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Transformation of Agriculture Land into Tea Garden: Change in Biodiversity

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ABSTRACT

Any transformation or change in the ecosystem has got a rippling effect. It invites a reciprocal change in the landscape, life, and livelihood of hundreds and more hundreds for the visible and invisible life forms. Tea gardening in North Bengal, covering Hill area of Darjeeling, is an internationally recognized ecosystem and with a unique cultural identity. Due to persistent low and uncertain return from the traditional rice cultivation, the transformation of paddy fields into tea garden has been a recent trend for the Dooars part of West Bengal also. Elucidating the factors, impacts, and perceptions of farmers, mainly small and marginal, sixty respondents, who have been transformed themselves from a classical rice grower to tea garden growers, have been selected by systematic random sampling for the study. Age (X_1), education (X_2), family education (X_3) and ratio of peripheral plant (X_9) variables have been found to exert strong and determining contribution to this transformational process. The changes in the farmer's practices from intensive farming to perennial tea gardens invite some ecological benefits including enrichment of the biodiversity which proportionally influences the ecosystem.

Keywords: Biodiversity, Ecosystem change, Land use change, Tea garden, Transformation

INTRODUCTION

The transformation of an ecosystem has got a rippling effect on the millions of life processes, counts of biodiversity, microbial activity and the brunt of global warming and climate change. Indian agriculture has experienced some significant progressive changes previously, a lot of which have been sporadic to a couple of chosen crops or locales. Therefore, its general execution as far as feasible development has been somewhat humble (Gulati and Ganguly, 2010). The drastic transformation of farmlands into the perennial tea garden in North Bengal of West Bengal of India generates a cascading effect on both the biophysical and social ecology of North Bengal, where India ranks second in the world in production of tea (Madhumita and Singh 2020). However, this propensity has gone up with the gradual decline of income from agriculture, availability of labour for farming, increase of cost of input in agriculture and rising expectation for an occupation that will be away from agriculture. Every ecosystem over the trajectories of time and space has got an initial equilibrium and capable of generating ecological services to support different communities (flora, fauna and *Homo sapiens*) for their sustainable growth and existence.

The change of the Indian rural part has been driven by a few components including supply-side factors, for example, strategies to push development, better and productive utilization of assets like land and labour; presentation of innovation and expanded utilization of modern inputs like chemical fertilisers and expansion of irrigation infrastructure (Sharma, 2015). The agricultural performance has become less volatile during the decade of 2000 and has turned resilient, as observed from the year-to-year growth in the face of fluctuations in monsoons and its adverse impact on production systems (Kavery and Pandey 2016). Agricultural development is particularly significant for creating nation like India to address the food security as well as income, livelihood as well as economic growth of the nation.The drivers of agricultural transformation are multidimensional, interrelated, and change over time, but they can be organized into categories to provide a better opportunity

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for pragmatic diagnostics and decision making on national priorities. The effective agrarian transformation has concentrated on the farming household, giving chances to ranchers to procure a better income. For a few, that will mean raising farm productivity or shifting the mix of production to include higher-value crops and livestock (Boettiger *et al.*,).

The achievement of any Agricultural Transformation depends on how well a large number of smallholders and little and medium-sized farmers can benefit from outside intervention to change cultivating rehearses as fast and adequately as could reasonably be expected. Pal *et al.* (2019) revealed that in hilly areas, income from animal husbandry, marginal works and labouring, are positively correlated with diversity whereas more land holding, income from agriculture, possession of household assets, average family education and maximum family education are negatively correlated with diversity. In the Northern part of West Bengal, the transformation in agriculture mainly occurred within the farmers who have few or very fewer landholdings. Generally, low capital venture, great atmosphere condition, least dangers of crop disappointment, exceptional yield status, specialized help from surplus workers from huge tea gardens and a locally accessible market for green tea leaves pulled in a segment of the neighborhood and eager youth to construct little tea developing framework. Hence, there is immediate need to resolve the conflict and rebrand agriculture using a reformed and youth-inclusive policy framework (Tripathi *et al.,* 2019). Because, youth are for the most part instructed and jobless, anxious to snatch the open door unfurled by this new idea, and enticed by the possibility of cutting out their personalities through independent work in these little tea gardens. The associated and commonly synchronized relationship among and between these physical, natural and social echelons has been the main player for guiding a social change vis. a vis. a biological change too (Bera *et al.,* 2014).

