# Does climate change perception make livelihood diversification more effective?

## Evidence from the consumption mobility study of rural households

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# Does climate change perception make livelihood diversification more effective? Evidence from the consumption mobility study of rural households[1]

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**Abstract**

Poor households engage in multiple activities to maintain their consumption in face of economic hardships or exogenous shocks. In this paper, we try to examine the effectiveness of such livelihood diversification to increase or maintain the inter-temporal consumption level conditional to the climate change knowledge of the households. We use a cross sectional survey data of 1200 households from central and western parts of Odisha and estimate multiple regression models with and without the assumption of endogeneity of occupational diversification index. Results clearly establish that households perceiving climate change significantly are able to benefit from diversification and maintain or improve their consumption intake over time, whereas those with no significant climate knowledge, are not able to benefit from diversification. In India, offering avenues for diversification has been a prime government policy with a view to augmenting farmers' income; however, such policies will have limited effects unless farmers are given the correct climate education to be able to choose the right activities which can increase their income and stabilise consumption.

**Key words:** Climate change, livelihood diversification, consumption mobility, Odisha, farmer's income

**JEL Classification: J24, Q12, Q54**

[1] This study uses the data collected under the ICSSR sponsored project on climate change, livelihood diversification and wellbeing in rural Odisha.

## 1. Introduction

Whether diversification is adopted as an intelligent strategy or a forced option is an important question. Why households go for multiple occupations has received attention in terms of diversification of necessity and diversification by choice (Ellis, 2008). If it is pursed to enhance income and consumption, it reflects on the households' motivation to progress. On the other hand, households may be adopting it as a desperate attempt to maintain their minimum consumption requirements as the main source of livelihood gets eroded. Morduch (1995) urged that diversification always played a role in the context of 'consumption smoothing'. While the risk-averse households protect consumption levels by borrowing and using insurance mechanisms, another common way is to diversify economic activities and make conservative production and employment choices (Kochar, 1999). As climate change is eroding traditional livelihoods, some households might have been pursuing diversification to sustain their consumption at the bare minimum levels while some others by adopting these strategies may be getting better off compared to those who did not. Traditionally, livelihood diversification was resorted to under income stress, where weather factors played some role, but were random and less frequent. With climate change, changing weather and extreme events are systematic and more frequent and livelihood diversification is being resorted to by majority to adapt to such changing scenarios. In the context of Sub-Saharan Africa, studies predict that food production will be adversely affected by climate change and variability and cause knock-on implications for household wellbeing in natural resource dependent communities (Lobello et al., 2011; Thornton, et al., 2011). Thus, the dependence on one source of income, particularly in the agriculture sector, may strain the consumption and therefore, the households may have to adopt different sources of livelihood in different seasons (Antwi-Agyei et al., 2014). Even in a specific quarter some of the members from a household may have to depend on several sources of income to reduce the consumption risks. As climate change is proved to threaten food security by decreasing quantity produced and quality of food (FAO, 2010; Schlenker and Lobell 2010), going for multiple occupations by earning members can be attributed to climatic changes. Livelihood diversification constitutes a component of climate smart agriculture as well (FAO, 2016). It is also being argued that rural livelihoods, which are diverse are less vulnerable than the undiversified ones (Ellis, 2008). Thus, investigating the role of climate change knowledge in determining whether the diversification is forced or intelligently adopted is a worthy research question which this research paper tries to answer.

## 2. What determines diversification?

Diversification behaviour varies across economic and social class of adopters. Six determinants of diversification, i.e. seasonality, risk, labour markets, credit markets, asset strategies, and coping strategies are mentioned in the literature (Ellis, 2008).Workers from landless and sub-marginal households have a greater tendency to become 'multi-active' (Bhaumik, 2007). The caste dimensions in the context of diversification are also important (Mosse, 2018) and the climate change is expected to generate unequal outcomes across social categories (Islam and Winkel, 2017). In general, while certain positive changes could be discerned for the scheduled castes in terms of occupational diversification outcomes, similar changes were missing for the scheduled tribes (Gang et al., 2013). This study concluded that the asymmetrical outcomes of SCs and STs on occupational convergence with the non-scheduled households may be related to locational differences between the SCs and STs, as well as the political economy factors relating to the greater political mobilisation of the SCs versus the STs, thereby bringing in the role of political economy as a possible determinant of diversification.

While analyzing the relationship between rural diversification and poverty in India through the National Sample Survey data for the years 1987/8, 1993/4 and 1999/0, it has been noted that agricultural wage employment grew over time and a growing fraction of agricultural labourers could not diversify to non-farm sector due to low education and a low caste status (Kijima and Lanjouw, 2005). Given this observation, the non-farm sector is less likely to provide opportunities to the low-income households to reduce income risks from climate change, though, the expansion of non-farm employment influences poverty indirectly by pushing up agricultural wages. A strong correlation is seen between agricultural labour including women in agriculture and low consumption levels (Ajani and Igbokwe, 2013; Kijima and Lanjouw, 2005). With less possibility to shift to the non-farm sector, such low-income households in the agriculture sector are unlikely to mitigate the adverse climate change effects unless they pursue multiple activities throughout the year.

Occupational diversification, especially distress diversification and rural-urban migration are seen to be influenced by the forces of development and features like degradation of forest and other natural resource base, inequality in land ownership, prevalence of poverty and agricultural backwardness, etc. (Rani and Shylendra, 2002). Improving the local resource base and its management can potentially reverse this trend. If the non-farm sector itself is not

demand induced the shift strategy adopted at the household level may not deliver a better outcome. Two kinds of distress diversification have been identified (Bhalla, 1989), in which non-agricultural rural activities become an absorber of the residual labour force: the first is the case of supplementary workers who have no main occupation, but engage in some subsidiary work to supplement household income and the second is the case with those who have a main occupation and also engage in the secondary activity. Diversification into different activities by the households is influenced by factors such as their access to land, family size, and nearness of the village to a town (Basant, 1993).

