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Assessment of spatial and temporal dynamics of livelihoods: A methodological perspective*

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Abstract:

Increased international attention to rural poverty alleviation and sustainable development underscores the need for better tools for analyzing the factors and conditions that shape livelihoods and for assessing the livelihood impacts of project- and policy-interventions. The first aspect encompasses important spatial dynamics, while the second addresses both temporal and spatial dynamics. To be effective, such approaches must accommodate the complex and multidimensional nature of livelihood systems by: i) using appropriate indicators of livelihoods outcomes and embracing multiple components of a livelihood system; ii) analyzing the influence of multiple and complex factors, including development interventions; iii) addressing differential impacts by taking appropriate aggregation at the village level. Powerful new geomatics technologies offer new ways to deal with spatial variability, and can be combined with innovative social-science approaches for more efficient socio-economic data collection and analysis. This

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paper discusses key principles for designing appropriate methods and reports lessons learned from our own experience in Jharkhand state, India and Kutai Barat district in East Kalimantan, Indonesia. In these two study areas, with relatively low levels of development and high forest cover, we assessed livelihood systems by: i) using available, broad range data of assets and socio-economic data in indices of development from secondary source; ii) using geomatics tools for sampling and analyses that encompass a range of theoretically important variables (e.g. road access; market access; proximity to large projects; tribal affiliation; topography; land suitability); iii) identifying key factors that characterize within-village stratification and designing household sampling accordingly; iv) aggregating unit of analysis to address differential impacts and relationships among livelihood components. Multilevel regression analysis is used to address hierarchical or differential structure in the data. The paper provides guidance for improved landscape-scale livelihoods analysis and targeting and identifies a way forward for further method improvement.

Keywords:

India, Indonesia, geomatics, sampling techniques, multilevel regression, forest contribution, sustainable livelihoods, household strategy, geographical context, impact evaluation, landscape scale

1. INTRODUCTION

Increased international attention to rural poverty alleviation and sustainable development underscores the need for better tools and methods for assessing livelihoods and livelihoods change. Conceptual and theoretical models have become much more holistic and sophisticated, with wide recognition that poverty and livelihoods encompass much more than income. Inclusion of non-monetary based and shifts in concepts and definition of poverty from lack of income and wealth to lack of asset for livelihood outcome generation in the late 1990s. The sustainable livelihoods framework (Carney 1988; Scoones 1998; Bebbington 1999; Ellis 2000), which conceptualize five capitals: human, physical, natural, financial and social capital as means for producing livelihood outcome, have fundamentally changed the way scholars, policy makers and development agencies (pioneered by Department for International Development (DFID), UK) think about and address poverty. Simultaneously, empowerment and institutional started to gain recognition as important poverty dimensions championed by Sen (1999). Large development

organizations such as the World Bank have adopted these concepts of broader poverty definition and developed approaches around them (e.g. PRSPs).

At the same time, empirical methods have not been able to keep pace with the conceptual development. Data requirements for poverty assessment have always been heavy. Household surveys are notoriously expensive and difficult to do and therefore studies with broad coverage are rare, while extensive government surveys (census) provide insufficient detail. The livelihoods approach provides a much more comprehensive, multi-dimensional framework within which to understand livelihoods. But, individual aspects of livelihoods are difficult to measure. And, as explored by Agrawal and Redford (2006), the various dimensions are not independent of one another and it is not possible to establish equivalence across dimensions, e.g., how do we compare a reduction in childhood mortality with an improvement in forest quality? This makes it difficult to generalize findings even within a location, and more so across locations. Angelsen and Wunder (2006) also points out the distinction (and the need of it) of conceptual analysis and measurement of poverty. They argue that income and consumption are best measurement of poverty in terms of categorization of poverty level, while sustainable livelihoods and five-capital approaches are useful tool for conceptual analysis, especially in particular localities.

Better approaches are needed to assess the current state of livelihoods and to measure change in order to better target policy and project-level interventions and to assess their livelihood impacts. These are of particular importance to local and nation government as well as donors. Moreover, as we increasingly appreciate landscape approaches and more integrated livelihoods, we need better ways to analyze the factors and the conditions that shape livelihoods in order to improve conceptual understanding of the multiple factors that influence livelihoods choices and outcomes, to provide a basis for testing concepts (hypotheses), to provide improved information and analysis for policy development, to facilitate measuring the livelihoods impacts of particular interventions, and to provide a basis for geographic targeting.

Context is always important in any social systems and that geography matters is also well-known. Therefore to be effective, livelihood approaches must accommodate the complex and multidimensional nature of livelihood systems by: i) using available, broad range data of assets and socio-economic data in indices of development from secondary source; ii) using geomatics tools for sampling and analyses that encompass a range of theoretically important variables (e.g. road access; market access; proximity to large projects; tribal affiliation; topography; land

suitability); iii) identifying key factors that characterize within-village stratification and designing household sampling accordingly; iv) aggregating unit of analysis to address differential impacts and relationships among livelihood components. The recent years have witnessed the progresses in livelihood approach, particularly in combining qualitative and quantitative methods, integrating spatial and socio-economic data, poverty mapping and indicators and indices development. Powerful new geomatics technologies offer new ways to deal with spatial variability, and can be combined with innovative social-science approaches for more efficient socio-economic data collection and analysis.

With the recognition of the need to assess livelihoods, appreciation of the complex nature of the system and the advances in the techniques and methodological development, the time probably is ripe for aiming for a livelihoods approach that is cost efficient, comprehensive, integrated, and empirically and theoretically sound. This paper offers a brief overview of the conceptual and theoretical background, and of available approaches and methods. On this basis we develop key principles for designing appropriate methods. We then report lessons learned from our own experience in conducting two different assessments, using related but different approaches, in Jharkhand state, India and in Kutai Barat district in East Kalimantan, Indonesia. We focus on the methodology development, problems encountered and solutions proposed. The paper provides guidance for improved landscape-scale livelihoods analysis and targeting and identifies a way forward for further method improvement.

2. LIVELIHOOD CONCEPTS AND APPROACHES

(a) Definitions of livelihoods and of poverty

Concepts of poverty have advanced markedly in recent years. Agrawal and Redford (2006) trace the development, from early definitions that relied on purely income or nutritional measures. Better understanding of the conditions of the poor led to including measures of longevity, literacy and health and is reflected in an index based measure such as Human Development Index, proposed by UNDP in 1970s. Further, factors such as vulnerability, risk, opportunity, power and voice have been included in definitions of poverty. Sen (1999) were very influential in elaborating the idea that livelihoods are determined by people's capabilities. As de Haan and Zoomers (2005) describe it, there was a basic shift from the notion of poor people as passive victims to one of an active role played by the poor to provide for themselves despite the lack of

access to adequate services and income. A number of authors (Chambers and Conway 1992; Ellis 1998a; Bebbington 1999; Leach et al 1999) developed important insights into environmental aspects, which fed into the sustainable rural livelihoods framework (Scoones 1998; Carney 1998). The framework recognizes the five capitals, human, physical, natural, financial and social as the basic needs for people to make their living. With strong support from large development organizations like DFID and Care International that approach has become widely accepted and adopted as a conceptual framework. The main strengths of what is widely known as the Sustainable Livelihood Approach (SLA) are that it is holistic and people centered. However, as Angelsen and Wunder (2006) pointed out, SLA is useful mostly for conceptual analysis in a local context.

Also important in understanding livelihoods is emerging recognition of the importance of diversification in (especially rural) livelihoods as livelihood strategies. Ellis (2000) has advanced understanding in this area, underlining the importance of multiple income and employment activities in mitigating risk and reducing vulnerability. Diversification can be stemmed from either distress push or demand pull strategies. The recognition has important implications to rural development. For example, as many activities require migration, it is necessary to consider that livelihoods may be lived in multiple locations (Adato and Meinzen-Dick, 2002).

The socio-economic and geographic context is also very important in determining peoples' opportunity sets. Some issues are especially important at the local level; others have broader spatial extent, with sub-national or national relevance. The capabilities of people to take up opportunities and transform them into their livelihood outcome vary according to either households or community assets. Often lack of access to community level asset can impose serious limitation for some individuals or groups to make their livelihoods. Caste, geographical barrier, weak institution and population pressure can be the driving forces of the differential access among individuals or communities.

