ECONOMIC CHALLENGES AND DEFICIENCIES IN APPLICATION OF SCIENTIFIC FARMING PRACTICES: BARRIERS TO SUSTAINABLE TEA CULTIVATION FOR SMALL GROWERS

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Abstract—
The Tea Board of India classifies 'small growers' as cultivators with farm size under 25 Acres in contrast to 'large plantations' which uses land of 25 Acres or more. Despite their smaller farm sizes, Indian small tea growers collectively produced 710 million kg of tea leaves in the 2022 season, surpassing the 656 million kg output from large plantations. This study aims to assess the significance of tea cultivation as an occupational choice for small grower households and to assess the level of adoption of scientific farming practices among small tea growers. Findings from primary data reveal that most small growers rely heavily on tea cultivation, with little or no diversification into other crops due to land scarcity and economic constraints. This study also found that small tea growers had deficiencies in understanding and application of seven critical scientific farming practices. Results of statistical tests underscore the significant influence of both landholding size and occupational status on adoption of selected scientific farming practices (soil testing, mulching, maintenance pruning of bushes, and use of organic pesticides) among small tea growers. These results highlight the need for targeted intervention strategies to improve adoption of sustainable farming practices by small growers and their economic stability.

Keywords— *"Monoculture"," Soil testing", "Economic vulnerability", "Sustainable faming", "Scientific farming practices*"

I. INTRODUCTION

Our minds often conjure images of vast green waves of tea bushes in a serene hillside estate, when we think of 'tea plantations'. Such plantations are typically owned by large corporations which also set up factories to process raw tea leaves into consumable tea. But there exist another significant group of tea leaf producers which are often overlooked. The Tea Board of India classifies 'Small Growers' as tea cultivators with farm size under 25 Acres in contrast to 'large plantations' which uses land of 25 Acres or more.

The most significant aspect of tea leaf production by small growers is that the volume of leaf produced in small farms surpasses the volume of tea leaves produced in large plantations. As per the production data provided by Tea Board of India, small growers produced 710 million Kg tea leaves in 2022 season while large plantations produced 656 million Kg tea leaves. This feat can be attributed to small tea growers of two states - West Bengal and Tamil Nadu. In both state, small growers produced much more than the large plantations. In other states, large plantations still produce more tea leaves than the small growers (Tea Board of India, 2023).

Small tea plantations began to appear in the early 1960s, primarily in the southern states of Tamil Nadu & Kerala. In West Bengal, the emergence of small growers started in the early 1990s. This shift was particularly noticeable in the districts of North Bengal. The shift towards tea cultivation among small farmers was further driven by the escalating economic vulnerability of the small farmers due to erosion of state support from the farm sector in the Neo-liberal policy context and concomitant monetization of smallholder economy. The small farmers who adopted tea farming have mostly replaced paddy cultivation & pineapple cultivation (Bissonnette & De Koninck, 2017; Mallick 2022).

Tea Board of India started collecting and publishing data on small tea growers from 1998. According to TBI data, at the national level, there was 86517 small growers in 1998. In 2022, the number of small growers jumped to 229526.

In West Bengal, number of small growers jumped to 36559 in 2022 from 809 in 1998. There are three main tea producing regions in West Bengal - Darjeeling Hills, Dooars, and Terai. Production figures provided by TBI shows that contribution of small growers of Terai region (135 M. Kg) is much larger than contribution Dooars (109 M. Kg) and Darjeeling hills (0.44 M. Kg).

With this background, this paper set the following objectives for the study:

1) To assess the economic challenges faced by small tea growers and the significance of tea cultivation as an occupational choice to them.
2) To assess the level of adoption of scientific farming practices among small tea growers.
3) To analyse the influence of landholding size and occupational status on the adoption of scientific farming practices.