On the whole, the occupational diversification has been observed as a vital tactic in order to cope with crisis and seasonal stress in both farm and non-farm activities by those who are dependent on livelihood sources that are impacted by seasonal factors and are, thus vulnerable to climate change effects (Ajani and Igbokwe, 2013). Whether similar patterns can be retrieved from our sample data from Odisha needs to be explored. Particularly from inter-temporal data the upward mobility and factors influencing mobility can be studied in order to reflect on the climate change effect and the effectiveness of the strategy to cope with the phenomenon. One important aspect of wellbeing is consumption; thus, by focussing on consumption changes over time and relating it to livelihood diversification, we may comprehend the dynamics of wellbeing. Diversification adopted in the face of compulsion and in a situation of stagnancy may result in a bunch of residual or low productivity activities whereas diversification as an attempt to explore newer pathways in a vibrant situation to reduce income risks and smooth consumption can be highly beneficial.

Climate change adaptation is a two-step process – perception of climate change and associated risks and then steps taken to minimize their adverse effects (Fussel and Klein, 2006; Deresa et al., 2011). Perception has to be correct, otherwise, steps taken can lead to a maladaptation. Correct perception depends on factors like knowledge (education), access to information, resource availability, orientation, beliefs, etc. Over and above, it may be inferred that climate change adaptation strategy and the livelihood diversification strategy are inter-woven: in order to reduce the climatic adversity occupational diversification may be pursued though its presence under other circumstances cannot be ruled out. The rest of the paper is organised as follows: Section 3 presents the materials and methods that include the description of study area, the data used, the theoretical and econometric estimations. Section 4 presents the summary analysis and the results, where we show the distribution of

households in terms of consumption pattern measured as calorie intake and the inter-temporal changes in it and the econometric analysis to understand the determinants of change in calorie intake. Finally, section 5 discusses the results and summarises the major findings. The study is based on the primary data gathered under the ICSSR project on climate change and occupational diversification in Odisha.

## 3. Material and Methods

### 3.1 Study area and data used

This study is based on four districts of the state of Odisha in India, where extreme weather events like cyclones, floods, droughts, heatwaves etc. are a common phenomenon. Odisha's entire coastline of 480 kilometres is exposed to frequent cyclones, floods and waterlogging and its southern region is extremely exposed to heatwaves and frequent droughts seriously affecting people's livelihood and the macro economy (Das 2012; Das and Smith 2012; Bahinipati 2014; Mishra et al. 2016; Panda, 2016). As per the Government of Odisha calculation, the state suffered ₹1.05 Billion economic loss due to the extreme events (i.e. cyclone, flood and drought) during the 1970s, which increased to ₹ 6.82 billion, ₹ 70.81 billion and₹ 105.04 billion during the 1980s, 1990s and 2000s, respectively (GOO 2004, 2011). About 70 per cent of Odisha's population depend on agriculture for their livelihood, which is itself highly vulnerable to climate change (Mishra et al., 2015). Apart from high dependency on the agriculture sector, Odisha stands second among the 14 states in the country with the highest incidence of poverty after Bihar. While Bihar topped the list registering the incidence at 33.34 per cent, Odisha followed it at 32.59 per cent in 2011-12. With this background of co-existence of extreme weather, extreme poverty and high agricultural dependency, it was thought appropriate to study areas in Odisha to understand the research issues posed in the paper.

We study 1200 households from four districts of central and western Odisha, namely Dhenkanal, Angul, Sambalpur and Bargarh. These districts suffer from repeated climatic extreme events, are mostly rain fed, are witnessing multiple developmental programs by the government and are still economically very backward (PRD, 2014). Of the four districts, the first two are from relatively prosperous mid-central zone of the state and the latter two are from the southwest zone which is drought-prone and characterized by persistent crop failures. Dhenkanal and Anugul are economically little better off with approximately 18-19% population below poverty line compared to Sambalpur and Bargarh, where poverty ratio

average is around 41% (GOO, 2017). The choice of these four districts also accounts for heterogeneity in livelihoods and climatic stress. Whereas heat waves and flood are more common to Dhenkanal and Anugul, the other two districts witness frequent draughts and heat waves (Das, 2016). Heat waves being the common disaster in all four districts, we selected two blocks from each of the four districts based on the frequency of flood and draught. Based on the last 20 years data, we selected blocks from Dhenkanal and Anugul which are most and least affected by floods and from Sambalpur and Bargarh, the ones most and least affected by draughts.

From each selected block, four panchayats were selected on the basis of their distance from block head quarter (closest, farthest and in between). To select the sample villages from each of the chosen panchayats, all villages were first put into three groups (small, medium and large) on the basis of population and then, one village is chosen randomly from each group for the study. Thus, the study tried to account for disaster frequency, urbanization, governmental care as well as population density in selection of study area. Thus, the study area comprised of 96 villages which were drawn from four districts, eight blocks and 32 gram panchayats. Next, we decided to study 300 households from each district and followed population weighted sampling to select number of households from a village of a district. Finally, rural households from each sample village were chosen randomly. The sample households are distributed between the chosen blocks on the basis of the share of each block's households in the total number of households of the selected blocks in the district. Similarly for the gram panchayats and villages.

The following weighted formula is used to select the number of households for a village of a district.

$$HHijk = \left(\frac{BiHH}{\sum_{i=1}^{2} BiHH}\right)\left(\frac{PjHH}{\sum_{j=1}^{4} PjHH}\right)\left(\frac{VkHH}{\sum_{k=1}^{3} VkHH}\right) * 300 = B(i) * P(j) * V(k) * 300 \qquad (1)$$

In Eq. 1 $HH_{ijk}$ is the number of households chosen for the k$^{th}$ village of j$^{th}$ Gram Panchayat of the i$^{th}$ block. In Eq. 1, *B* represents a block (i =1 and 2), *P* represents a panchayat (j =1 to 4) and *V* represents a village (k =1 to 3).

$B_iHH$ is total number of households in the i$^{th}$ block, $P_jHH$ is total number of household in the j$^{th}$ Panchayat and $V_kHH$ is total number of households in the k$^{th}$ village.

*B(i)* is the weightage for the $i^{th}$ block households,

*P(j)* is the weightage for the $j^{th}$ Panchayat households and

*V(k)* is the weightage for the $k^{th}$ village households.

