = \delta_0 + \delta_1 \textit{Age}_i + \delta_2 \textit{Farmingexperience}_i + \delta_3 \textit{HH\_education}_i + \delta_4 \textit{HH\_size}_i + \delta_5 \textit{Access trainig\&extensionservice}_i + \delta_6 \textit{Access\_credit}_i + \delta_7 \textit{Govt\_support}_i + \delta_8 \textit{Distance\_market}_i + \delta_9 \textit{HH\_sex}_i + \delta_{10} \textit{Membership\_association}_i + \delta_{11} \textit{Income\_othersources}_i + \delta_{12} \textit{Landholdingsize}_i + \delta_{13} \textit{Duration\_kiwicultivation}_i + \delta_{14} \textit{D\_Valley}_i + \delta_{15} \textit{L\_Subansiri}_i + w_i \quad ......(6)$$

Finally, assuming truncated normal distribution as considered by (Mandal and Maity, 2022), one stage maximum likelihood method has been used for the estimation of SFA model as it is an improvement over two step method (Kalirajan and Shand, 2001). The simultaneous estimation of both production function and inefficiency model enable consistent estimation of the technical inefficiency terms even if they are correlated with the inputs and incorporates the non-positive nature of the inefficiency values (Bhattacharyya and Mandal, 2016).

III

RESULTS AND DISCUSSION

3.1 Kiwi in Arunachal Pradesh

Kiwi cultivation in Arunachal Pradesh was first started in 1990s as a trial plantation at Regional Apple Nursery, Dirang in West Kameng district (Government of Arunachal Pradesh, 2019). Later on, cultivation of kiwi was extended to other districts of the state. Over the years, the area under kiwi cultivation, along with its production, has increased. The area under kiwi cultivation was 1000 hectare in 2007-08 but increased to 2430 hectare by 2024-25 with some fluctuation (Figure 2). There was also positive growth of kiwi production during 2007-08 to 2024-25 with CAGR 27.41 per cent, which was greater than the growth of the area under the crop (05.06%).

Arunachal Pradesh still has a significant share in area and production of kiwi in the country, although it has declined during the reference period. Table 2 depicts that the share of the state in area under kiwi in the country was 88.24 per cent in 2011-12 and it came down to 56.64 per cent in 2024-25. In terms of production, the state accounts 80.36 per cent of total kiwi production of the country in 2011-12 and it declined to 38.46 per cent in 2024-25. Thus, despite the declined share of Arunachal Pradesh in both area and production, still the state account more than half of the kiwi cultivated area of the country although it is slightly lesser in case of production.