II. METHODOLOGY

For the current study, 200 small growers were selected from Terai tea producing region of West Bengal. Two blocks (Kharibari and Phansidewa) from Terai region selected as the study area because small tea growers are concentrated in these two blocks in large numbers. Two Gram Panchayats (Buragunj, Kharibari) from Kharibari block, and two Gram Panchayats (Ghoshpukur, Bidhannagar –I) of Phansidewa block were selected then. From each Gram Panchayat, 50 small growers were identified. Thus 200 small growers were selected from different villages of two blocks as respondents. Small growers were interviewed using an interview schedule. The responses were coded and analysed using spreadsheet applications.

III. FINDINGS AND DISCUSSION

A. Profile of the Households

Majority (67.0 %) of the sample households were Scheduled Caste households. Proportion of Scheduled Tribe households (22.0 %) were much less. The combined large proportion SC & ST communities (89%) means that the most tea growing households are from historically marginalized groups. Muslim & Christian households comprised only 7.5 percent & 2.0 percent of the sample households. Rest of the households belonged to other castes.

Academic qualification data revealed that all the household heads were literate. However, there were eighteen (9.0 %) household heads who did not study beyond Class V. It was also found that 22 household heads (11.0 %) had graduate or post-graduate qualification.

B. Land used for tea cultivation vis-a-vis other crops

Table 1 show the data regarding that land used by small growers for tea cultivation. A significant majority of small growers operate on land smaller than 3 Bigha[1]. Out of 200 surveyed small growers, 133 growers (66.5%) fall into the "less than 3 Bigha" category. Another 43 small growers (21.5%) cultivate tea on land between 3 and 6 Bigha, while only 24 small growers (12%) possess landholdings larger than 6 Bigha.

According to the Tea Board of India's Baseline Survey Report (March 2022), the average size of land used for tea cultivation by small growers in West Bengal is just 0.662 hectares, which is equivalent to 1.64 acres or approximately 2.61 Bigha. The field data aligns closely with the statistic mentioned in Tea Board of India's report. These figures highlight that the sample households engaged in small tea cultivation were dominated by households with very limited land resources.

[1] Bigha is a unit of land area measurement traditionally used in rural Bengal. 1 Bigha = 0.625 Acre = 0.253 Hectare (approx.).

TABLE 1: OWNERSHIP OF LAND USED EXCLUSIVELY FOR TEA CULTIVATION

Land area used for tea cultivation	Number of small growers
Less than 3 Bigha	133 (66.5)
3 to 6 Bigha	43 (21.5)
More than 6 Bigha	24 (12.0)
Total	**200 (100.0)**

(Figures in parentheses are percentages. 1 Bigha = 0.253 Hectare.)

Data in Table 2 shows data regarding land used by small growers for cultivating crops other than tea. Out of the 200 small growers, 92 growers (46%) have no land available for cultivating any crops other than tea while 94 growers (47%) possess less than 3 Bigha of land for other crops. Only a small fraction, 11 growers (5.5%), have 3 to 6 Bigha, and just 3 growers (1.5%) have more than 6 Bigha allocated for non-tea cultivation.

TABLE 2: OWNERSHIP OF LAND USED FOR CULTIVATING OTHER CROPS

Land area used for other crops	Number of small growers
No Land for cultivating other crops	92 (46)
Less than 3 Bigha	94 (47)
3 to 6 Bigha	11 (5.5)
More than 6 Bigha	3 (1.5)
Total	200 (100.0)

(Figures in parentheses are percentages. 1 Bigha = 0.253 Hectare.)

Overall, data shown in Table 1 and Table 2 indicates that a substantial portion of small growers are highly dependent on tea cultivation, with limited or no land allocated for cultivating other crops. The small landholdings reflect land scarcity or economic constraints among small growers, restricting their ability to expand or diversify agricultural practices.