*B(i)*P(j)*V(k)*300* is the sample size for the $k^{th}$ village (of $j^{th}$ panchayat and $i^{th}$ block). After selecting the sample size, random sampling is done to select and survey the households. This procedure is repeated for each of the districts.

A structured questionnaire was prepared based on the findings of detailed focussed group discussions in two villages of each of the districts (not covered in the sample). The questionnaire was pre-tested, modified and then used for the household survey. The survey was completed during September to December of 2016.

### 3.2 **Methodological Approach**

We use multiple analytical tools to derive the results. This study uses consumption mobility between the time of the survey and five years before as an indicator of wellbeing to explain the impact of livelihood diversification. To minimise recall bias, we collect weekly consumption data of households in terms of quantity consumed and then combine the different goods consumed by the family, today as well as five years ago, in terms of their calorie equivalent, not monetary values. As poor households buy their groceries from local markets, where prevailing prices may be different from the wholesale price of the state and households may not be able to report the local prices correctly, we decided to use calorie content. Eq. 2 shows how total consumption of the household is converted to total calorie consumed.

$$TC_h = \sum_{n=1}^{N} q_n cal_n \qquad (2)$$

In Eq. 2, $TC_h$ is total calorie consumed by household *h* in a week, the family consumes *N* number of commodities, $q_n$ is the quantity consumed of $n^{th}$ commodity and $cal_n$ is the average calorie content of the commodity. We convert weekly consumption of different commodities

by the households in to the calorie equivalents following National Sample Survey (NSS) of India's guidelines and nutritional charts of dieticians from medical literature.[2]

Next we convert the family size of the household into the equivalent consumer units following NSS consumer unit equivalence weights that takes into account the age and gender of family members. The consumer unit of a family was defined as the following:

$$CU_h = \sum_{i=1}^{n} w_i^{jk} \qquad (3)$$

where *CU* is the total consumer unit of the $h^{th}$ family having n members (i=1, 2, ..n), $w_i$ is the consumer unit equivalence weight of the $i^{th}$ member of $j^{th}$ age group and $k^{th}$ gender category in the family. Thus summing the weight equivalence of all *n* members of the family, the total consumer unit (*CU*) is derived. Average consumption of the household is defined as the total calorie units consumed by the household divided by the total consumer units of the household as defined in EQ. 4.

$$C_h = \frac{TC_h}{CU_h} \qquad (4)$$

$C_h$ is measured for present level of weekly consumption as well as for the weekly consumption five years ago. After dividing $C_h$ by 7, the daily per capita calorie is measured for both the time units and their difference $dC_h$ (Eq. 5) is called the consumption mobility, which is used as the main outcome variable for measuring the impact of occupational diversification.

$$dC_h = C_{h\,(t)} - C_{h\,(t-5)} \qquad (5)$$

In Eq. 5, $C_{h\,(t)}$ is average daily calorie consumed during the year t, the year of the survey and $C_{h\,(t-5)}$ is the average daily calorie consumed five years before.

To define occupational diversification index, information on month wise occupation of the household head is used and it shows the number of different types of occupation he/she is doing throughout the year. Diversification index is simply taken as the number of different occupations the head has taken up in different months of the year. It is defined as:

[2] Calorie conversion rates are used from: https://www.iitk.ac.in/hc/food-exchange-list, accessed on 22nd September 2017.

$$D_h = \sum_{f=1}^{12} O_f \Leftrightarrow O_f \neq O_m \qquad (6)$$

where $D_h$ is diversification index of the $h^{th}$ household, *O* is occupation type (farming, wage labour, dairy, brick work, etc.), *f* and *m* are months. The occupations are counted only if the occupation in $f^{th}$ month of the year is different from the occupation in $m^{th}$ month.

We also defined a climate knowledge indicator for the household if the household head is aware of at least one of the climate change indicators over the area, the set (X) of indicators being change in average rainfall, change in average temperature, frequency of extreme rainfall events or erratic rainfall pattern in recent years. We define climate change awareness as a dichotomous (no=0, yes=1) variable as defined below.

$$CC\_A_h = \begin{cases} =1 \; if \; x=1 \; for \; any \; of \; the \; X \\ =0 \; if \; x=0 \; \forall \; X \end{cases} \qquad (7)$$

In Eq. 7, $CC\_A_h$ is climate change awareness dummy for the $h^{th}$ household, x is one of the climate change indicators from the set of X indicators as described above and $CC\_A_h$ equals 1 if any of the x indicators equals 1 for the $h^{th}$ household head. If all x are zero, $CC\_A_h$ is zero for the household. As the area studied is very remote and the awareness level of households is very low, we consider the household head climate aware if he/she is aware of at least one of the climate change indicators.

We define household's change in calorie consumption ($dC_h$) over time (consumption dynamics) as a function of income (Y), climate change (captured by climate change awareness of households) and the set of other household level and social factors (S) that influence taste and habits. As agricultural sector is seriously affected by climate change (Mendelssohn, 2014; Nelson et al., 2014) and both productivity and crops grown by households are changing over time, the climate change indicators ($CC\_A_h$) are expected to influence change in food habits. Income is defined as a function of the livelihood diversification ($D_h$) undertaken by the household. Further diversification is assumed to depend on climate change awareness ($CC\_A_h$) and few other household level and locational factors (Z). Eq. 8 and 9 explain the consumption and diversification functions. As diversification depends on climate knowledge and few household level features like number of working members or work knowledge acquired from family (caste related), it is likely to be endogenous and hence, the estimation of Eq. 8 is likely to comprise endogeneity bias. We,

therefore, use the estimated value of (diversification) from Eq 9 as an instrument and estimate the consumption change from Eq. 10.

$$dC_h = f(D_h, CC\_A_h, S) \qquad (8)$$

$$D_h = d(CC\_A_h, Z) \qquad (9)$$

$$dC_h = f(d(CC\_A_h, Z), CC\_A_h, S) = f(\hat{D}_h, CC\_A_h, S) \qquad (10)$$

### 3.3 Econometric Estimation

We estimate Eq. 9 with Ordinary Least Squares (OLS) estimates and derive OLS, logistic and multinomial logistic estimates for Eq. 8 and 10 after putting the change in $dC_h$ into different categories (increase = 1, decrease or no change = 0; increase = 1, decrease = 0 and no change = 2). We also estimate Eq.8 with and without climate change awareness dummy and compare the results. Variables used in the estimation are described in the result section.