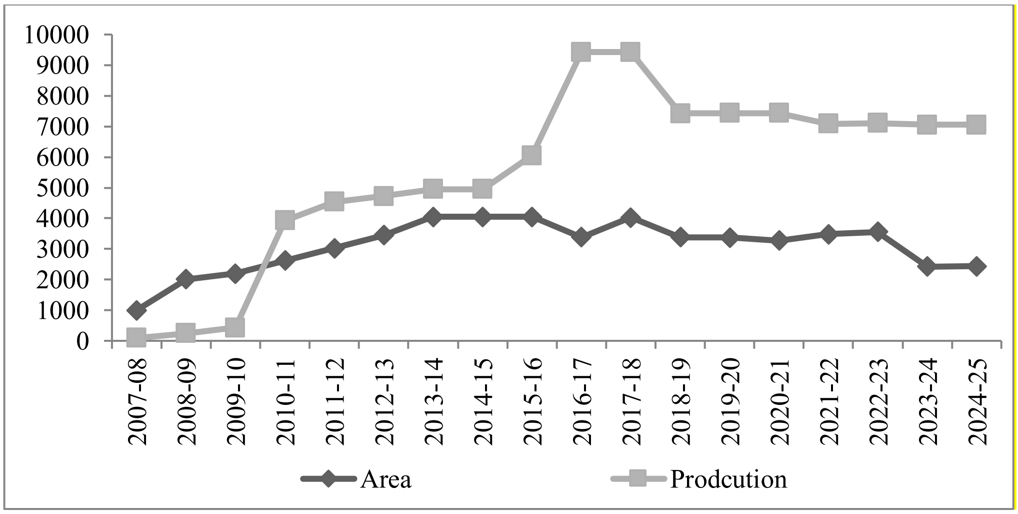


FIGURE 2. GROWTH OF AREA (IN HA) AND PRODUCTION (IN MT) OF KIWI IN ARUNACHAL PRADESH

SOURCE: COMPUTED FROM SECONDARY DATA COLLECTED FROM DEPARTMENT OF HORTICULTURE, 2019, DEPARTMENT OF ECONOMICS & STATISTICS (GoAP), 2022 AND DEPARTMENT OF AGRICULTURE AND FARMERS WELFARE, 2025.

TABLE 2. STATE'S SHARE IN TOTAL AREA AND PRODUCTION OF KIWI OF THE COUNTRY (IN PER CENT)

Year	Area	Production
2011-12	88.24	80.36
2012-13	87.34	69.01
2013-14	85.81	49.21
2014-15	86.39	56.47
2015-16	79.72	56.81
2016-17	84.48	78.57
2017-18	89.39	78.57
2018-19	67.71	57.13
2019-20	67.40	53.09
2020-21	65.44	46.46
2021-22	68.34	44.75
2022-23	65.44	39.28
2023-24	55.76	40.68
2024-25	56.64	38.46

SOURCE: COMPUTED FROM NHB DATA, HORTICULTURE STATISTICS AT A GLANCE (GoI), 2015 & 2019, AGRICULTURE STATISTICS AT A GLANCE, 2021 AND DATA FROM MINISTRY OF AGRICULTURE AND FARMER WELFARE, GOI, 2025

The average size of kiwi cultivated area of the sample kiwi growers was 0.86 hectares as a whole (Table 3). Across locations, size of kiwi cultivated area was largest in Dibang Valley (1.1 hectare) and smallest in West Kameng (0.68 hectare) and it was 0.8 hectares in Lower Subansiri. The average years of plantation of kiwi by sample farmers was 6.85 years and it was 9.23 years, 7.73 years and 3.75 years in West Kameng, Lower Subansiri and Dibang valley respectively. It was found that sample farmers, on an average, allotted 48.59 per cent of total cropped area for kiwi cultivation. Location-wise, the area allotted to kiwi was 60.66 per cent, 43.74 per cent and 41.27 per cent in Dibang Valley, West Kameng and Lower Subansiri, respectively.

TABLE 3. SIZE AND PERCENTAGE SHARE OF KIWI CULTIVATED AREA AND AGE OF KIWI IN SAMPLE LOCATIONS

District	Size of kiwi cultivated area (in ha)	Kiwi cultivated area as % of total cropped area	Plantation years of kiwi
West Kameng	00.68	43.74	09.23
Dibang Valley	01.10	60.66	03.75
Lower Subansiri	00.80	41.27	07.73
Overall	00.86	48.59	06.85

IV

EMPIRICAL RESULTS

The regression analysis was based on 123 observations as rest of the sample kiwi growers were not on production stage. The descriptive statistics of explanatory variables is presented in Table 4. Kiwi growers allotted an average area of 00.98 hectare per sample farmer[2]. Sample farmers have produced kiwi by using an average of 271 man days of family labour and around 447 man days of hired labour yearly. On an average, kiwi farmers have planted 281 saplings and applied about 2617 kg of manure in a year. The yearly average use of pesticide in kiwi orchard was 0.28 litres. The average age of head of household was 48.32 years with a farming experience of 17.24 years and they have attended 9.32 years of schooling. Average household size was five members and the distance from the sample area to the market place was about 10 km. Average years of involvement in kiwi production was 08.07 years. Out of the total sample growers, about 35 per cent, 16 per cent and 49 per cent of the samples were from West Kameng, Dibang Valley and Lower Subansiri respectively. Around 60 per cent farmers in the study area were found to have attended training programmes and availed extension services. About nine per cent farmers have accessed credit and about 50 per cent have received government support for kiwi cultivation. More than half of the farmers were male and about 41 per cent of sample farmers were found to be associated with the farming or marketing associations. Apart from farming, about 55 per cent of the sample farmers have alternative sources of income.