C. Tea cultivation as primary & secondary occupation

As shown in Figure-I, tea cultivation is the primary occupation for 155 (77.5 %) small grower households out of 200 surveyed households. Rest of small growers (22.5 %) indicated that tea cultivation itself was not primary source of income for them, rather tea cultivation was secondary occupation. Among such small growers, 'cultivating other crops' was primary occupations for 9.5 percent families. This suggests that 9.5 percent small grower families supplement their income or diversify their farming practices by growing tea while growing other crops like paddy & vegetable is the key occupation for them.

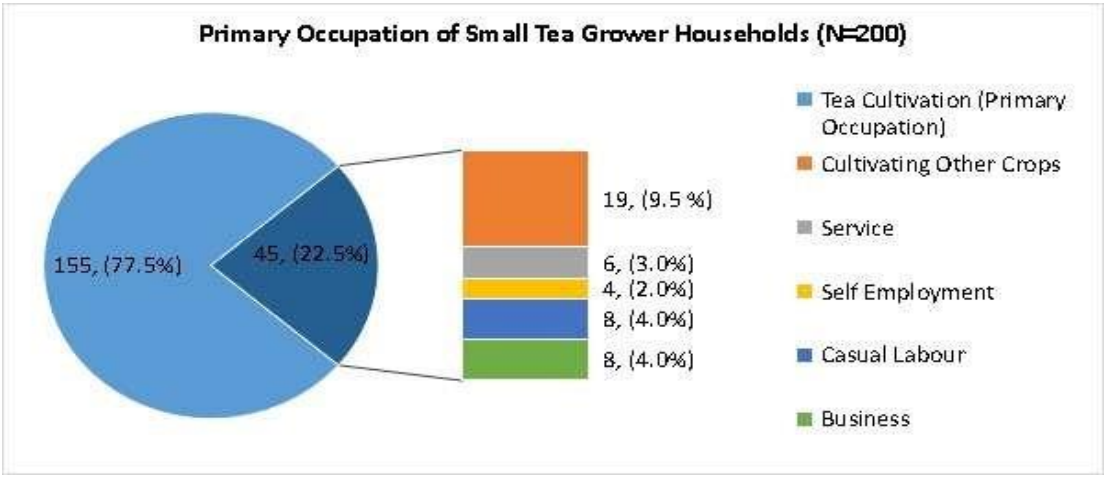

Figure 1: Primary occupation of small grower households

Few other sectors collectively account for a small portion of the primary occupations small grower households. These sectors include service (3.0 %), self-employment (2.0 %), working as casual labour (4.0 %) and business (4.0 %).

Presence of a variety of secondary occupations were also found among the small growers in the study area. Out of 200 surveyed households, 21 households (10.5%) indicated their sole dependence on tea cultivation as primary source of income. They reported that they had no secondary occupation. Farming was the most common secondary occupation, practiced by 89 households (44.5%). This suggests that despite engaging in tea cultivation, many families continue to rely on farming other crops including rice, vegetables, and pineapples.

Ten (10) households (5%) were found to be engaged in small businesses as a strategy of income diversification. A smaller number of households are involved in various forms of manual or casual labour. These included stone grinding (3.5%), working in a tea-processing factory (3.5%), and vehicle driving (2.5%).

Thus, data on occupation shows that farming remains a critical livelihood, either as a primary or secondary occupation. Most households pursue secondary occupations, highlighting the need to supplement income from tea cultivation, which

may not be sufficient on its own. Only a small percentage are involved in factory work or vehicle driving, indicating limited access to industrial employment or skill-based jobs. The presence of a notable number of households engaged in casual labour and stone grinding also points to economic vulnerability and limited livelihood options.

D. Critical deficits in application of scientific farming practices

Through individual interviews, the researchers found that many small tea growers had deficiencies in understanding and application of seven (7) critical scientific farming practices. These practices are:

1) Monoculture and poly-culture cropping
2) Organic farming methods
3) Soil testing
4) Interpretation of soil testing results
5) Fertilizer application
6) Use of pesticides
7) Mulching
8) Pruning of bushes

These deficiencies are briefly discussed in following sub-sections.