## 4. Results

### 4.1 Description of the sample households

We study 1200 households from eight blocks of four districts of Odisha. Table 1 shows the caste composition of these households and they are either scheduled caste (SC), scheduled tribes (ST) or other backward castes (OBC). As these categories mostly belong to economically lower strata of Odisha economy, the paper speaks of the poorer section of the society.

Of these households 66% lived in katcha houses, 18% in semi pucca houses and rest 16% in pucca houses. Nearly 32% did not possess any land and just 18% of the households had some source of irrigation in their land, the dominant types being public and private tube wells. Regarding primary source of income, it was either agriculture (52%) or non-agricultural enterprises (17%) or wage and salaries (18%) as the dominant categories. On asset ownership, nearly half of the households owned television set, 27% motor cycles, 28% mobile phones, 43% ceiling fans/coolers, 0.4% cars and 0.2% air conditioners in 2016 when the survey was conducted. The average annual income was reported to be around USD600 during the survey, which was around USD545 five years back.

**Table 1: Caste composition of the Sample households**

| Sl. No | District | Blocks | Caste Category of sample households | | | | |
|---|---|---|---|---|---|---|---|
| | | | SC | ST | OBC | Others | Total |
| 1 | Dhenkanal | Hindol | 73 | 21 | 87 | 08 | 189 |
| | | Kamakhyanagar | 44 | 03 | 65 | 01 | 113 |
| 2 | Angul | Pallahara | 11 | 155 | 00 | 00 | 166 |
| | | Athamallik | 04 | 130 | 00 | 00 | 134 |
| 3 | Bargarh | Paikmal | 11 | 106 | 44 | 00 | 161 |
| | | Gaisilet | 35 | 56 | 35 | 13 | 139 |
| 4 | Sambalpur | Kuchinda | 19 | 90 | 32 | 02 | 143 |
| | | Jujumora | 59 | 49 | 47 | 00 | 155 |
| 5 | Total (4 districts and 8 blocks) | | 256 | 610 | 310 | 24 | 1200 |

### 4.2 Change in Calorie consumption over time

Mobility in the literature has been envisaged in terms of income and occupation changes over time. As Fields (2005) argued, income mobility can be considered to be time independent if units (households/individuals) experience different extent of change over time. Using the information from the primary survey we distribute the households across various calorie classes based on present and past consumption figures. Since the survey was conducted only at one point in time and the information was collected on present and past consumption (5 years ago), recall problems may not be negligible. First, we compare the present and past average weekly consumption of different commodities by households and do a mean comparison test. Table 2 shows the significance of the differences of the means. Over time consumption of every item has increased and there is significant difference in mean values of all items. As expected consumption of items like rice, wheat, vegetables, pulses, etc. have increased by comparatively higher amount compared to consumption of other items.

**Table 2: Weekly consumption of food items by the households (in kg)**

| Food items consumed | Average household Consumption in a week Now (2016) | Average household Consumption in a week five years before | Ttest of the differences of the mean |
|---|---|---|---|
| Rice | 9.67 | 8.87 | 0.80*** |
| Wheat | 1.07 | 0.95 | 0.13*** |
| Other Cereals | 0.12 | 0.099 | 0.025*** |
| Pulses | 1.3 | 1.18 | 0.13*** |
| Vegetables | 2.69 | 2.45 | 0.25*** |
| Fruits | 0.25 | 0.21 | 0.04*** |
| Nonveg | 1.19 | 1.12 | 0.07*** |
| Dairy | 0.28 | 0.27 | 0.01** |
| Oil | 0.75 | 0.74 | 0.01** |
| Spices | 0.18 | 0.17 | 0.01*** |
| Sugar | 0.76 | 0.74 | 0.02*** |

Next, the consumption data collected were converted to average daily calorie consumed per consumption unit of households following Eq.2 to Eq.5 for present and past year are compared. We put the average daily calorie consumption into different group and the two way distribution between present and past are shown in Table 3.

Along the leading diagonal of Table 3 only 248 (20 %) households are seen to have remained stagnant while almost double the number (451) registered an increase and a slightly more than that (501) moved into the lower consumption size classes. Hence, we have reasons to believe that different households may have adopted different strategies as a result of which there are significant variations in the outcomes.

**Table 3: Change in Average Daily Calorie Consumption over time**

| | Daily calorie consumption now | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Daily calorie consumption five year before | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Total |
| | 1 | **13** | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 |
| | 2 | 2 | **14** | 4 | 9 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 |
| | 3 | 1 | 7 | **32** | 15 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 65 |
| | 4 | 0 | 1 | 13 | **56** | 24 | 10 | 5 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 112 |
| | 5 | 0 | 0 | 3 | 16 | **63** | 41 | 14 | 3 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 143 |
| | 6 | 0 | 0 | 0 | 5 | 18 | **60** | 37 | 24 | 7 | 3 | 1 | 0 | 0 | 0 | 0 | 155 |
| | 7 | 0 | 0 | 0 | 1 | 8 | 14 | **41** | 20 | 16 | 11 | 2 | 0 | 0 | 0 | 0 | 113 |
| | 8 | 0 | 0 | 0 | 0 | 1 | 7 | 19 | **34** | 24 | 16 | 5 | 1 | 0 | 0 | 0 | 107 |
| | 9 | 0 | 0 | 0 | 0 | 2 | 2 | 6 | 12 | **36** | 17 | 11 | 14 | 1 | 0 | 0 | 101 |
| | 10 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 7 | 11 | **20** | 13 | 10 | 3 | 0 | 0 | 67 |
| | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | 10 | **23** | 13 | 3 | 1 | 0 | 60 |
| | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 6 | 13 | **28** | 14 | 8 | 0 | 75 |
| | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 0 | 7 | **11** | 11 | 1 | 35 |
| | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 4 | 3 | 9 | **27** | 13 | 59 |
| | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 10 | **43** | 56 |
| | Total | 16 | 25 | 56 | 102 | 123 | 141 | 126 | 106 | 111 | 87 | 72 | 78 | 43 | 57 | 57 | 1200 |