(b) Livelihood studies: current tools and methods

In general livelihood studies can be categorized into two broad types based on their objectives: (a) those that identify constraint and opportunities, provide options and anticipate consequences/impacts for poverty alleviation by measuring poverty or livelihood status and analyzing reasons for poverty, and (b) those that capture trends and/or measure impacts of

interventions/projects, document lessons learnt and recommend further options. Normally, a type (a) study is conducted once in a 'typical' year, not a year of natural disaster, of economic crisis or of other shocks, while a type (b) study is comprised of series of surveys: a baseline survey prior to a project/intervention of interest and at least another survey after the project/intervention takes place, with taking into account some time lags to allow the intervention to make an impact. Some surveys in the intermediate time steps before a full impact is expected are often useful, especially when impact pathways and processes are of particular importance.

Most studies fall under type (a) studies while studies of type (b) as not as common. Two recent examples of project and intervention impact studies are from Souter et al (2005), which relies on perception and qualitative approach, and Hettige (2006), which tries to measure road impact on livelihoods in several communities. The studies of livelihoods styles, pathways and trajectories that define strategies as having a long term time horizon (de Haan and Zoomers 2005), but we tend to include them into this type of study.

A variety of interesting approaches for assessing and analyzing livelihoods have been developed in recent years. One of the most common approaches is poverty mapping for targeting (e.g., Henninger 1998: Bigman and Fofack 2000; Davis 2003; Elbers et al 2001; Kristjanson et al 2005). These studies use (mainly) secondary data, usually at a national scale, to map the location of poor people according to several definitions (absolute poor; headcount; poverty ratio). The main rationale for this work is to identify areas with high proportions of poor people. The underlying assumption is that poverty alleviation programmes addressed to these areas will reach their targets and have less "leakage" to the non-poor.

Poverty maps, in conjunction with other thematic maps, allow for analyses of the relations between poverty and other features. For example, Bigman and Fofcak 2000 present case studies that integrate data from various sources in a GIS and use village surveys to identify significant community variables that best explain average well-being and prevalence of poverty at the village level. Dewi and Puntodewo (2004) and Dewi et al (2005) show that geographical factors are important in determining village level poverty measured by development index. Sunderlin et al (2006) overlay poverty maps (head-count and ration) of several countries with forest cover maps to do a simple analysis of the co-existence of forests and poverty.

SLA framework driven econometric analysis that combines concepts of five capitals with income as livelihood outcome have been pioneered by Jansen et al (2005, 2006). They compile extensive data sets of different nature from different sources and integrate them in an attempt to analyze relationships between measurable five capitals with income. These are exemplary works which efficiently make use of the luxury of access to a comprehensive dataset cover extensive areas, collected over the years by multiple institutions.

Other authors develop more qualitative approaches for assessing livelihoods impact. Ashley and Carney (1999) and Ashley and Hussein (2000) test an approach specifically designed for project impact assessment. Their approach is based on the SLA framework, and uses participatory methods to investigate impacts on assets and activities. They consider: overall livelihoods strategies and priorities; project impacts on livelihoods; differences of impacts between stakeholders. The approach is limited by the difficulties to compare results and to develop causal links.

Bond and Mukherjee (2002) and Bond et al (2003) also use the livelihoods framework as a base to build an impact assessment tool. Their Livelihoods Assets Tracking Tool (LAST) uses a participatory approach to develop locally relevant indicators of the five capital assets at the household level. It is mainly a tool for detecting change, and again there are problems with attribution of the cause of change, and with comparability across locations. However, as they tool uses a "scaled continuous variables", they speculate that the LAST scores might be used as direct indicators (Bond et al 2003).

(c) Gaps

Huge gap between theoretical and empirical literatures and studies have been recognized (Agarwal and Redford, 2006) and SLA has proven difficult to use empirically. Many of the "capital assets" are difficult to measure (Ellis and Freeman 2005) and suitable indicators for various capital assets vary across context and can not be made equivalent for comparison. Agarwal and Redofrt (2006) summarize this from Baluch and Masset (2003) and Bradshaw and Finch (2003):

> *"It is precisely this lack of mechanisms to establish equivalence or the nature of cause and effect relationships that is reflected in different groups of people being classified as poor or chronically poor depending on the dimension of poverty under consideration"*

Further, existence of causalities among different dimensions is conceptually understood but nature and strength across different contexts are unknown. The difficulties explain the lack of analytical rigor in empirical studies of livelihoods, which mostly rely on descriptive statistics, in which only mean is compared while variability is usually treated as noise rather than anything meaningful. Therefore, conclusions are not easily generalizable.

In addition, SLA usually only encompass specific local context (Angelsen and Wunder 2006), which makes micro to macro policy links difficult to draw (Ellis and Freeman 2005; Rakodi 1999). Also comparison and extrapolation as well as impact assessment beyond qualitative impact pathways are hard to make beyond any specific contexts. These lead to a limited contribution that SLA is capable to make to theory development, while at the same time it is not very cost effective. Other than this, distinction among poverty level, whilst of particular importance for targeting poverty, is not clear cut. Beside of being holistic in terms of sectors and components, incorporating geographical aspects should be useful since often opportunities for generating income is not only cross-sector but also cross-location (ODI 2003).

3. ASSESSMENT OF SPATIAL AND TEMPORAL DYNAMICS OF LIVELIHOODS (ASTL)

In addressing gaps discussed above, we propose a new approach for the assessment of spatial and temporal dynamics of livelihoods (ASTL) that combines SLA framework with income based measure and geography approach (economic geography). The overall objective is to translate livelihoods concepts and theories into a practicable scientific approach that provides a robust and reliable means to analyze current livelihoods relationships, test and develop theory, and assess the impacts of project and policy interventions. Specifically we aim for an approach that: (i) accommodates a broad definition of livelihoods; (ii) recognizes the importance of regional/geographic context; (iii) is theory-driven, rather than purely data-driven; (iv) addresses multiple levels and accommodates context specificity; (v) is parsimonious and technically valid; (vi) is practical and useable; (vii) makes efficient use of available secondary data; (viii) allows comparison across places and time; and (ix) results in some useful analysis for policy development.

(a) Approach for Assessment of Spatial and Temporal dynamics of Livelihoods (ASTL)

In essence, the ASTL approach uses a combination of data from various sources to characterize current livelihoods status and to analyze the relationships between livelihoods status and a range of other characteristics. It uses actual measures of individual variables along with a range of indicators and indices. It allows for extrapolation from detailed data with limited coverage to more general data with broader coverage. It explicitly incorporates context by using GIS technology to link socio-economic data with landscape, infrastructure and other spatially-explicit features. And it relies on robust statistical methods for analyses at different scales, and for the generation of models with predictive power.

Given the diverse and multi-faceted nature of livelihoods, it is necessary to incorporate and utilize a wide range of available data. Census data and other government statistics on household and/or village socio-economic and cultural characteristics are available in most countries. Various maps, satellite images and GIS data-bases covering multiple themes, are increasingly available at relatively low cost. In some cases, there may also be supplementary data available in the form of project baseline data, natural resources inventories (i.e. for integrated conservation and development projects), and surveys conducted by NGOs and other development and conservation agencies. There may still be a need for primary data collection. As discussed, census and other similar data have wide coverage and are collected regularly but typically lack the detail required for a thorough livelihoods assessment.

We set out some guiding principles in designing a sampling frame, deciding on where, whom, when, what and how to measure since we believe that there is no one-size fits all sets of variables or sampling design. The resulting data will be well-suited to meta-analysis, without trading its context specificity for comparability. Further, we propose sets of analytical tools to explore relationships among variables to come up with ways to formalizing the analytical results to be compared across different contexts and geographical regions

(b) Data Collection

Secondary data

Available secondary data serves two main purposes. It provides general information about population and local socio-economic characteristics, and about the local geographic contexts, all of which is very useful in study design as well as in the analysis itself.