Change of the structure and working of landscapes and biological systems by people is extensive. In earthbound frameworks, the scale thereof has prompted requires the substitution of the more normally perceived biomes with a lot of anthropogenic biomes, which spread more than 75 per cent of sans ice land and incorporate 90 percent of its net essential efficiency (Ellis and Ramankutty, 2008). Worldly changes in biodiversity as a result of scene change have ordinarily been exhibited by utilizing space for time substitutions, with correlations made among generally untransformed secured regions and coordinated changed zones (Chown, 2010). In our present study, we identified and decomposed the relationship among and between some exogenous variables to identifying the root cause behind the diversity change of the ecosystem which is led for the transformation of the conventional crop-based agricultural lands into a tea garden.

MATERIALS AND METHODS

A study has been carried out for sixty farmers who have transformed their farming practices towards Tea Garden of Falakata Block, Madarihat Block, and Alipurduar-1 block of newly formed Alipurduar District of West Bengal. The purposive, as well as simple random sampling techniques have been adopted for the present study. The district, Blocks, and Villages are purposively selected for the study. An exhaustive list of respondents has been prepared with the help of block officials for villages. From the prepared list, twenty respondents have been selected from each block for final data collection. Essential information has been collected through an appropriate questionnaire based on the objective of the study. Focused group discussion has been used for the collection of baseline data of the villages. Although the study focuses on the Alipurduar district, it is held that the results generated from this study are relevant to many nearby areas of Alipurduar district with a similar climate and socio-economic structures.

Appropriate operationalization and measurement of the variables have helped the researcher to land upon the accurate conclusion. Therefore, the selected variables for this study had been operationalized and measured in the following manner: (1) Independent variables and (2) Dependent Variables.

(1) Independent variables

- **Age (X_1):** It denotes the chronological age, years, and the months elapsed since the birth of the respondent. It was measured by counting the chronological age.
- **Education (X_2):** Education status of the respondents has been considered for the study and denoted by the real numbers (i.e. 1, 2, 3…etc.)
- **Family education (X_3):** The average family education status of the respondents has been

considered for the study and denoted by the real numbers (i.e. 1, 2, 3…etc.).

- **Cultivated land area (X_4):** Total cultivated lands (in terms of Bigha) (farmlands as well as tea garden lands) has been considered for the study.
- **Non-cultivated area (X_5):** The total area of the lands under homestead, barren and pond area (in terms of Bigha) has been considered for the study.
- **Mean change in land under cultivation (X_6):** The changing percentage of the area of conventional farmlands into an area of perennial tea garden lands has for the study.
- **Mean change in average garden size (X_7):** The changing percentage of the area of perennial tea garden size has been considered for the study.
- **Mean change in total income (X_8):** The changing percentage of Total Income has been considered for the study.
- **Ratio of peripheral plant (X_9):** The ratio of the peripheral plant situated in the perennial tea garden and peripheral plant situated in the earlier crop field has been considered for the study.
- **Ratio of pesticide use (X_{10}):** The ratio of the pesticide used in the perennial tea garden and the earlier crop field has been considered for the study.
- **Ratio of fertilizer use (X_{11}):** The ratio of the fertilizer used in the perennial tea garden and the earlier crop field has been considered for the study.
- **Garden age (X_{12}):** The chronological age of the garden from which year the farmer started tea cultivation in his or her farmlands has been considered for the study.

(2) Dependent variable

- **Mean change of diversity (Y):** The changing percentage of the diversity of the ecosystem has been considered for the study.

RESULTS AND DISCUSSION

The subjective information is measured utilizing explicit numerical methodology. Then four kinds of data analysis i.e. Co-efficient of correlation, multiple regression analysis, Stepwise regression analysis, and path analysis has been done to evaluate the information. The results of the evaluation are discussed as follows.

Table 1 presents the coefficient of correlation (r) between mean change of diversity (Y) and 12 Causal Variables (X_1-X_{12}). It has been found that the following variables have emerged as the significant predictors of mean change of diversity (Y), and these predictor variables are, education(X2), family education (X_3) and ratio of peripheral plant (X_9).

Education (X_2), has recorded a positive and significant correlation to imply that for the respondents

Table 1: Co-efficient of Correlation (r) between mean change of diversity (Y) and 12 Causal Variables (X_1-X_{12})

Causal Variables (X_1-X_{12})	Dependent Variable (Y)
Age (X_1)	-0.133
Education(X_2)	0.284*
Family education (X_3)	0.356**
Cultivated land area (X_4)	0.037
Non-cultivated area (X_5)	0.022
Mean change in land under cultivation (X_6)	0.004
Mean change in average garden size (X_7)	-0.145
Mean change in total income (X_8)	-0.138
Ratio of peripheral plant (X_9)	0.781**
Ratio of pesticides use (X_{10})	-0.072
Ratio of fertilizer use (X_{11})	-0.097
Garden age (X_{12})	-0.126

**Significant at 1% level of significance; *Significant at 5% level of significance.

Diversity Changes (Y_1) (Decade Wise Decline)

Decades → / Parameter ↓	1985-1995	% Change (+/-)	1996-2005	% Change (+/-)	2006-2018	% Change (+/-)
Tree						
Birds						
Animals						
Insects						
Any Other						

had higher education, as the result suggests, greater has been the impact on diversity. Family education (X_3), has recorded a positive and significant correlation to imply that for the respondents having higher family education, greater the mean change of diversity.