### 4.2.1 Calorie consumption of different income class

The distribution of these households (with no consumption mobility, upward mobility and downward mobility) as per the income size classes confirms that at the top income levels only a negligible number of households are located (Table 4). On the other hand, the bottom and the middle-income classes comprise the maximum number of households which have remained stagnant or undergone a mobility in terms of consumption. While around 61 per cent of the households with upward mobility belonged to the bottom and the next income ranges, a slightly higher proportion of the households among those which experienced downward mobility belonged to these income classes. Hence, it is difficult to subscribe to the view that those with lower incomes only experienced a decline in quality consumption. Within the same income ranges if not an equal, a slightly lower percentage of the households did register an improvement in their consumption intake. Hence, within the comparable ranges of income the differences in consumption mobility are seen which can be attributed to

the differences in the behaviour of the households. This prompts us to pursue the mobility issue econometrically.

**Table 4: Distribution of households of different income groups as per their calorie consumption status over the last five years**

| Change in calorie consumption status | Income groups (in Rs.) | | | | | |
|---|---|---|---|---|---|---|
| | <20k | 20k-50k | 50k-100k | 100k-200k | >200k | Total |
| No change (households on the diagonal) | 33 (0.028) | 164 (0.137) | 49 (0.041) | 2 (0.002) | 0 | 248 (0.207) |
| Upward (households above the diagonal) | 42 (0.035) | 233 (0.194) | 167 (0.139) | 3 (0.003) | 6 (0.005) | 451 (0.376) |
| Downward (households below the diagonal) | 62 (0.052) | 300 (0.25) | 133 (0.111) | 4 (0.003) | 2 (0.002) | 501 (0.418) |
| Total | 137 (0.114) | 697 (0.581) | 349 (0.291) | 9 (0.008) | 8 (0.007) | 1,200 (1) |

Figures in parenthesis are %s of total number of households.

### 4.2.2 Occupational diversification and calorie consumption

Further classifying the households in terms of consumption mobility and diversity of economic activity, interesting results are discernible (Table 5). Diversity of economic activity is defined as the number of activities adopted by the household head/principal earner. Nearly half of the households which experienced no mobility did not diversify the activities and more than one third had two activities. Similarly, nearly half of the households with downward mobility did not diversify. On the other hand, a large majority of the households with upward mobility had at least two activities. This tends to suggest that diversification has been a necessary condition for improvement in economic wellbeing though all those who diversified actually did not witness improvement over time. Hence, two types of diversification seem to have taken place: one is efficiency driven being associated with welfare gain and another is distress-led which rather resulted in a decline in the economic

wellbeing. In the face of climate change one set of households is able to succeed and another registers a deterioration; further, as mentioned above, both the sets are present in similar income classes. In other words, two comparable sets of households are pursuing diversification but one is able to improve while the other struggles. Thus, there seems to be no pattern, neither with income nor with livelihood diversification, of the change in consumption intake. Does that mean geography plays or other household level factors play a major role in deciding whether diversification strategy would turn out to be successful? Or does the perception about climate change makes a significant variation in the outcome? The econometric exercises may bring clarity on this aspect.

**Table 5: Distribution of households as per their economic activity diversity index and calorie consumption status over the last five years**

| Change in calorie consumption status | Number of income generating activities in a year | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | Total |
| No change (households on the diagonal) | 113 (0.094) | 94 (0.078) | 10 (0.008) | 17 (0.014) | 10 (0.008) | 4 (0.003) | 248 (0.206) |
| Upward (households above the diagonal) | 133 (0.111) | 203 (0.167) | 90 (0.075) | 17 (0.014) | 7 (0.006) | 1 (0.0008) | 451 (0.375) |
| Downward (households below the diagonal) | 223 (0.186) | 182 (0.152) | 44 (0.037) | 27 (0.03) | 19 (0.016) | 6 (0.005) | 501 (0.418) |
| Total | 469 (0.39) | 479 (0.399) | 144 (0.12) | 61 (0.051) | 36 (0.03) | 11 (0.009) | 1200(1) |

Figures in parenthesis are %s of total number of households.

### 4.3 Regression results: did climate change awareness have any decisive effect on consumption mobility?

A very significant percentage of the sample households (a little more than half) did not have the knowledge about climate change and among them a large majority experienced either no change or rather got worse-off by registering a decline in calorie consumption. On the other

hand, among those with knowledge about climate change a little more than 50 per cent got better-off over time. We explore the impact of climate change awareness and other factors on calorie intake by estimating different multivariate regressions. First we estimate Eq. 8 that assumes diversification and climate change knowledge to be exogenous to each other. We derive both OLS, Logit and multinomial logit estimates without and with climate change dummy. Table 6 shows the OLS, Table 7, the Logit and Table 8, the multinomial logit estimates.

The OLS results of the regression of the difference in per capita calorie consumption over a period of five years (Table 6) indicates that caste wise, OBCs are worse-off compared to the general caste while across religions Muslims are better off compared to the Hindus and the Christians. The occupational diversification does not turn out to be significant. Much of the effect is picked up by income and the number of consumer unit, though income does not have a linear relationship with consumption increase. Besides, geography plays a crucial role as five out of eight regions are different from the comparison group. Knowing the climate change well or having better perception about climate change seems to improve the consumption (Model 2 in table 6).