Ideally, the following sets of data should be available:

- GIS maps of medium to large scale that provide locations of settlements (villages, towns, cities), village boundaries, road and other transportation networks, land use and land cover (and, if more than one time step is available, land-use and land-cover change), land suitability for agriculture, elevation, climate, land tenure, location of industry and infrastructure projects/enterprises.
- Census data that includes demography, socio-economic data and amenities, in a tabular format that can be linked to a GIS database.

For studies that focus on particular projects and interventions, or on communities with specific characteristics, relevant maps of distribution of those specific interests should be collected. The sources of these data, and level of effort needed to collect and compile them, vary from country to country, but generally for developing countries some significant time and resources are required. Among the issues are access regulations, differing map scales and base maps, language, availability of up-to-date data and reliability. National statistics bureau, census bureau, and other government offices will be a good place to start, and in some occasion, private companies will be the best shot. Most likely land use and land cover change maps are not available or accessible. In that case, some remote sensing analysis will be necessary to conduct in order to produce maps from satellite images, especially in studies where livelihoods are heavily forest and/or land dependent.

Primary data

To avoid bias and myopic view, a livelihood study should cover more than one and, ideally, several communities. Even more so, a study that aims to assess impacts should include communities that are directly, indirectly and not impacted by project or intervention of interest prior to and after a project or an intervention takes place.

Generally in a livelihood study, sampling should be done at least at two levels: village/community, and household. In deciding the number of strata in communities and designing the sample frame, we should aim to capture:

- maximum variation of livelihood activities and assets of the population (source of data: census and available GIS data);

- maximum variation of livelihood options generated locally and regionally (source of data: census, focus group discussion during preliminary survey);
- representative strata that are drawn from the population and decided based on the specific research question and hypotheses to capture the most important distinguishing factors. Variables derived from GIS data can be used to classify villages. An impact assessment study study should add another factor that captures the project and non-project influence. A factorial design may be useful to explicitly cover interaction between strata and project/intervention;
- maximum variation of livelihood activities and assets within particular strata of interest are captured in the sample set. A sound experimental design with randomization and sufficient replication should be conducted. The samples can be selected from the village classification resulting from the GIS analysis above.

Once a set of village samples is selected, a survey is designed to collect data on village and households. Typically a village survey uses a semi-structured interview with key village informants (individuals and/or focus groups) as a way to collect key context information about village conditions, main livelihood activities, the local calendar of activities, land tenure, opportunities and constraints (including recent shocks), village amenities, prices and market. This information is rarely available from secondary sources, but even if it data is available it is worth doing as cross-check to assess the reliability of the secondary data. In case of discrepancies, primary data should be considered more reliable.

The household survey is used to capture detailed information about household demography, income (and/or consumption) and assets. For both types of study, the household survey seeks to capture:

- structural differences, if any, in access to any of the capitals needed by people for making livelihoods. For example, land/resource access may be different for different social groups. A type II study has to take into account that the project/intervention of interest might specifically target some aspect of access or some particular members of a community. Where there is structural heterogeneity within a community, a stratified random sampling of households is needed; otherwise random sampling will be suitable. A PRA to select household samples is required for stratified sampling;
- maximum variation of livelihood activities and assets within the village. Interviews with key informants during reconnaissance visits and a review of available literature should provide

and overview of scope of livelihoods portfolios, to be used as a basis to develop the survey instruments. Later the household samples should be selected randomly within the above strata, if applicable.

A preliminary survey at least in a subset of village samples is usually necessary unless the study areas have been well-studied previously and/or reliable background information is fully available. A follow-up, second visit to test the survey instrument is highly recommended.

Before designing the survey instrument and after a preliminary survey, the team of researchers should have good ideas of what indicators or variables to measure for each of the five capitals at the household and community levels and people's activities in making their livelihoods which are relevant in capturing the widest variation at least within the boundary of study area. Available relevant literatures should also be consulted in deciding on the variables. These variables should then be expressed in question forms that are unambiguous by all means. When it applies, unit and time period of measurement have to be stated explicitly, or when local units are allowed, conversion rate to a standard unit has to be recorded systematically. A questionnaire should be tested at least once in wide set of cases to allow the researches to fix it. Once the questionnaire is finalized, some data entry tools should be prepared carefully. A good data entry procedure is an absolute necessity in getting high quality dataset in reasonable time frame. Another key factor to reliable dataset is a well trained and highly committed survey team and data manager(s).

(c) Analysis and tools

After a dataset is completed and checked for its validity and consistency, exploratory data analysis is a necessary step to look at the data distribution and then to remove outliers and also variables that do not show enough variation in the dataset. In deciding analysis to perform and during the analysis, the following set of criteria should be useful:

- directional relationships assumption must be valid and drawn from comprehensive study of livelihood research within local and regional context;
- distinction between levels of data, e.g., household capabilities from local/regional context, is clear;
- interpretation is comprehensive, valid and carefully done using data and knowledge gathered by various means and from different sources;
- analysis should be designed and theory-driven with anticipated problems and solutions;

- choices of analysis should be made on parsimony principle.

We propose four sequential, general, steps of analysis:

- Index and thematic group development by combining several variables into one, e.g., combining each income variables from each and every particular forest products into a variable income from forest product; cronbach alpha, principal component analysis, biplot are examples of statistical tool that can be used;
- Aggregating the unit of analysis into structural groups, if any, that retain common characteristics , e.g., cluster analysis to group households into household strategy group based on income shares;
- Descriptive analysis on statistics of important variables, how they distribute among unit of analysis and structural groups, associations among variables of interest, e.g., cross-tabulation, anova, box plot;
- Model fitting on livelihood outcome against potential determinant factors with some econometric analysis. Livelihood outcome should be selected carefully to fit the purpose of the study. In many studies, total income is opted.

By the last point, we suggest a step further from descriptive analysis which are commonly conducted in livelihood studies in order to come up with some analytical and somehow predictive results, which are comparable with other study of similar nature. However this should be done with some precautions. We do agree fully with Ellis and Freeman (2005) who consciously devoid of arrows implying causality or feedback in the livelihood framework because:

> *"Livelihoods are complex and changing. Although of course they encompass links between cause and effect, as well as cumulative processes, these cannot be captured adequately in such a simplified representation"*.

Rather than assuming to reveal causalities, by model fitting we try to address association and characterization. We argue that despite of the oversimplification, coming up some model with predictive power is possible and useful due to:

- the accumulated body of work, both conceptual and empirical, that have been produced by researchers and practitioners during the last decade in different continents;

- the specificity and the clear boundary of subset of livelihoods aspects we address, e.g., livelihood outcome, activities and assets, such as distinction among inherent factors to households and external factors are clear;
- links between micro-meso levels are addressed explicitly in the analysis.

In particular we would like to propose the use of multilevel regression modelling for the analysis of livelihoods data. Multilevel regression has been commonly used in social, medical and biological sciences to model data of hierarchical structure, i.e., the existence of different levels of variation. By taking into account hierarchy in the variation, multilevel regression provides tools to understand where and how effects are occurring and therefore it allows more complex questions to be addressed. In addition, ignoring the existence of hierarchy in the analysis can create serious technical problems which lead to invalid conclusions (Rasbash et al. 2005).

Hierarchical dataset is usually resulted from a multistage sampling; for instance a set of villages is sampled within some strata, and then households are sampled within sampled villages. This involves measurement of households as well as village, or in other words households nested within villages. Multilevel regression modeling helps to reveal differences in variance among units of analysis in different groups which comprise the levels, in the case of our example, differences in variance among households (lower level) in different villages (upper level).

Most commonly, data is modeled by either of the two approaches:

- Data aggregation or disaggregation. Under aggregation approach, the upper level of measurement unit serves as the unit of analyis, which use statistics derived from the lower level (e.g., villages are used as the unit of analysis and average size of agricultural land owned by households in a village becomes a village level variable). Whilst under disaggregation approach, the lower level of measurement unit serves as the unit of analysis with assigning some constant values (e.g., households are used as the unit of analysis and every household in a given village is assigned the same number of school facilities). The aggregation approach tends to reduce the statistical power, in which variation among households in a given village is treated as noise and therefore removed. The disaggregation approach violates the independence among unit of analysis, which leads to underestimation of standard error and therefore show significance when it is actually accounted to chance. This modified unit also can cause ecological fallacy, i.e, the actual processes, and therefore relationships, do not actually happen at the specified unit of analysis. For instance size of

agricultural land owned might correlate strongly with strategy at the household level but not at the village level.