E. Mon-culture and poly-culture cropping:

Small tea growers of the study area typically rely on mono-culture cropping, which leads to soil degradation over time. They were aware that persistent mono-cropping may degrade soil quality. One small tea grower lamented, "*Bujhte parchi matir khoti hochhe… kintu onno kono uppay dekhte pachhi na*" ("We understand that the soil is deteriorating.… but we don't see any alternative"). Some of them have seen experimental efforts of polyculture. They shared experiences about unsuccessful efforts with poly-culture crops like bay leaf, beetle nut, and black pepper. But in absence of any available inter-cropping models and guidance, growers remain trapped in a cycle that threatens sustainability.

F. Organic farming methods:

Small growers expressed frustration over lack of government initiatives in terms of training or capacity-building programs regarding organic farming practice. One small grower expressed frustration and stated, *"Korte hobe, korte hobe…. Bolche. Kivabe korbo… seta bolche na*" ("They keep saying that organic farming …. 'Should be adopted, should be adopted'… but they don't tell how to do"). The absence of firsthand training or demonstrations has left growers ill-equipped to transition to eco-friendly methods.

G. Soil testing

Many small growers were indifferent to testing of soil. Proper soil testing and understanding of pH levels are essential to determine the right type and amount of fertilizer needed for optimal plant growth. Tea plants grow well in slightly acidic soil with a pH between 4.5 and 5.5. The soil's pH should be tested to ensure it is suitable for tea cultivation. The soil is also analysed for its nutrient content, including nitrogen, phosphorus, potassium, and other essential minerals. Based on the results, soil amendments should be added to correct any deficiencies. If the soil is too acidic, lime may be added to raise the pH to the desired level for tea cultivation. Organic matter, such as vermi-compost or cow-dung, is also added to the soil to improve its fertility and structure. This enriches the soil with essential nutrients and promotes healthy plant growth. Only 19.0 percent of small growers tested soil at least once before or after they started tea cultivation. Rest 81.0 % of small growers don't test soil, even though there were at least four laboratories within the sub-division of Siliguri where the villages under the study were located. Out of four (4) laboratory, three (3) were supported by Government and one (1) is managed by a private firm. However, 32.0 percent of small growers reported that they applied lime to decrease acidity. In other words, at least 13.0 percent of the small growers assumed that applying lime in the soil would help without knowing whether the soil of their lands was acidic or alkaline.

H. Interpretation of soil testing results

Almost half (47.3 per cent) of the 38 small growers who tested soil at least once, reported that they face difficulties in interpreting the results of soil testing as the result sheets are technical and do not provide elaborate interpretation or recommendation. They complained that there was very little support from the laboratories in interpreting the result of the results. This lack of ability to understand soil testing results hinders ability to make informed decisions about fertilizer application.

I. Fertilizer application

It was found that all small growers (100%) regularly apply cow-dung as the regarded it as a low-cost and locally available fertilizer. Only 3.0 percent small growers used other bio-fertilizers apart from cow-dung. All small growers (100%) use chemical fertilizers. Using fertilizers without a clear understanding of the soil's requirements, can lead to sub-optimal plant growth and productivity. However, small growers reported that they have not faced any problem on plant growth till date which could make them suspicious about incorrect use of fertilizer.

J. Use of pesticide

The data on use of pesticides indicated that chemical pesticide spray is widely used. It was found that 98 percent of growers incorporated it into their routine. Such wide use indicates a strong preference for conventional pest and nutrient

management methods. On the other hand, organic pesticide spray is used by only 36 percent of growers. The causes of moderate adoption rate of organic foliar spray were less availability in local shops and lesser awareness about organic alternatives among the small growers. However, unscientific use of pesticides may result in resistance of pests to the pesticides. small growers reported two trends which may be associated with resistance of pests to the pesticides. These are:

- Red spider mite attacks are becoming more common during dry seasons. Red spiders attack the upper surface of the mature leaves and lay eggs on the leaves. Infested leaves become reddish and results in reduced photosynthetic activity of leaves, subsequently leaves wilt and defoliation occurs due to increased transpiration and moisture loss.
- Instances of looper moths (caterpillars of *Geometridae* family) attacks are rising during rainy seasons. small growers also reported that new types of looper moths are now being seen which they did not see earlier. The infestation began with eating young leaves of tea. Loopers leave pin holes on leaves, and sometimes causing severe damage to the entire bushes.