[2]Inregression analysis area has been taken in Bigha (equal to 0.13387 hectare)

TABLE 4. SUMMARY STATISTICS OF EXPLANATORY VARIABLES

Non- Categorical Variable	Mean	Std. Dev.	Min.	Max.
Land	00.98	00.72	00.01	02.83
Family Labour	270.57	160.75	00.00	832.00
Hired Labour	446.59	1071.92	00.00	8800.00
Sapling	280.96	324.41	10.00	1500.00
Manure	2616.67	4294.41	00.00	31500.00
Pesticide	00.28	01.50	00.00	12.00
Age	48.32	12.07	27.00	90.00
Farming experience	17.24	10.58	03.00	50.00
Educational attainment	09.32	05.30	00.00	15.00
Household size	05.13	01.76	02.00	10.00
Distance to the nearest market	09.55	06.99	00.00	32.00
Landholdings size of farmer	03.86	02.84	00.04	11.18
Years of involvement in kiwi cultivation	08.07	07.49	01.00	19.00
Categorical Variables			Per cent	
West Kameng			34.96	
Dibang Valley			16.26	
Lower Subansiri			48.78	
Access to agricultural training and extension services			60.16	
Access to credit			08.94	
Government Support			49.59	
Sex of the head of the household			17.89	
Membership of any cooperative association			41.46	
Income from sources other than agriculture			56.91	

Source: Field Survey, 2021-22

Before proceeding to the estimation of SFA model, Likelihood Ratio Test was carried out to examine the presence of inefficiency among the kiwi growers. The LR test was significant (Table 5) implying presence of inefficiency among the kiwi growers and, thus, the SFA was found to be appropriate in present context.

TABLE 5. LIKELIHOOD RATIO TEST

LR $chi^2(12)$	80.40***
Prob>chi^2	00.00

*Note: *** indicates significant at 1%*

TABLE 6. RESULT OF THE STOCHASTIC FRONTIER ANALYSIS (TRUNCATED-NORMAL DISTRIBUTION)

Input variables	Number of Obs.		123
	Wald chi^2 (6)		66.86***
	Prob>F		0.000
	Log likelihood		-177.56
	Coeff.	S. E	P value
Land	00.85***	15.54	0.000
Family Labour	-00.03	00.20	0.885
Hired Labour	00.17*	00.09	0.052
Sapling	00.66***	00.13	0.000
Manure	-00.07	00.10	0.445
Pesticide	-00.37	00.43	0.389
*Familylabour**	-00.47	01.19	0.690
*Hiredlabour**	00.73	00.57	0.200
*Manure**	-00.59	00.73	0.416
*Pesticide**	-01.21**	00.61	0.049
Constant	04.68***	01.68	0.005
Inefficiency Variables			
Age	00.02	00.02	0.319
Farming experience	-00.04**	00.02	0.041
Educational attainment	-00.01	00.04	0.820
Household size	-00.06	00.10	0.556
Access to agricultural training and extension services	-00.25	00.49	0.607
Access to credit	01.13	00.87	0.201
Government Support	-01.61**	00.65	0.014
Distance to the nearest market	00.02	00.03	0.628
Gender of the head of the household	00.53	00.49	0.274
Membership of any cooperative association	-00.56	00.49	0.251
Income from sources other than agriculture	00.29	00.43	0.490
Landholdings size of farmer	00.12	00.10	0.245
Years of involvement in kiwi cultivation	-00.56***	00.13	0.000
Dibang Valley *(D_Valley)*	02.18***	00.76	0.005
Lower Subansiri*(L_Subansiri)*	00.03	00.54	0.958
Constant	03.95***	01.32	0.003
Lnsigma^2	00.28	00.20	0.169
ilgtgamma	-00.46	00.84	0.585
Sigma^2	01.32	00.27	-
gamma	00.39	00.20	-
Sigma_u^2	00.51	00.35	-
Sigma_v^2	00.81	00.17	-