- Completely-pooled or unpooled regression fitting. This approach takes only the lower level data and fit the data to either single, completely pooled ordinary regression, or to *n* number of regression lines with varying intercepts depending on the number of the upper level unit, i.e., upper level unit is treated as a dummy variable. In the case of completely pooled ordinary regression, only variation among households is taken into account while village level variation and covariation between household and villages are completely ignored.

Whilst livelihoods undeniably encompass multiple level from micro, meso and macro, and policy to respond to livelihoods needs are of multiple level, we feel that an analysis which enable us to tease apart determinant factors operate at different levels are very useful.

Without meaning to be prescriptive, we think an outline of general steps is useful as a loose guideline for conducting the analysis, or at the least, as an example.

- Decide on indicators of livelihood outcome. This can be total income, income categories, household strategies or other outcome relevant to the local context and also fit to the purpose of the study;
- Decide on meaningful levels that will be explicitly addressed, e.g., 4 levels for national, district, village and households;
- For each level, decide on the variables relevant for the case study (can be from PRA and interview with key informants, literature etc), which cover assets (see figure for some rough ideas of sets of variables);
- Fit in the multilevel regression model and interpret the following with consulting descriptive results and qualitative analysis:
    - which of the capitals at each level contribute significantly to livelihood outcome;
    - which household typology driven mostly by community level factors and what are that particular community factors;
    - which household typology driven mostly by district level factors;
- Link to different level of policy recommendation;
- Meta-analysis, comparisons etc are conducted on the nature and strength of relationships among typology and assets plus other factors

4. TWO CASE STUDIES OF ASTL

In this section we are going to present two livelihood studies we conducted in two study areas which share some common characteristics as well as some contrasting evidences. We follow closely the ASTL approach outlined in the previous section in sampling, data collection and analysis. GIS analysis is used for sampling, data is collected and compiled from different sources, i.e., household and village survey[†], topographical maps, administrative boundary, satellite imageries and census data. In Jharkhand study, village category is determined from GIS data based on accessibilities and forest cover prior to sampling and used to select villages. For Kutai Barat, with more complicated nature and variation in access means, i.e., between different river network and road, GIS data cannot function as a sole data source to categorize villages based on access. Preliminary survey was conducted to systematically find ground information. The results lead us to decide on using cluster sampling based on three eco-zones in the district. K-means and hierarchical cluster analysis are performed to produce and interpret household strategy grouping. Cross-tabulation does help in revealing patterns of household strategies with livelihood outcome category and with some higher level aggregation. As the livelihood outcome we opt for household total income (cash and subsistence) and households are grouped based on income categories using local poverty line[‡] as the baseline (1=lower than poverty line, 2=higher than poverty line but less than twice of poverty line, 3=the rest). Further, we fit the data into some regression analysis using multilevel linear model with household total income as the dependent variables and indicators of five capitals at household and village level as independent variables. Household strategy grouping, village access category, village and district are used as levels in model fittings. We used MLwinN (Rasbash et al. 2004) for the multilevel analysis.

(a) Forest-based livelihoods in Jharkhand, India

This study was initiated in 2004, with the objectives of assessing current livelihoods and forest dependence in forest-fringe communities in the state, and establishing baseline information for subsequent analysis of the impact of a planned Joint Forest Management programme.

Jharkhand is a new state that was created in a bifurcation of former Bihar state. It has a primarily agricultural economy, rolling topography, relatively high levels of forest cover, and a high tribal

[†] Due to a limiting space, survey instruments are not presented here, but they are available by request.
[‡] Poverty line is Rp. 139,000 per person per month for Kutai Barat,2003, based on official statistics (BPS Kutai Barat, 2004), and Rs. 333.07 for Bihar, 2000, based on official statistics (Dhongde, 2003)

population. It is a resource-rich state, with large deposits of minerals and an active mining sector. There is an active and violent maoist insurgency that is concentrated in the remote and more forested areas of the state. Although potentially a wealthy state, a combination of mismanagement, poor service delivery, and violent crime in the hinterland areas has prevented rural infrastructure development such that road and rail networks are very poorly developed and education and health services in rural areas are exceptionally rudimentary.

In these conditions there is considerable reliance on forests and forest products in overall livelihood strategies. The planned JFM programme seeks to engage local people more actively in forest management in order to provide better forest-based livelihoods opportunities and to encourage more effective local forest management and conservation.

Our study was developed to assess current livelihoods conditions in forested areas and analyze the relationships between livelihoods and a variety of other factors. This included a quantitative assessment of total income and assets, with detailed data collection on income sources. Village- and household-level surveys were conducted using a stratified random design. We used GIS to randomly select villages in three classes: high forest access + low road access; high forest access + high road access; low forest access + high road access. There is negligible area in the fourth possible combination (low forest + low road), and this was left out. Figure 1 shows the location and distribution of village samples and their classes in three districts in Jharkhand.

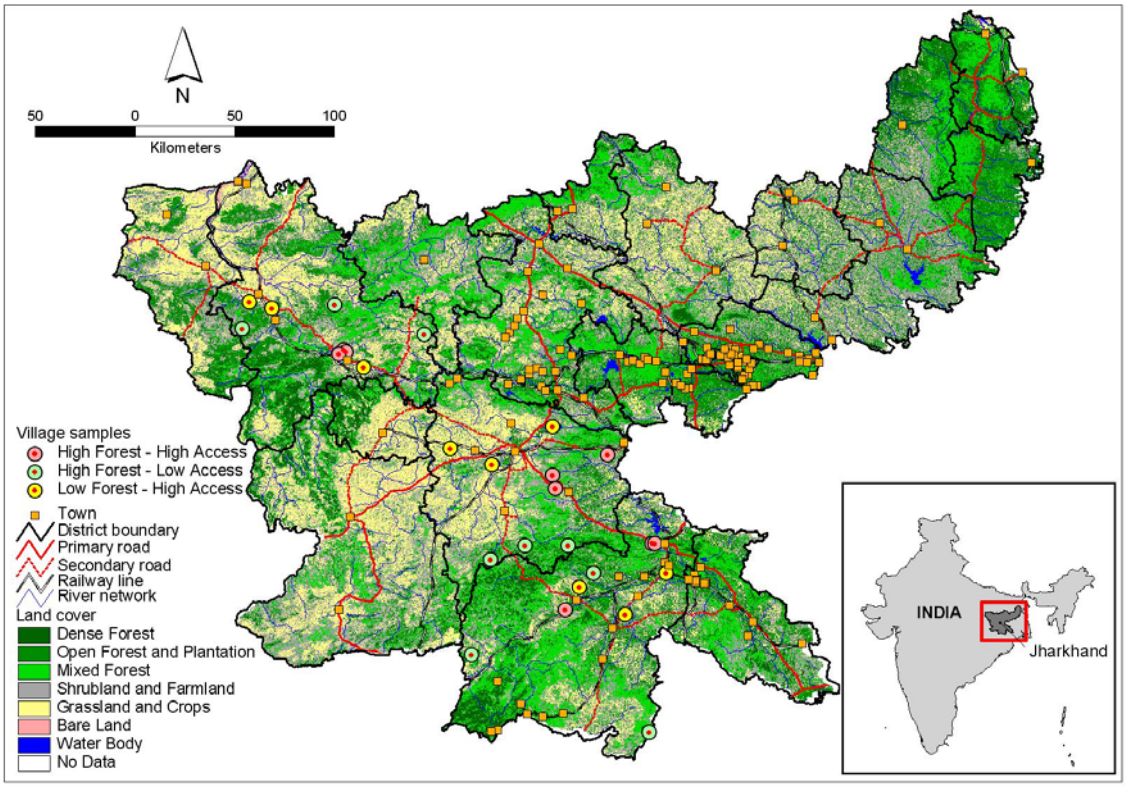

Figure 1. Jharkhand study area

Results and discussion

Cluster analysis of households based on income shares from each sources result in 5 household strategy groups: agriculture based, non-farm based, forest product based, labor and/or gatherer, and livestock based. Table 1 presents the summary statistics of differences among characteristics of income shares from different sources, household physical assets and land owned by livelihood strategy.