**Table 6: OLS results on difference between daily per capita calorie consumption today and five years back**

| Explanatory variables | Model 1 | Model 2 (accounts for climate change awareness) |
|---|---|---|
| | Estimated Coefficients | |
| cunsumer_unit | 47.49*** (9.42) | 46.98*** (9.42) |
| Income | 249.32*** (60.67) | 241.45*** (60.77) |
| Income sq. | -31.90*** (9.32) | -30.86*** (3.31) |
| Land owned | -6.20* (3.77) | -6.18* (3.77) |
| Occupational div_index | -14.42 (16.07) | -14.69 (16.06) |
| Pucca | 110.80** (44.48) | 109.57** (44.43) |
| Semipucca | 95.30** (39.76) | 94.03** (39.72) |
| Others | 7.23 (99.01) | 24.17 (99.37) |
| OBC | -86.49** (42.92) | -81.46* (42.96) |
| SC | 4.87 (45.56) | 3.45 (45.52) |

| | | |
|---|---|---|
| Islam | 145.46** (73.59) | 160.76** (74.02) |
| tv_own | -46.23 (32.42) | -43.65 (32.42) |
| mobile_own | 33.04 (35.85) | 30.21 (35.84) |
| Aware of climate change | ---------- | **59.59* (33.85)** |
| GAISILET | 246.27*** (73.64) | 211.22*** (76.05) |
| HINDOL | 407.80*** (74.46) | 372.42*** (77.05) |
| JUJOMORA | 151.05* (78.64) | 150.99w* (78.55) |
| KAMAKHAYA_NAGAR | 226.07*** (80.00) | 220.03*** (79.98) |
| KUCHINDA | -4.27 (75.63) | -7.37 (75.57) |
| PALLAHARA | -33.30 (62.25) | -21.68 (62.53) |
| PAIKMAL | 215.14*** (69.5) | 204.09*** (69.71) |
| Constant | -339.80*** (79.69) | -353.13*** (79.97) |

Next, we tried to pose the issue of consumption change in a binomial logit framework treating those with a rise as one category and those with no change or deterioration as another. The results shown in Table 7 are not much different from the base-run though six geographical dummies turn out to be significant in the logit specification and more, importantly, the knowledge about climate change is seen to play a striking role. We estimate two models, one without the climate change awareness and another with it, and this variable is highly significant, though the significance of other variables remains the same. The impact of occupational diversification is possibly picked up by the income variable. However, it may also be argued that the positive and negative role of diversification, as seen from the tabular analysis, has possibly neutralized the impact.

**Table 7: Logit regression results: Dep. Variable (household above the diagonal = 1)**

| Explanatory variables | Model 1 | Model 2 (accounting for awareness of climate change) |
|---|---|---|
| | Estimated coefficients | |
| cunsumer_unit | 0.26*** (0.05) | 0.26*** (0.05) |
| Income | 0.79** (0.31) | 0.71** (0.31) |
| Income sq. | -0.08 (0.05) | -0.07 (0.05) |

| | | |
|---|---|---|
| land_owned | -0.01 (0.03) | -0.01 (0.03) |
| Occupational div. index | -0.09 (0.08) | -0.09 (0.08) |
| Pucca | 0.49** (0.22) | 0.49** (0.22) |
| Semipucca | 0.34* (0.21) | 0.35* (0.21) |
| Others | 0.31 (0.50) | 0.46 (0.51) |
| OBC | -0.34 (0.22) | -0.31 (0.22) |
| SC | 0.17 (0.23) | 0.16 (0.23) |
| Islam | 0.58 (0.36) | 0.73** (0.37) |
| tv_own | -0.17 (0.16) | -0.13 (0.17) |
| mobile_own | 0.27 (0.18) | 0.25 (0.18) |
| Aware of climate change | ---------- | **0.52*** (0.17)** |
| GAISILET | 2.00*** (0.41) | 1.72*** (0.42) |
| HINDOL | 2.96*** (0.42) | 2.69*** (0.43) |
| JUJOMORA | 1.59*** (0.43) | 1.61*** (0.43) |
| KAMAKHAYA_NAGAR | 1.41*** (0.45) | 1.39*** (0.45) |
| KUCHINDA | 0.62 (0.46) | 0.60 (0.46) |
| PALLAHARA | 0.74** (0.37) | 0.85** (0.37) |
| PAIKMAL | 1.49*** (0.40) | 1.39*** (0.40) |
| _cons | -3.30*** (0.46) | -3.47*** (0.47) |

***, **, * imply level of significance to be 1%, 5% and 10% respectively.

### 4.3.1 Multinomial logit results

Since the characteristics of the households which were able to maintain their consumption over the five years period and those which experienced a decline are different, as evidenced from the tabular analysis, we estimated a multinomial logit model with no change, decline and increase as three separate categories. Table 8 shows the marginal effects of the multinomial logit regression for the three categories separately.

**Table 8: Marginal effect of multinomial logit regression**

| Marginal effect (dy/dx) after mlogit | Y = Decrease in calorie consumption | Y = Increase in calorie consumption | Y = No change in calorie consumption |
|---|---|---|---|
| Number of Consumer unit in the household | -0.032*** (0.008) | 0.051*** (0.009) | -0.020* (0.010) |

| | | | |
|---|---|---|---|
| Income | -0.022 (0.132) | 0.112 (0.076) | -0.091 (0.099) |
| Income squared | -0.050 (.103) | 0.008 (0.041) | 0.042 (0.064) |
| Land owned (acre) | 0.002 (0.002) | 0.0001 (0.005) | -0.002 (0.005) |
| Occupational diversity index (number of different occupations) | 0.047*** (0.012) | -0.017 (0.016) | -0.030* (0.017) |
| Pucca house | -0.021 (0.032) | 0.095** (0.043) | -0.074 (0.047) |
| Semi pucca house | -0.021 (0.031) | 0.066* (0.040) | -0.045 (0.042) |
| Belong to general caste | 0.032 (0.089) | 0.091 (0.100) | -0.123 (0.124) |
| Belong to OBC | 0.013 (0.033) | -0.059 (0.043) | 0.046 (0.046) |
| Belong to Scheduled Caste | -0.022 (0.039) | 0.030 (0.045) | -0.007 (0.050) |
| Religion Islam | 0.033 (0.059) | 0.149** (0.072) | -0.182** (0.088) |
| Own TV | -0.019 (0.024) | -0.029 (0.032) | 0.048 (0.034) |
| Own mobile phone | -0.028 (0.025) | 0.041 (0.034) | -0.013 (0.038) |
| Aware of climate change | 0.034 (0.025) | 0.101*** (0.033) | -0.135*** (0.035) |
| Block GAISILET | -0.190*** (0.053) | 0.316*** (0.079) | -0.126 (0.084) |
| Block HINDOL | -0.621*** (0.126) | 0.575*** (0.087) | 0.046 (0.109) |
| Block JUJOMORA | -0.082* (0.051) | 0.309*** (0.083) | -0.227*** (0 085) |
| Block KAMAKHAYA_NAGAR | -0.323*** (0.063) | 0.266*** (0.085) | 0.057 (0.087) |
| Block KUCHINDA | -0.071 (0.047) | 0.101 (0.089) | -0.030 (0.085) |
| Block PALLAHARA | -0.027 (0.038) | 0.165** (0.071) | -0.139** (0.069) |
| Block PAIKMAL | -0.271*** (0.051) | 0.253*** (0.075) | 0.018 (0.077) |