K. Mulching

Mulching refers to applying a layer of materials (like wood chips, straw, leaves, or gravel) around the base of the tea plants to suppress weed growth, retain soil moisture, and regulate soil temperature. Mulching was adopted by 31.5 percent of growers. It was found that low adoption rate of mulching was due to lesser awareness among the small growers.

L. Maintenance pruning of tea bushes

Another significant issue identified was the cycle of pruning for proper maintenance of tea bushes. It was found that 22.0 percent of the small growers had not pruned their tea plants even once in the last five years, despite a common recommendation of experts & expert growers that pruning should be done every four years. These growers believed that pruning after four years was unnecessary and wasteful, as the bush takes time to recover after pruning. As a result, they pruned their plants once every six to seven years. However, prolonging the pruning interval is not beneficial for the long-term health of the tea plants and lead to decreased productivity on long term.

M. Statistical significance of adoption of scientific practices across land size

Table 3 shows the percentage of tea growers adopting four specific practices categorized by land size used for tea cultivation. The practices are *soil testing, mulching, organic pesticide use, and maintenance pruning.*

TABLE 3: TEA GROWERS ADOPTING SPECIFIC PRACTICES CATEGORIZED BY LAND AREA

Land used for tea cultivation	Do Soil Testing (%)	Practice Mulching (%)	Use Organic Pesticide (%)	Do Maintenance Pruning (%)
Less than 3 Bigha (N=133)	9.8	15.8	24.8	72.9
3 to 6 Bigha (N=43)	20.9	62.8	62.8	86.0
More than 6 Bigha (N=24)	66.7	62.5	50.0	91.7

(Source: Field data; values are percentages)

It can be seen that:

1) Soil testing increases with land size.
2) Mulching and organic pesticide use are adopted more by medium and large landholders than small ones.
3) Maintenance pruning is widely practiced across categories but increases steadily with land size.

To assess the influence of land area on the adoption of specific agricultural practices, Chi-Square Tests of Independence were conducted for four variables: *soil testing, mulching, organic pesticide use, and maintenance pruning.*
The results of Chi-Square Tests of Independence are presented in Table 4. The results suggest that 'landholding size under tea cultivation' is a significant predictor of adoption for three practices ($df = 2$, threshold value=13.82, $p < 0.001$) with larger growers showing higher adoption rates for *soil testing, mulching, organic pesticide use*. However, for maintenance pruning practice, the test result revealed a statistically significant association between landholding size and the adoption of maintenance pruning practices among small tea growers ($df = 2$, threshold value=9.21, $p < 0.01$).

TABLE 4: CHI-SQUARE RESULTS SUMMARY FOR LAND AREA

Practice	χ^2 Value	df	p-value	Inference
Soil testing	54.91	2	$p < 0.001$	Highly significant association
Mulching	52.73	2	$p < 0.001$	Highly significant association
Organic pesticide use	29.13	2	$p < 0.001$	Significant association
Maintenance pruning	13.59	2	$p < 0.01$	Significant association

(Note: df = 2, threshold value=13.82, p < 0.001, AND df = 2, threshold value=9.21, p < 0.01)

During interview with small growers, it was found that growers thought that soil testing, mulching materials, or using organic pesticide require upfront costs and time. But growers having very small size of land perceive that the benefits of improved practices are not enough to justify this effort or expense. Hence, they opt to continue traditional methods. These

are the reasons why larger growers have higher adoption rates than smaller growers. Growers having larger landholding place greater emphasis on long-term bush productivity and better yield management due to better resource availability.