Household strategy group does not distribute evenly in each income class. Figure 2a shows the strong tendency of livelihood based households to be found in the highest income class and forest product based in the lowest one. Similarly, there is a strong association between household livelihood strategy and the village category based on access and forest cover. Significantly bigger proportion of households in villages of low forest cover and high access are belong to non-farm based and labor/gatherer group compared to those in villages of high forest cover. In village of high forest cover and high access, non-farm based households is significantly higher than those with high forest cover but low access (Figure 2b). This finding leads us to believe that household

livelihood strategy can in fact serve as an appropriate way to aggregate/group households. We explore this further in the regression analysis.

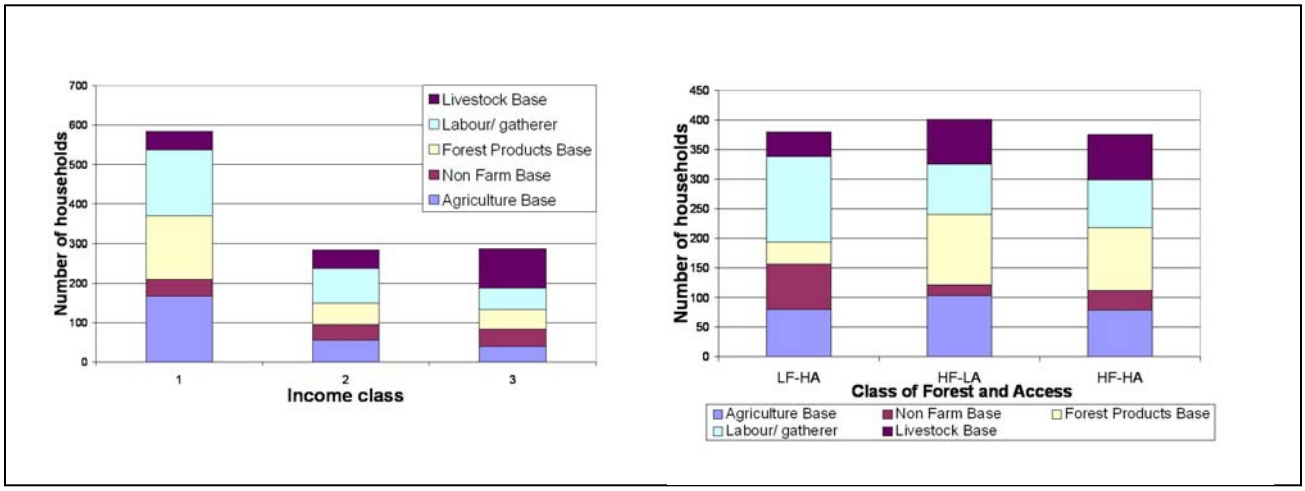

Figure 2. Crosstabulations between household income class and village access with household livelihood strategy (Chi-square d.f. 8; p-value=0.000 for both)

Table 1. Summary statistics of household income, asset and land use by livelihood strategy

Number of households	Livelihood strategy											
	Total sample		Agriculture Base		Non Farm Base		Forest Products Base		Labour/ gatherer		Livestock Base	
	1156		262		127		263		311		193	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Cash Income (Rupees)												
Forest Products	4,013	730	4,015	1,528	1,398	613	8,752	2,697	2,411	492	1,855	610
Agriculture	1,824	665	5,638	2,808	2,375	1,588	115	28	269	73	1,116	330
Non Forest & Non Farm Business	9,737	890	3,260	541	38,111	6,909	1,757	265	12,160	1,086	6,831	765
Forest Bussiness	307	73	373	219	278	108	136	41	424	183	281	90
Labour & Gatherer	1,920	170	1,843	398	979	449	480	84	3,817	412	1,552	399
Transfer income	1,193	165	959	401	2,016	929	498	105	1,729	279	1,051	273
Livestock	737	89	891	186	502	186	264	68	709	208	1,372	282
Total cash income	19,731	1,439	16,979	3,449	45,659	8,198	12,000	2,728	21,519	1,440	14,059	1,205
Subsistence												
Forest Products	5,114	309	2,480	241	1,434	166	11,831	1,203	3,578	200	4,435	287
Agriculture	5,322	500	15,486	2,006	5,448	857	1,366	122	701	81	4,276	435
Livestock	6,159	564	1,074	311	1,140	218	835	211	395	51	32,909	2,589
Total subsistence	16,595	849	19,040	2,172	8,022	1,040	14,032	1,337	4,674	268	41,620	2,916
Asset (Rupees)												
Asset_prod	16,524	1,281	24,271	3,501	26,955	5,226	10,450	1,949	7,328	1,571	22,240	3,050
Asset_Animal	9,910	384	12,770	830	10,134	976	9,352	736	5,643	564	13,518	1,233
Cons_durables	5,292	658	7,785	1,631	7,690	1,527	2,889	548	4,831	1,646	4,347	1,408
Financial_Asset	5,596	422	7,700	1,029	6,644	1,751	3,664	746	3,497	530	8,063	1,109
Total	37,322	1,887	52,527	5,124	51,423	6,965	26,354	2,654	21,298	2,501	48,169	4,861
Don (hectare)												
Don 1	0.442	0.028	0.498	0.048	0.646	0.163	0.372	0.063	0.245	0.031	0.638	0.051
Don 2	0.375	0.025	0.496	0.047	0.547	0.139	0.393	0.057	0.208	0.024	0.346	0.045
Don 3	0.279	0.019	0.365	0.040	0.401	0.110	0.284	0.029	0.241	0.028	0.137	0.026
Total Don	1.106	0.061	1.363	0.107	1.602	0.373	1.063	0.128	0.704	0.065	1.129	0.080

Table 2. Determinants of income level

Explained variable (y_{ijk}): Natural logarithm of total income (in rupees), N = 1156

Household level (level 1)		Household strategy group level (level 2)	Village level (level 3)	
Random coefficients at this level:				
		Constants (β_{0jk}) LAND_TOTAL (β_{1jk}) JFM (β_{2jk})		
Explanatory variables	Coefficient (α)	$V(u_{jk})^a$ = 0.405 -0.013 0.008 -0.255 0.006 0.190	Explanatory variables	Coefficient (α)
HH_MEMBER	-0.154***		POPUL_TOTAL	-0.005
AGE_HHH	0.002		P_FEMALE	9.699
EDU_HHH	0.002		P_SCHEDULE	3.027***
SEX_HHH	0.126		P_ILLIT	-2.767**
ASSET_TOTAL	0.092***		P_MARG_HHIND	-12.466**
A_CONSUMER	0.098		P_MARG_OFFFARM	-1.335
A_FINANCIAL	0.009		P_MARG_OTH	-5.550**
LAND_TOTAL	0.053**		TOLA	-0.249**
L_DON1	-0.216**		SCHOOL	-1.155**
L_MANAGED	0.006*		DIST_MARKET	0.031
TREES_TOTAL	0.001**		DIST_TOWN	-0.027***
T_5YEARS	0.210**		TANK	-1.346***
DIST_FOREST	-0.017*		HANDPUMP	-2.789***
JFM	-0.057		POST_OFF	1.691**
			ROAD_PAVED	1.673***
			ROAD_MUD	-0.184
			FOOT_PATH	0.806**
			IRR_WELL	6.792
			IRR_TANK	-27.861**
			IRR_TOT	-0.067
			NON_CULTIVATE	0.113

*** Coefficient significant at the 1% level.
** Coefficient significant at the 5% level.
* Coefficient significant at the 10% level.
$V(e_{ijk})$ = 0.643 .
[a] $V(u_{jk})$ is the estimated variance-covariance matrix of the error term at household strategy level