Two important features emerge sharply: households which could not perceive climate change appropriately their perusal of multiple activities actually resulted in a decline in the calorie consumption intake, indicating the distress-led struggle of the households at the lower end with limited perception. On the other hand, households with climate change perception could reduce the probability of not having any change in their calorie consumption – rather they

could raise the probability of experiencing an increase in their consumption even without diversification. With climate change perception it is difficult to be in the same consumption bracket without experiencing any change and the change is confirmed in terms of a rise in consumption. At the same time diversification in terms of more than one number of activities is not crucial for any improvement; rather without climate change perception it is a desperate strategy of some of the households for survival though it does not enable them to sustain their consumption. Households with declining consumption and accessing more than one number of activities rather portray their vulnerability in the face of climate change that is taking place in a state for the last twenty years. These findings and also the success stories of those with climate change perception have important policy bearing in terms of the efficacy of the state initiative to make the population of the climate change affected area aware of the reality and empower them with necessary support to adopt the coping mechanisms. Without such initiatives the individual attempts to raise the number of activities is only a matter of last resort with a major decline in wellbeing as the obvious outcome.

### 4.4 Accounting for endogeneity between climate change awareness and diversification index

We examine the endogeneity issue of livelihood diversification through 2SLS estimates: first by estimating occupational diversity index as a function of climate change awareness, caste dummies and family size and then using its predicted value as an explanatory variable in the regression for consumption change as explained in Eq. 10. We estimate the same models as shown in Table 6, 7 and 8 with the exception that the diversification index is replaced by its predicted value in the estimation. Table 9 shows the 2SLS and Logit estimates. The impact of diversification on consumption change is positive in both the equations. In other words, when diversification is envisaged as a function of climate change knowledge, it works as an intelligent strategy of reducing the consumption risks and helps improve the consumption levels. In other words, those who are able to perceive the climate change appropriately are also the ones to follow diversification effectively. Such initiatives contribute significantly to augment the living standards as the livelihood diversification strategies are adopted thoughtfully to augment the income.

Considering separately the rise and decline in consumption over time in relation to no change the multinomial logit results also confirm the beneficial effect of diversification resulting from climate change knowledge. The predicted value of diversification which is actually determined by the climate change knowledge raises the probability of experiencing a rise in

consumption, and more importantly, this effect is seen to be statistically significant (Table 10). On the other hand, diversification tends to reduce the probability of undergoing a decline in consumption over time or the probability of remaining stagnant, though it is not statistically significant. When diversification is envisaged as a decision of the household not necessarily determined by climate change knowledge, it may not help augment income and consumption as the efforts may not have the requisite direction. On the other hand, climate change knowledge helps sharpen the efforts and makes household more careful in adopting the right strategy for income augmentation. To put it differently, households with climate change knowledge are able to take recourse to livelihood diversification more categorically compared to the ones who pursue it without adequate or specific knowledge about climate change. This also unravels the fact that not all attempts towards diversification are outcome enriching as failures due to wrong decisions may be prevalent. Besides, some of the livelihood sources are pursued out of desperation and as a matter of last resort which can only provide minimum subsistence support and not any significant upgradation.

**Table 9: Instrumental variable regression result**

| Explanatory variables | Y= difference in daily calorie consumption (2SLS results) | Y= Increase in calorie consumption=1 and 0 for no increase or decrease (Logit regression results) |
|---|---|---|
| Number of Consumer unit in the household | -18.03 (20.64) | 0.024 (0.11) |
| Income | 224.68*** (60.58) | 0.637** (0.32) |
| Income squared | -30.25*** (60.58) | -0.067 (0.05) |
| Land owned (acre) | -6.34* (3.74) | -0.012 (0.03) |
| **Predicted value of** Occupational diversity index (number of different occupations) | 2324.33*** (655.51) | 8.608** (3.41) |
| Pucca house | 101.75** (44.19) | 0.466** (0.23) |
| Semi pucca house | 83.31** (39.58) | 0.298 (0.21) |
| Belong to general caste | 13.88 (98.77) | 0.427 (0.51) |
| Belong to OBC | -1272.61*** (337.13) | -4.729*** (1.76) |
| Belong to Scheduled Caste | -32.79 (46.26) | 0.021 (0.24) |
| Religion Islam | 181.12** (73.78) | 0.817** (0.37) |
| Religion Christianity | 90.59 (154.21) | 0.802 (0.73) |
| Own TV | -43.51 (32.22) | -0.120 (0.17) |
| Own mobile phone | 34.30 (34.74) | 0.314* (0.18) |
| Aware of climate change | -672.42*** (209.09) | -2.200** (1.08) |

| | | |
|---|---|---|
| Block GAISILET | 190.96** (75.52) | 1.652*** (0.42) |
| Block HINDOL | 354.04*** (76.49) | 2.659*** (0.43) |
| Block JUJOMORA | 130.45* (78.20) | 1.532*** (0.43) |
| Block KAMAKHAYA_NAGAR | 210.40** (79.47) | 1.390*** (0.46) |
| Block KUCHINDA | -13.29 (75.12) | 0.625 (0.46) |
| Block PALLAHARA | -32.19 (62.16) | 0.772** (0.38) |
| Block PAIKMAL | 167.83** (65.35) | 1.246*** (0.38) |
| Constant | -3994.74*** (1022.6) | -17.057*** (5.35) |