*Note: ***, ** and * indicates significant at 1%, 5% and 10% respectively*

The estimated SFA model (Table 6) showed that coefficient of input variables like land, hired labour and number of saplings planted were positively significant, implying positive marginal productivity which is natural. The estimated coefficient of dummy variable for pesticide was significant indicating that the factor had some impacts on the production, and hence, omission of this variable with zero value would have led to incorrect model specification.

As per the results of technical inefficiency model, the coefficient of farming experience was turned out to be negatively significant at five per cent. This implies that farming experience makes kiwi growers more efficient. Abbeam et al. (2012); Idumah and Okunmadewa (2013) and Ameachi et al. (2014) also find similar impact of farming experience on the efficiency of the farmers. The coefficient of government support was negative and significant at five per cent. This means, support from the government in the forms of subsidized or freely provided saplings, boundary material, tools and equipments etc enable the farmers to cultivate kiwi more efficiently. This may be because kiwi cultivation requires continuous maintenance and substantial initial investment and under such circumstances, access to government support may allow the kiwi farmers to invest adequately resulting in improvement in their efficiency. Mandal and Maity (2022) also found that same impact of government support on efficiency of farmers in Assam, adjacent to Arunachal Pradesh, in case of field crops. The coefficient of the variable years of involvement in kiwi cultivation was negatively significant at one per cent. This implies that the farmers that engaged in kiwi cultivation for longer duration was more efficient, which is quite obvious, because longer involvement in the activity improves the knowledge of the farmers in different aspects related to enhancing output. The coefficient of district dummy D_Valley was positive and significant at one per cent implying that farmers from Dibang Valley district were less efficient compared to the farmers of the reference district West Kameng. Thus, efficiency of kiwi farmers was not same across sample districts.

Gamma value 0.39 revealed that about 39 per cent of output variation was due the technical inefficiency of the farmers, and rest 61 per cent was due to the random shocks.

4.1 Efficiency Estimates

Table 7 showed that the predicted mean technical efficiency of sample farmers was 53 per cent with a variation from 0.60 per cent to 95 per cent. This depict that with the existing level of input mix, there is a scope for rising kiwi output on an average by 47 per cent. Thus, there is substantial scope for enhancing kiwi output through improvements in the technical inefficiency of sample farmers. Further, 43 per cent of sample kiwi growers were found to be operating with technical efficiency below 50 per cent. There was also a large scale variation in mean technical efficiency scores across sample districts. Across the districts, predicted mean technical efficiency of West Kameng was found to be highest (68 per cent) followed by Lower Subansiri (49.60 per cent) and Dibang Valley (32.90 per cent) respectively.

TABLE 7. DISTRIBUTION OF FARMERS BY EFFICIENCY SCORES

Efficiency score¯	Overall		West Kameng		Dibang Valley		Lower Subansiri	
	Freq.	Per cent	Freq.	Per cent	Freq.	Per cent	Freq.	Per cent
0-20	35	28.46	07	16.28	12	60.00	16	26.67
20-30	05	04.07	00	00.00	00	00.00	05	08.33
30-40	06	04.88	02	04.65	00	00.00	04	06.67
40-50	07	05.69	01	02.33	02	10.00	04	06.67
50-60	08	06.50	03	06.98	00	00.00	05	08.33
60-70	09	07.32	03	06.98	02	10.00	04	06.67
70-80	10	08.13	03	06.98	02	10.00	05	08.33
80-90	26	21.14	14	32.56	01	05.00	11	18.33
90-100	17	13.82	10	23.26	01	05.00	06	10.00
Total	123	100	43	100	20	100	60	100
Minimum	00.60		03.00		00.60		01.80	
Maximum	95.00		94.80		93.30		95.00	
Average	53.00		68.00		32.90		49.60	

A district-wise comparison of distribution of sample farmers by technical efficiency scores is presented in Figure 3. It was found that kiwi farmers in West Kameng district were the most efficient in terms of median value, and the variation in efficiency scores in the district was relatively lesser. In terms of median value of technical efficiency scores, farmers in Lower Subansiri were placed in the second position followed by those in the Dibang Valley. However, the variation in technical efficiency scores among the kiwi growers was greater in Lower Subansiri as compared to Dibang valley.