For the model fitting we explored livelihood strategy, village, village class and district as levels in the hierarchical models. Table 2 presents the best fit model resulted from our extensive exercises using variables listed in table 3 (Appendix). The following are some immediate interpretations from the best fit regression model:

- Household and village level variables explain 83% of the total variations (0.643 from 0.778) in the household income per capita. Household strategy grouping explains the rest (17%) of the variations. Neither district nor village category helps to explain variation in the household income;
- Human capital at the household level does not correlate positively with the income level; in fact the higher the number of household member is the lower the total income per

capita. The exploratory data analysis shows that the number of household members correlate positively and strongly with the number of household members aged less than 15 years. This common age structure in the households explains the pattern since children contribute to lowering household income per capita but do not contribute to producing income;

- Physical asset at the household level contributes positively to income;
- Natural capital at the household level, in terms of area of total land owned and land managed associate positively and significantly with income level. However, the proportion of land owned which is categorized under don 1 (fertile, irrigated land) shows unexpected pattern. The reasons for this might due to the facts that this is a relative measure rather than absolute and also where livestock is important, fertile agricultural land might not the key to income and also potentially irrigated status does not really guarantee the actual productivity. Total number of trees and mature trees owned associate positively and strongly with income level. This shows that agroforest contributes to income. The association between access to forest and income is not very strong but the tendency is that the closer a household to a forest the higher the income level is;
- Social capital in terms of household JFM involvement does not show any significant relationship with income, however when random coefficient is taken into account at household strategy group level, JFM explains some substantial percentage of variations. It strongly covariates negatively with constants/intercepts. This shows that relationship between JFM and household income levels is different for different household strategy groups. Similarly, but less strongly, total land owned associates with household income level differently in different household strategy group;
- At the community level, human capital shows interesting relationships with income level. The higher the proportion of scheduled caste population in a village the higher the income level of households live in the village. The opposite patterns are evident with proportion of illiterate population, marginal households whose source of income is households industry, off farm labor and others. The higher the number of tola/hamlets the lower household income level. These could be due to different reasons, i.e., high number of migrants with lower income, land quality is poor or water is limited which drives population to spread geographically;
- Number of schools in a village negatively associates with household income, which perhaps reflects that rather than forming one natural village, the combination of hamlets might only be an administrative status. Another possibility is the number of schools does

not always reflect the quality of education services since there is other important determining factors such as quality of teachers and teacher absenteeism;

- Physical assets, in terms of distance to town, show that with better access to town, household income is higher. The existence of paved road shows positive correlation. Foot path, with lower coefficient than paved road, also shows positive association, but not mud road. The possible explanation is that the foot path is usable for transporting livestock for the whole year while mud road most probably is seasonal. Water related facilities do not show the expected pattern (number of tanks, hand pumps and irrigated areas by tanks show negative associations with household income). Particularly for hand pumps, it is possible that the census only considers the number of facilities available in a village without taking into account the functionalities of the facilities. In some villages we visited, many of the hand pumps are not in working conditions. Number of tanks and the area of land irrigated by tank are negatively associated with household income. The pattern is not so puzzling if we consider that water harvesting means by tanks are not the best alternative such that only in marginalized areas people are reliance on tanks. Therefore the existence of tanks shows that water is limiting in the areas and so does other facilities. Another guess is inequality in distribution, where tanks are only owned and dominated by a few privileged households.

(b) The impacts of road development in East Kalimantan, Indonesia

This study is built on a series of studies conducted in the area that looked at various aspects of forest-based livelihoods. We focus on the impact of road building/improvement, as a means of informing policy. This is of particular importance because of the active process of infrastructure development in the state. Temporal changes are ‘simulated’ by spatial changes by covering a large number of communities and extensive spatial coverage to ensure that variation is captured.

The study area is remote, with limited road access and with high reliance on river transport. It is a forest and mineral rich area with low population density as a mixture of indigenous (several Dayak tribes) and immigrants from other areas of Indonesia. Public investment has been limited, but private investment for natural resource extraction, especially logging and mining, and plantation development has been extensive and intensive. Land is abundant and labor tends to be a limiting factor on agricultural production, however in some occasion land pressure is experienced due to competing land uses by the local people and private companies. Households

depend on rice-based swidden agriculture and some permanent agriculture, forest products, agroforestry, fishing, off farm labor, and non-farm employment.

The survey was conducted in 2004/5 in Kutai Barat and Pasir districts and it covered 42 villages from a total of 200 villages in the districts, and involved 840 respondents. Within each village, a minimum of 10% of the total number of households were randomly selected and surveyed. Figure 3 shows the study area and the village samples.

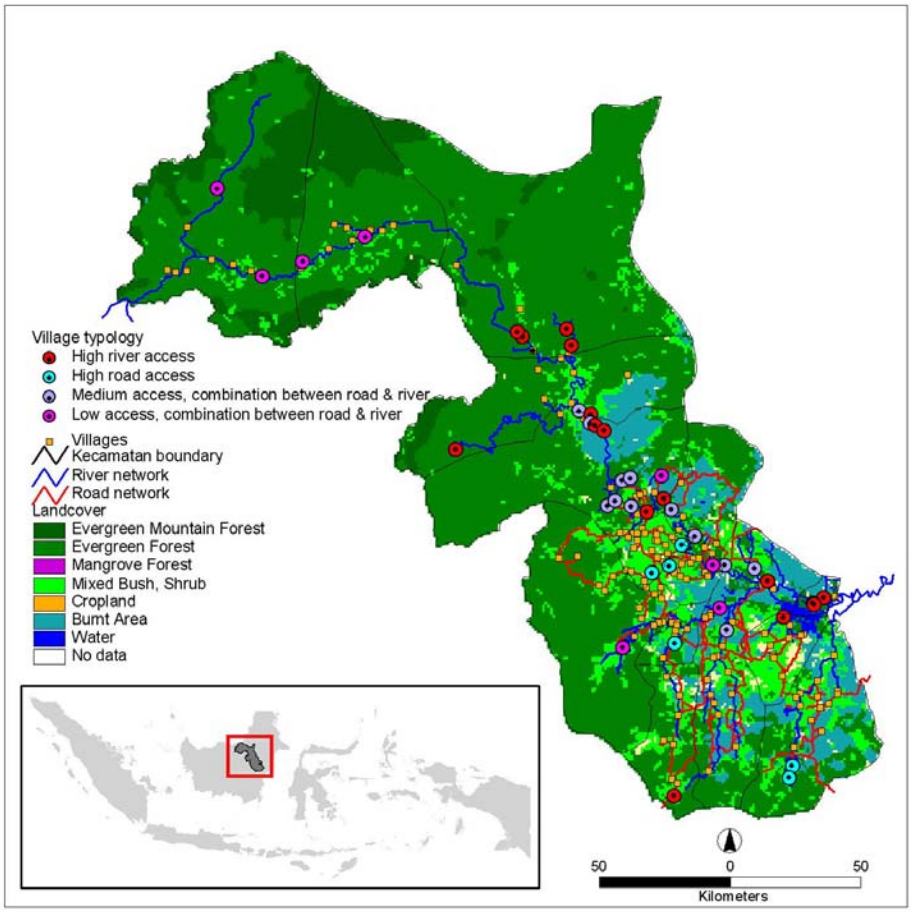

Figure 3. Kutai Barat study area

Results and discussion

Five household strategy groups produced by the cluster analysis based on income sources and land uses are: mixed income, paddy rice based, non farm based, agroforest based and off farm based. Table 4 presents the summary statistics of differences among characteristics of income shares from different sources, household physical assets and portfolio of land uses by livelihood strategy.