**Table 10: Instrumental variable regression: Marginal Effects (dy/dx) from multinomial logit estimates**

| Explanatory variables | Y==0 (decrease in daily calorie consumption) | Y==1 (increase in daily calorie consumption) | Y==2 (no change in daily calorie consumption) |
|---|---|---|---|
| Number of Consumer unit in the household | -0.009 (0.02) | 0.005 (0.02) | 0.004 (0.02) |
| Income | 0.002 (0.14) | 0.091 (0.08) | -0.093 (0.10) |
| Income squared | -0.066 (0.11) | 0.015 (0.04) | 0.051 (0.07) |
| Land owned (acre) | 0.003 (0.003) | -0.001 (0.01) | -0.002 (0.01) |
| **Predicted value of Occupational diversity index (number of different occupations)** | -0.810 (0.55) | 1.654** (0.64) | -0.844 (0.70) |
| Pucca house | -0.012 (0.03) | 0.090** (0.04) | -0.077* (0.05) |
| Semi pucca house | -0.010 (0.03) | 0.055 (0.04) | -0.045 (0.04) |
| Belong to general caste | 0.052 (0.09) | 0.081 (0.09) | -0.134 (0.12) |
| Belong to OBC | 0.446 (0.28) | -0.909*** (0.33) | 0.464 (0.36) |
| Belong to Scheduled Caste | -0.007 (0.04) | 0.004 (0.05) | 0.003 (0.05) |
| Religion Islam | 0.012 (0.06) | 0.167** (0.07) | -0.180** (0.09) |
| Religion Christianity | -0.033 (0.11) | 0.161 (0.15) | -0.128 (0.18) |
| Own TV | -0.023 (0.02) | -0.024 (0.03) | 0.047 (0.04) |
| Own mobile phone | -0.051** | 0.052 (0.03) | -0.001 (0.04) |

| | | | |
|---|---|---|---|
| | (0.03) | | |
| Aware of climate change | 0.291* (0.18) | -0.422** (0.21) | 0.131 (0.22) |
| Block GAISILET | -0.163*** (0.05) | 0.303*** (0.08) | -0.140* (0.08) |
| Block HINDOL | -0.612*** (0.13) | 0.572*** (0.09) | 0.040 (0.11) |
| Block JUJOMORA | -0.069 (0.05) | 0.294*** (0.08) | -0.225*** (0.08) |
| Block KAMAKHAYA_NAGAR | -0.308*** (0.06) | 0.265*** (0.09) | 0.043 (0.08) |
| Block KUCHINDA | -0.076 (0.05) | 0.107 (0.09) | -0.031 (0.08) |
| Block PALLAHARA | -0.016 (0.04) | 0.150** (0.07) | -0.134** (0.07) |
| Block PAIKMAL | -0.187*** (0.05) | 0.224*** (0.07) | -0.037 (0.07) |

## 5. Discussion and Conclusion

This paper based on primary survey data from the rural areas of Odisha, which has been majorly affected by climate change, examines the impact of climate change knowledge of the rural population on diversification strategy adopted to mitigate the challenges and experience upward mobility. The mobility pattern is not seen to be time dependent in the sense different households experienced different magnitudes of change in consumption while some witnessed no major change over time. Mobility envisaged both quantitatively and qualitatively in terms of inter-temporal difference in calorie consumption and logistic regressions respectively, brings out insightful results. Farm households affected by climate change may explore livelihood diversification but it may not ensure any significant improvement unless they have the knowledge of climate change and adopt diversification strategies accordingly. These findings corroborate the findings of other studies on chances of mal-adaptation if climate change is not perceived correctly by poor households (Mehta et al., 2019; Hitayezu, et al., 2017). Also, from the technical point of view the diversification initiative may not be an exogenous variable. Since it is adopted in the face of a crisis there is reason to believe that such initiative is guided by other variables. The knowledge about climate change, for example, helps farm households work out more specific livelihood strategies which can improve the outcomes even when encountered with a crisis.

The findings tend to support this line of logicality: as the endogeneity problem associated with diversification initiative is overcome by first regressing diversification on climate change knowledge and then using its predicted value as the determinant of consumption mobility, the coefficient of diversification turns out to be statistically significant. And this is evident in alternate specifications of consumption mobility captured in terms of the magnitude of difference in inter-temporal calorie consumption and also the directions of change relative to no change in consumption. Even when we suppress the magnitude of change and simply consider the direction of change compared to those with no change or a decline as seen in terms of a binomial and a multinomial logit regression, the predicted value of diversification turns out to be the key determinant of upward mobility. Climate change knowledge is the main instrument which helps determine effective strategies relating to livelihood exploration, and adoption of multiple activities is the key to success even when confronted with a major crisis. On the other hand, the absence of instrumentation does not bring out the robustness in the key finding. In other words, diversification independent of climate change knowledge does not establish a beneficial impact on consumption mobility, invariably. Households with climate change knowledge are rather able to identify and prioritise the most efficient strategies for diversification. On the whole, while diversification is the key to upward mobility, it needs to be strengthened by significant interventions by the government at the grass root level, primarily through imparting climate change knowledge. Some of the other variables which are significant in the mobility equation include caste and geography, which would imply the effectiveness of caste and geographic interventions.

On the whole, the government agencies will have to work more efficiently at the village level in order to disseminate the climate change knowledge. At the moment the government is keen to augment the farmers' income through diversification.[3],[4] However, as our results show, diversification per se may not turn out to be an effective strategy unless prompted by the climate change knowledge. Similarly, certain specific caste groups are susceptible to greater vulnerability, and hence, they will have to be assisted with more scientific knowledge which may help them identify the appropriate ways of occupational diversification. The policy interventions cannot escape the geographic dimension as specific regions encounter greater climatic adversity. The farm households in such regions will require special attention to remain successful in initiating their diversification approach and reduce the consumption risks.

[3] https://agricoop.nic.in/sites/default/files/NABARD_Monograph.pdf

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