Alongside the challenge of environmental change, the loss of biodiversity is mankind's fundamental battleground for sustainability. Biodiversity is the establishment of solid biological systems and sustainable human development. It addresses all parts of our lives - from our security to our government assistance, from our social relations to our wellbeing. Mainstreaming biodiversity into education and learning is one of UNESCO's needs. Education carries supportability to advancement endeavors; it is the best approach to shape better approaches for seeing the world, new practices, and behaviour and makes biodiversity preservation conceivable. Education for Sustainable Development (ESD) is practiced to preserve biodiversity and test options for reconciling preservation (UNESCO, Natural Sciences, Biodiversity and Education, 2017)

In another case, it is evinced that the ratio of peripheral plant (X_9), has recorded a positive and also significant correlation to imply that for the respondents having higher Peripheral plants in their tea has got a dominant effect on plant diversity. Elimination hazard is higher for young and fast-evolving plant lineages and cannot be explained by correlations with simple biological traits. We find that the most defenseless plant species are in any case walking towards annihilation at a progressively quick pace yet, surprisingly, independently from anthropogenic effects (Davies *et al.,* 2011).

Table 2 presents the estimation of the cause-effect relationship between mean change of diversity (Y) and 12 causal variables (X_1-X_{12}). It has been found that the collectively 12 variables have explained 65.80 per cent of variance embedded with the consequent variable mean change of diversity (Y). The standard error of the estimate is 31.816.

Table 3 presents the stepwise regression analysis to imply that, which are the few variables out of the whole plethora of variables have been retained at the last step (11^{th}) to contribute substantially to the consequent variable that is mean change of diversity (Y). The variable ratio of peripheral plant (X_9) has been retained at step eleven and contributed 61.10 per cent to imply that the said variable is extremely important causal variable to interpret the reason and spectrum of the variance of the consequent variable, in its behavior and performance. The standard error of the estimate is 30.54105. So, ratio of peripheral plant (X_9) is the most important causal variable to interpret the variance embedded with the mean change of diversity (Y). Here, Ratio of peripheral

Table 3: Stepwise Regression Analysis: mean change of diversity (Y) Vs. 12 Causal Variables (X_1-X_{12})

Variable	Reg. coef. B	S.E. B	Beta	t value
Ratio of peripheral plant (X_9)	20.318	2.131	0.781	9.536

Table 2: Multiple Regression Analysis: mean change of diversity (Y) Vs. 12 Causal Variables (X_1-X_{12})

Variable	Reg. Coef. B	S.E. B	Beta	t Value
Age (X_1)	0.730	1.211	0.123	0.603
Education(X_2)	0.783	1.598	0.063	0.490
Family education (X_3)	2.676	2.683	0.111	0.997
Cultivated land area (X_4)	0.055	1.761	0.004	0.031
Non-cultivated area (X_5)	1.137	6.388	0.023	0.178
Mean change in land under cultivation (X_6)	0.153	0.164	0.104	0.930
Mean change in average garden size (X_7)	-0.094	0.129	-0.091	-0.726
Mean change in total income (X_8)	-0.052	0.134	-0.044	-0.387
Ratio of peripheral plant (X_9)	18.859	2.484	0.725	7.591
Ratio of pesticides use (X_{10})	-3.856	6.673	-0.057	-0.578
Ratio of fertilizer use (X_{11})	-2.160	23.091	-0.009	-0.094
Garden age (X_{12})	-3.282	3.276	-0.196	-1.002

Table 4: Path Analysis: Decomposition of Total Effect into Direct, Indirect and Residual Effect: mean change of diversity (Y) vs. exogenous variables (X_1-X_{12})