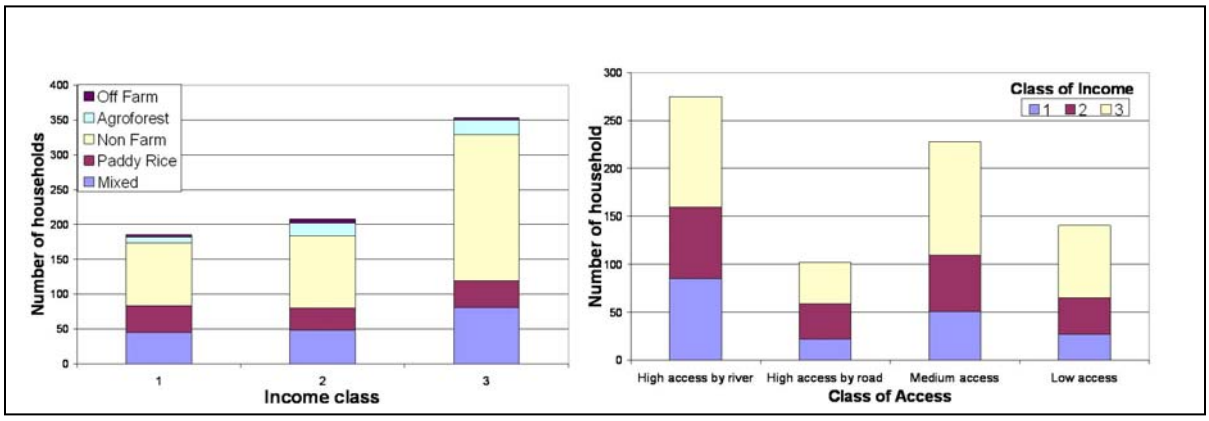

Figure 4. Crosstabulation between household income class and village access category with household livelihood strategy (Chi-square d.f.8, p-value= 0.021, Chi-square d.f. 12, p-value= 0.000 respectively)

Table 4. Summary statistics regarding income, asset and land use, by livelihood strategy

Number of households	Livelihood strategy											
	Total		Mixed		Paddy Rice		Non Farm		Agroforest		Off Farm	
	746		174		108		405		47		12	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Income (Rupiah)												
Rice	70,891	3,662	122,725	9,178	101,638	10,523	43,389	3,783	57,475	12,720	23,333	15,731
Crop	152,457	11,909	279,584	31,221	307,610	48,163	71,160	9,112	58,805	12,750	23,333	15,731
Timber	110,076	23,330	170,275	32,468	425,692	148,360	13,739	2,072	17,200	4,381	11,806	4,583
Non Timber Forest Products (NTFP)	139,681	20,806	204,313	36,356	564,006	119,651	19,108	7,060	0	0	0	0
Agroforest	151,473	20,909	227,089	54,006	49,782	16,826	38,483	19,495	1,117,519	133,085	0	0
Off Farm	23,300	5,513	22,241	7,449	22,037	8,066	1,852	1,023	883	883	861,667	206,951
Non Farm	1,086,112	57,565	787,250	79,546	99,512	25,904	1,632,039	90,345	32,128	11,039	2,083	2,083
Total Income	1,663,099	66,813	1,690,752	137,620	1,468,640	188,073	1,776,380	93,444	1,226,535	139,718	898,889	210,020
Income portfolio	1.453	0.019	2.190	0.030	1.387	0.029	1.193	0.014	1.211	0.033	1.095	0.040
Asset (Rupiah)												
Transportation asset	5,363,852	263,333	6,124,205	603,556	4,325,879	650,482	5,459,977	356,119	4,251,851	795,384	4,791,574	1,465,378
Production asset	2,068,164	143,111	2,405,783	279,080	2,541,772	482,885	1,945,183	190,880	876,284	288,662	1,729,012	795,158
Livestock asset	343,096	66,185	663,622	219,508	461,781	226,757	175,872	39,427	197,708	109,159	840,561	754,185
Consumer durables	2,220,957	89,194	2,052,430	191,342	1,588,656	208,388	2,506,126	120,906	2,019,259	356,822	1,520,828	683,355
Processing asset	281,711	43,263	455,663	137,217	265,693	113,374	234,357	43,383	138,547	64,785	62,479	32,629
Financial asset	913,458	137,621	1,430,485	399,753	157,414	102,893	1,006,260	181,979	170,207	112,034	0	0
Total Asset	11,197,015	435,123	13,138,376	1,099,956	9,349,579	1,161,487	11,332,526	540,118	7,660,170	1,046,844	8,953,333	3,294,816
Land use (hectare)												
paddy field	0.728	0.031	1.157	0.073	0.998	0.073	0.489	0.036	0.720	0.100	0.208	0.114
Rubber field	0.331	0.028	0.587	0.078	0.244	0.056	0.123	0.023	1.376	0.142	0.292	0.156
Rattan field	0.430	0.046	0.759	0.127	0.236	0.061	0.301	0.051	0.761	0.291	0.458	0.257
Export plant field	0.028	0.009	0.104	0.035	0.007	0.005	0.003	0.003	0.021	0.021	0.000	0.000
Timber extraction field	0.001	0.001	0.000	0.000	0.009	0.009	0.000	0.000	0.000	0.000	0.000	0.000
Fruit garden	0.223	0.022	0.261	0.047	0.206	0.043	0.228	0.033	0.106	0.053	0.125	0.125
Total Land use	1.739	0.075	2.867	0.192	1.685	0.147	1.144	0.078	2.985	0.362	1.083	0.412

Table 5. Determinants of income level

Explained variable (y_{ijk}): Natural logarithm of income per capita (in rupiahs), N = 730

Household level		Village level	
Explanatory variables	Coefficient (α)	Explanatory variables	Coefficient (α)
HH_MEMBER	0.063***	STUDENT_ENR	-0.002
AGE_HHH	-0.001	BIKE	0.035**
EDU_HHH	0.099***	BIKE_MOTOR	0.000
ASSET_TOTAL	0.098***	CANOE_MOTOR	0.001
A_PRODUCT	-0.322***	OTH_TRANSPORT	-0.093*
A_PROCESS	0.042	DIST_SUBDIST	0.000
LAND_TOTAL	0.034**	DIST_DISTRICT	0.006
L_EXPORT	0.257	FOREST	-0.005
L_TIMBER	-4.369	SHRUBS	0.024
EXPENSE_TOTAL	0.329**	CROPS	-0.526*
E_CLOTHES	1.938***	AGRIC_SUIT	0.000
E_HEALTH	0.391*	POPULATION	0.000
E_EDUCATION	0.029	FARMER	0.001
VISIT_TOTAL	-0.002	HEALTH_FAC	0.001
V_GOVT	-0.006	SCHOOL_P	0.000
V_COMM	-0.086***	SCHOOL_S	-0.033*
COLLECTIVE	0.010		

Random coefficient of intercepts (β_{0jk}) is 7.928 + v_{0k} +u_{0jk}, $V(e_{ijk})$ = 0.518, $V(u_{0jk})$ = 0.103, $V(v_{0k})$ = 0.071

Table 5 presents the best fit model from the list of variables given in table 6 (Appendix). Brief interpretation of results are as follows:

- Household and village level variables explain 75% of the total variations (0.518 from 0.692) in the household income per capita. The remaining variations are explained by household strategy grouping (15%) and village access category (10%);
- Human capital at the household level (number of household members and education of household head) correlate positively with the income level;
- Physical capital at the household level also shown positive association with income level, however the bigger the proportion of physical capital is in the form of production asset (mostly agricultural tools/equipments for planting and harvesting), the lower the income level is;
- Natural capital at the household level, in terms of land owned, shows significant positive association with income level;
- Social capital does not show much interesting pattern; number of community meetings attended in the other villages correlates negatively with income level. Presumably the inter-villages meeting held when there are some conflicts;
- At the village level, the five capitals do not show much association with the income level. The only highly significant variable associate with the income level is number of bikes passed the main road during the peak hour of a market day.

(c) General discussions

Both study show that household strategy matters in explaining relationships between 5 capital variables and income level. In the road study, the village access category (by river, by road, or by combination of road and river) also help in explaining the relationships. In Jharkhand case, more village level capitals demonstrate stronger and significant relationships with income level compared to those in Kutai Barat, while in Kutai Barat household strategy and means of physical access associate more with income level. It seems that village conditions and characteristics are more homogeneous in determining household income level in Kutai Barat compared to those in Jharkhand, except for the public investment in infrastructure. This probably also reflects the stronger coherence of a village as one community unit in Kutai Barat than in Jharkhand. The latter probably treat a group of hamlets as a village more for administrative purposes rather than a homogeneous community with regards to livelihood opportunities and constraints.