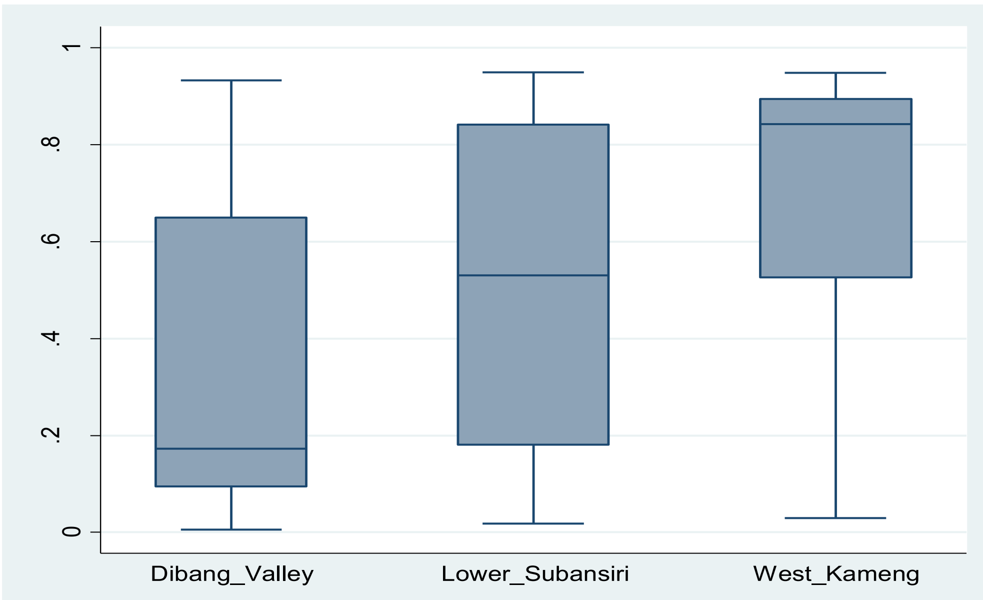


FIGURE 3. DISTRICT-WISE VARIATION IN EFFICIENCY SCORES OF SAMPLE KIWI GROWERS

IV

CONCLUSION AND POLICY IMPLICATION

Examining the technical efficiency of kiwi growers in Arunachal Pradesh, the average level of technical efficiency was found to be 53 per cent with a variation from 0.60 per cent to 95 per cent across households. Furthermore, a good proportion of sample kiwi cultivators were having technical efficiency level below the 50 per cent. This indicates a great scope to raise kiwi output in the study area by improving the productive efficiency of the farmers engaged in its cultivation. This will make kiwi more attractive as a source of livelihood in the study area and contributes to the availability of food grains. The estimated results of SFA depicted farming experience, access to government support and duration of farmers involved in kiwi cultivation significantly improved the technical efficiency of kiwi growers.

Thus, it is clear from the study that there is a great scope to enhance output of kiwi by realizing the maximum potential output through improving productive efficiency of the farmers. Based on the findings from regression analysis, it can be suggested for wider coverage of kiwi growers under the ambit of government support system. During the field survey, it was reported that government of Arunachal Pradesh had facilitated subsidized credit under the Atmanirbhar scheme for the development of horticulture. Enhancing coverage of kiwi growers under such schemes can be an effective policy option to boost kiwi production in the study area and making it more attractive source of livelihood as around half of the sample kiwi growers are yet to get government support.

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