Variable	Total effect	Direct effect	Indirect effect	Highest indirect effect
Age (X1)	-0.133	0.128	-0.261	-0.177(X_{12})
Education(X2)	0.284	0.063	0.221	0.157(X_9)
Family education (X3)	0.356	0.110	0.246	0.207(X_9)
Cultivated land area (X4)	0.037	0.006	0.031	0.030 (X_9)
Non-cultivated area (X5)	0.022	0.021	0.001	0.019 (X_{12})
Mean change in land under cultivation (X6)	0.004	0.106	-0.102	-0.058 (X_7)
Mean change in average garden size (X7)	-0.145	-0.093	-0.052	-0.088 (X_9)
Mean change in total income (X8)	-0.138	-0.042	-0.096	-0.048 (X_7)
Ratio of peripheral plant (X9)	0.781	0.725	0.056	0.032 (X_3)
Ratio of pesticides use (X10)	-0.072	-0.058	0.058	0.024 (X_6)
Ratio of fertilizer use (X11)	-0.097	-0.009	-0.072	-0.085 (X_9)
Garden age (X12)	-0.126	-0.2	-0.088	0.113 (X_1)

plant (X_9) has got the highest contribution that means the diversity of the ecosystem changed due to the transformation of the conventional agricultural lands to tea garden is majorly depends on the plantation of perennial trees like *Sal* (*Shorea robusta*), *Segun* (*Tectona grandis*), *Neam* (*Azadirachta indica*), etc. in the tea garden as a shady plant. The perennial plants are helped in recovering environmental losses by providing shelter to several animals as well as bird species.

Table 4 presents the Path analysis to decompose the total effect into the direct, indirect and residual effect of mean change of diversity (Y_1) vs. 12 exogenous variables (X_1-X_{12}). The variable ratio of peripheral plant (X_9) exerts the highest Total effect and also exerts the highest direct effect and the variable, age (X_1) records the highest indirect effect on mean change of diversity (Y_1).

The variable ratio of peripheral plant (X_9) has enrooted the highest indirect effect through as many as five exogenous variables. The path analysis depicts that 34.26 per cent variance in mean change of diversity (Y_1) cannot be explained. The variable ratio of peripheral plant has been the most prominent feature of the changing farm ecology and followed by the ingrate of Tea Gardens. If diversity is affected, then it offers a real concern to the ecologist across the class and affiliation.

CONCLUSION

The quick change of farmlands worldwide has been related to extensive changes in the social, economic, and ecological effects. While a wide range of social and economic impacts are seen in society, the biodiversity changes can likewise be observed. It is generally perceived that change in farming area use is a significant driver of biodiversity misfortune in developing countries (Sala, 2000). In this context, we can understand that Indian agriculture has been transformed. It transformed towards commercial farming from subsistence farming. The present study has envisaged polyhedral interactions amongst and between the consequent characters of these sub-ecological characters. The small farm holders support much richer biodiversity than do large scale plantations where the abundance and richness of trees were extremely low (Bolwig *et al.,* 2006). In our study, we can also observe that the transformation has occurred between the farmers who have very less amount of land and those farmers who are not completely engaged with the farming, along with the farming they also engaged with some other activities for their livelihood.

The responses of biodiversity to land-use changes uniquely among landmasses, yet that this heterogeneity is bound to reflect contrasts in the power of land-use pressures experienced and spatial inclinations in examining, as opposed to efficient contrasts in the natural affectability of species among locales (Phillips *et al.,* 2017). The study reveals that the biodiversity of the areas related to the tea garden is sounder than conventional farm lands. The northern terrain part of West Bengal predominantly identified for its wide range of biodiversity, but due to

the heavy and intensive cultivation practices, the ecological biodiversity affected vastly. The plantations are a lot of possible to completely benefit biodiversity (particularly in terms of favoring native over exotic species) once established on degraded or exotic land covers instead of as a replacement of natural ecosystems, whether or not those systems were originally forested or not and also the plantations often support fewer specialist species than natural ecosystems, under some conditions they'll play a crucial role in biodiversity conservation and healing, significantly at the landscape level (Bremer and Farley, 2010). Increasing tree cover in agricultural landscapes will support plant and invertebrate diverseness and considerably improve ecosystem functions that underpin ecosystem services based on the species/taxa (Barrios *et al.,* 2018). In the present scenario the small scale farmers who are mostly educated, younger, and have the least knowledge about the conventional farming techniques although have some entrepreneurial attitude influence the agricultural transformation towards high value economic crops. The biodiversity of a locale could be expanded by planting a range of local trees at different densities across all landscape positions (Cunningham *et al.,* 2015). The number of such trees depends upon the size of the garden and it is approximately ten to twelve trees per bigha. The farmers also plant some economical orchard plants like Papaya (*Carica papaya*) and most cultivable Areca nut (*Areca catechu*) in the outer boundaries of the garden. These types of practices automatically enrich the biodiversity of the ecosystem. Meanwhile, it is also suggested that a deep study of the ecosystem is needed to identify the positive as well as negative impacts of tea garden transformation on biodiversity.

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