In summary, it seems that in Jharkhand case, community level natural capital is limiting, institutions like JFM should be more efficient, coherence among hamlets should be improved. Livestock is an important source of income and shown to be associated strongly with high income level. However, trade-offs between livelihoods and forest protection should be considered in responding to this pattern. Kutai Barat, in contrast, does not show that community level natural capital is not limiting. Access category is important and therefore government should recognize the differences in needs for the kind of income opportunity in each access category. Social capital does not seem to be strong while household natural capital is important.

(d) Lessons learnt from case studies of ASTL

Due to the multidimensionality and interdependency nature of five capitals we should laterally look for better ways to summarize. Comparison and generalization across contexts are better be addressed by comparing the nature and strength of relationships among dimensions. The two advantages of these are that broad policy implication can be made and theoretical understanding is improved to set further research direction.

Cross-locational issues, contexts and geography should be taken into account by appropriate sampling. Evidences of significant associations of household strategies with village access class and income level shown from the case studies highlight the importance of a sampling design, without it such important pattern will not be revealed. Appropriate aggregation is important in addressing hierarchical structure of the data properly. Together with the analysis of determining factors of livelihood outcomes, ASTL can offer tangible results to policy development at different level, including links between micro to macro policy.

ASTL, as briefly discussed in this paper, offer ways to embrace the above issues without being too rigid and prescriptive. It all allows context specifity, while maintaining the multidimensional natures of livelihood systems. The approach recognizes and treats dimensions as interrelated with explicitly address hierarchy in the data structure in a flexible ways.

Despite of the strength, ASTL shares the weaknesses of other quantitative econometric approaches such as it excludes important variables in the equation due to their un-quantifiable or un-measurable characteristics or overlooked by the researchers due to their location-specific nature. For areas with strong globalization influence, there is a need to include another level of

variables which might be confounding with other levels. Some shock or new emergence trends which were not covered by the study may change the stationarity of the system such that the model needs some updates. And also because of the multidisciplinary nature the approach needs some mixed technical skills of everything and also some deep understanding of the area under study on top of broad knowledge of the livelihood issues as a whole. Needless to say, despite of the effort to outline some guiding principles of ASTL approach, there is no one size fits all approach since it depends on objectives of some studies. The last but not least is that data collection needs substantial resources and is time consuming.

4. CONCLUSION

In recognition of the gaps between current livelihood approach and the needs, we try to embrace econometric analysis into SLA framework by offering the assessment of spatial and temporal dynamic livelihood (ASTL) approach. While focusing more on providing principles and guideline, ASTL is far from being prescriptive. It argues that a proper sampling design will help addressing extrapolation problems, hierarchical structure in the system and context inclusion in a cost-effective manner. The multiple level analysis on the determinant factors of livelihood outcome serves two purposes: (i) it produces tangible results for policy development at different level, (ii) it enable comparison across context such that it can contribute to theory development as well as help to set future research direction. The two case studies from India and Indonesia briefly illustrate ASTL in practice. In summary ASTL offers an approach with the following advantages: (i) not too rigid and prescriptive, allowing for context specifity, (ii) maintaining the multidimensional natures, (iii) appreciate and treat dimensions as interrelated in the analysis, (iv) addressing hierarchical-multiple level explicitly but flexibly.

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APPENDIX

Table 3. Definitions and sources of regression variables

Variable name	Definition	Source
Household level		
HH_MEMBER	Number of household members	Household survey
AGE_HHH	Age of household head	Household survey
EDU_HHH	Education years of household head	Household survey
SEX_HHH	Sex of household head	Household survey
ASSET_TOTAL	Natural logarithm of total assets (rupees)	Household survey
A_CONSUMER	Proportion of total asset which is in the form of consumer durables	Household survey
A_FINANCIAL	Proportion of total asset which is in the form of financial	Household survey
LAND_TOTAL	Total land owned (hectares)	Household survey
L_DON1	Proportion of land owned which is of don 1	Household survey
L_MANAGED	Proportion of managed land during the last one year	Household survey
TREES_TOTAL	Total number of trees owned	Household survey
T_5YEARS	Proportion of trees older than 5 years	Household survey
DIST_FOREST	Distance from house to closest forest (km)	Household survey
JFM	Involvement in JFM activity	Household survey
Village level		
POPUL_TOTAL	Total number of population	Census
P_FEMALE	Proportion of female population	Census
P_SCHEDULE	Proportion of scheduled caste population	Census
P_ILLIT	Proportion of illiterate populations	Census
P_MARG_HHIND	Proportion of marginal households whose source of income is household industry	Census
P_MARG_OFFFARM	Proportion of marginal households whose source of income is farm labour	Census
P_MARG_OTH	Proportion of marginal household with other source of income	Census
TOLA	Number of hamlets	Census
SCHOOL	Number of schools	Village survey
DIST_MARKET	Distance to the closest main market (km)	Village survey
DIST_TOWN	Distance to the closest town (km)	Census
TANK	Total number of tanks	Census
HANDPUMP	Total number of hand pumps	Census
POST_OFF	Existence of post office	Census
ROAD_PAVED	Existence of paved road as the best accessibility means in the village	Village survey
ROAD_MUD	Existence of mud road as the best accessibility means in the village	Village survey
FOOT_PATH	Existence of foot path as the best accessibility means in the village	Village survey
IRR_WELL	Area of land per capita irrigated by well without electricity (ha)	Census

IRR_TANK	Area of land per capita irrigated by tank (ha)	Census
IRR_TOT	Total irrigated area per capita (ha)	Census
NON_CULTIVATE	Total area not suitable for cultivation per capita (ha)	Census

Table 6. Definitions and sources of regression variables

Variable name	Definition	Source
Household level		
HH_MEMBER	Number of household members	Household survey
AGE_HHH	Age of household head	Household survey
EDU_HHH	Education years of household head	Household survey
ASSET_TOTAL	Natural logarithm of total assets (rupiahs)	Household survey
A_PRODUCT	Proportion of total asset which is production asset	Household survey
A_PROCESS	Proportion of total asset which is processing asset	Household survey
LAND_TOTAL	Total land owned (hectares)	Household survey
L_EXPORT	Proportion of land planted with export commodities	Household survey
L_TIMBER	Proportion of land where timber is extracted	Household survey
EXPENSE_TOTAL	Natural logarithm of total expenses per capita (rupiahs) during one year	Household survey
E_CLOTHES	Proportion of expenses spent for clothing	Household survey
E_HEALTH	Proportion of expenses spent for health	Household survey
E_EDUCATION	Proportion of expenses spent for schooling	Household survey
VISIT_TOTAL	Number of total trips made during one year	Household survey
V_GOVT	Proportion of trips made to visit government offices	Household survey
V_COMM	Proportion of trips made for community meetings	Household survey
COLLECTIVE	Involvement in collective actions	Household survey
Village level		
STUDENT_ENR	School enrollment rate of school age children	Village survey
BIKE	Number of bikes passed the main road during the peak hour in a market day	Transport survey
BIKE_MOTOR	Number of motorbikes passed the main road during the peak hour in a market day	Transport survey
CANOE_MOTOR	Number of motorized canoes passed the main river during the peak hour in a market day	Transport survey
OTH_TRANSPORT	Number of other vehicles passed the main road and river during the peak hour in a market day	Transport survey
DIST_SUBDIST	Distance to closest subdistrict capital (kms)	GIS derivation
DIST_DISTRICT	Distance to closet district capital (kms)	GIS derivation
FOREST	Reachable forest area from settlement, road or river (sq. km)	GIS derivation
SHRUBS	Reachable shrub area from settlement, road or river (sq. km)	GIS derivation
CROPS	Reachable agricultural area from settlement, road or river (sq. km)	GIS derivation
AGRIC_SUIT	Reachable area that is suitable for agriculture from settlement, road or river (sq. km)	GIS derivation
POPULATION	Total number of population (households)	Census
FARMER	Proportion of farming households	Census
HEALTH_FAC	Frequencies of health services	Census
SCHOOL_P	Number of primary schools	Census
SCHOOL_S	Number of secondary schools	Census