N. Statistical significance of adoption of scientific practices across occupational status

Table 5 compares the percentage of small tea growers adopting various cultivation practices based on whether tea is their primary or secondary occupation. Soil testing, mulching, and organic pesticide use are more common among small growers for whom tea cultivation is a secondary occupation. Conversely, maintenance pruning is more widely practiced by growers for whom tea cultivation is a primary occupation.

TABLE 5: ADOPTION OF SPECIFIC PRACTICES BY OCCUPATIONAL STATUS IN TEA CULTIVATION

Occupational status of tea cultivation for the small grower	Do Soil Testing (%)	Practice Mulching (%)	Use Organic Pesticide (%)	Do Maintenance Pruning (%)
Primary Occupation (N=155)	12.9	23.2	29.0	84.5
Secondary Occupation (N=45)	40.0	60.0	60.0	55.6

(Source: Field data; values are percentages)

To assess the influence of occupational status on the adoption of specific agricultural practices, Chi-Square Tests of Independence were conducted for four practices. The results of Chi-Square Tests of Independence are presented in Table 6. The results of the Chi-Square Tests of Independence reveal statistically significant associations between growers' occupational status in tea cultivation (primary vs. secondary) and their adoption of key agricultural practices. Farmers engaged in tea cultivation as a secondary occupation exhibited notably higher adoption rates of soil testing, mulching, and organic pesticide use compared to those for whom it is a primary livelihood (df=1, threshold value= 10.828, $p < 0.001$).

TABLE 6: CHI-SQUARE RESULTS SUMMARY FOR OCCUPATIONAL STATUS

Practice	χ^2 Value	df	p-value	Inference
Soil testing	36.33	1	$p < 0.001$	Significant association
Mulching	29.13	1	$p < 0.001$	Significant association (Secondary occupation growers more active)
Organic pesticide use	23.97	1	$p < 0.001$	Significant association (Secondary occupation growers likely to use more)
Maintenance pruning	14.84	1	$p < 0.001$	Significant association (Primary occupation farmers prune more often)

(Note: df = 2, threshold value=13.82, $p < 0.001$)

However, maintenance pruning was more frequently practiced by primary occupation growers, also with a statistically significant association. Primary occupation growers place greater emphasis on long-term bush productivity since they are more dependent than secondary occupation growers on tea cultivation as a source of income.

IV. CONCLUSIONS

The findings of this study underscore the significant reliance of small grower households on tea cultivation as a primary source of income. However, tea cultivation as livelihood choice is constrained by land scarcity that hinder diversification. Many households engage in secondary occupations even though tea farming remains essential for them. This signals financial insufficiency of tea cultivation alone and the broader challenges of rural employment. Many growers also resort to casual labour or stone grinding works to sustain their households. The limited participation in industrial or skill-based jobs further highlights economic vulnerability of small tea growers.

The study identifies critical deficits in knowledge among small growers. The findings underscore the critical influence of both landholding size and occupational status on the adoption of scientific farming practices among small tea growers. Larger landholders demonstrated higher uptake of soil testing, mulching, and organic pesticide use while growers with tea cultivation as a secondary occupation outperformed their primary-occupation counterparts in adopting sustainable practices, perhaps due to diversified knowledge systems, alternative income security, or greater experimentation. These intersecting dimensions highlight the need for targeted intervention strategies that address the specific barriers faced by small tea growers, ensuring diffusion of scientific farming practices across all grower profiles.

Knowledge deficits can severely impact farming decisions, leading to inefficiencies, lower yields, and financial losses. Government and NGOs should focus on bridging these deficits through targeted training, awareness drive and access to expert advice. These are crucial for ensuring informed decision-making by small growers which, we expect, would lead to their economic stability and adoption of sustainable farming practices.

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