Potential for Small Area Estimation and Poverty Mapping at Constituency and at Gewog / Town Level in Bhutan

Feasibility Report
Phases 1 and 2

Professor Stephen Haslett
Dr Geoffrey Jones
Massey University
New Zealand

2 December 2008

Summary

The general conclusion of this report is that, based on the 2005 Population and Housing Census of Bhutan (PHCB2005) and the 2007 Bhutan Living Standard Survey (BLSS2007), small area estimation of poverty incidence, gap, and severity, and undernourishment are feasible for Bhutan at constituency level (of which there are 47). Constituencies consist of gewogs in rural areas, and towns in urban areas. Such small area estimates will also be feasible for the larger gewogs and towns, and are likely to be feasible for the majority of the remaining gewogs and towns (of which there are approximately 250 in total) even if they contain no sampled households from BLSS2007. If no small area estimates of undernourishment, and poverty incidence, gap and severity, are possible for the smallest towns and gewogs, suitable amalgamation of geographically adjacent areas should still provide suitably accurate small area estimates for poverty maps.

Additional evidence of feasibility for small area estimation of poverty is provided using poverty incidence measures at constituency level based only on BLSS2007 data. These direct estimates of rural poverty incidence and their standard errors (adjusted downward for the without-replacement sampling used in BLSS2007) are provided as part of this report at the specific request of the Bhutan National Happiness Commission as an aid to interim planning decisions.

It is recommended that funding be sought immediately from a variety of international donors for a full scale small area estimation study in Bhutan based on the 2005 census and BLSS2007 data.

Executive Summary

1. Small area estimation (SAE) is a mathematical technique to extract more detailed information from existing data sources by statistical modelling. The methodology is important because it produces finer level information than is possible for a sample survey analysed by standard methods, for poverty related variables that are not collected in the census. Small area estimates are often illustrated geographically using poverty maps. The cost of small area studies can be saved many times over by having this better poverty information at a finer level for use in aid allocation. The method is also important for providing comparisons of poverty at a fine level in different countries.

2. This report provides a brief summary of Phases 1 and 2 of a study, undertaken by staff from Massey University, New Zealand, to assess feasibility for small area estimation of poverty and poverty mapping in Bhutan at constituency and at gewog / town level. This report includes both background (Phase 1) and statistical analysis of survey data (Phase 2), but does not include small area estimates of poverty based on both survey and census data; such estimation and the consequent poverty maps needs to be a separately funded exercise.

3. The particular aspects of poverty that are considered here are poverty incidence, gap and severity relative to the national poverty line, with an additional focus on undernourishment (as measured by kilocalorie consumption). While the last of these four strongly reflects the food security interests and concerns of the sponsor of the feasibility study, which is the World Food Programme, this feasibility report also recognises the importance to a wide range of international aid agencies of all four measures, and the centrality of the first three to sound economic measurement of poverty.

4. For Bhutan, the data sources considered were the Population and Housing Census of Bhutan (PHCB) which was conducted in 2005, and the second Bhutan Living Standard Survey (BLSS) conducted in 2007.

5. This feasibility report includes preliminary statistical model fitting using the 2007 BLSS, which is Phase 2 of the Massey University / WFP Bhutan contract. The analyses in this report provide a detailed statistical assessment of poverty mapping feasibility.

6. The general conclusion of this report is that for Bhutan small area estimation of poverty incidence, gap and severity, and also undernourishment are possible for constituencies and larger gewogs, and also for smaller gewogs subject to appropriate amalgamation of geographically adjacent areas.

7. This conclusion is subject to resolution of geographical coding issues by using an integrated system linking the codes used to designate various administrative levels, (including: dzongkhag; dungkhag; constituency; gewog; or town; chiwogs in rural areas; and urban-blocks in urban areas), and the availability of this coding information to all members of the team undertaking the small area estimation.

8. No poverty estimates using small area estimation techniques are produced as part of this feasibility study. As noted above, such estimates require further funding

beyond the feasibility phase, and also the BLSS2007 data, the PHCB2005, and the integrated coding for dzongkhag (ie districts), gewogs / towns, and chiwogs / urban-blocks.

9. Additional evidence of feasibility for small area estimation of poverty is provided using poverty incidence measures at constituency level based only on BLSS2007 data. These direct estimates of rural poverty incidence and their standard errors (adjusted downward for the without-replacement sampling used in BLSS2007) are provided in this report at the specific request of the Bhutan National Happiness Commission as an aid to interim planning decisions.

10. Funding should be sought immediately from a variety of international donors for a full scale small area estimation study in Bhutan based on the 2005 census and BLSS2007 data.

11. The completion of this report follows extensive consultation with the Bhutan National Statistics Bureau (NSB) the Bhutan Gross National Happiness Commission (GNHC), and World Food Programme (WFP) - which commissioned this research - in Thimphu, Bhutan, 26 September - 8 October 2008. The authors are grateful for these extensive contributions. Viewpoints and opinions expressed in this report do not however necessarily reflect those of all or any of the organisations consulted.

1. Introduction

This assessment is in two phases, which together provide a feasibility assessment of the potential for small area estimation (SAE) in Bhutan of poverty incidence, gap, and severity, plus undernourishment measured via kilocalorie consumption. However neither of these phases includes provision of small area estimates. Both phases were completed during the period July to October 2008.

Phase One involved:

- Analysis of existing research and information on food security necessary for statistical assessment of kilocalorie consumption for small area estimation in Bhutan, based on reference material supplied by the World Food Programme and existing knowledge of small area estimation methods. The nutritional aspects of methods of estimating kilocalories from expenditure data did not form part of this phase.
- Analysis of relevant Bhutan questionnaires (in English) from the population census (PHCB2005), the national living standard survey (BLSS2007) which included household expenditure data, and other information supplied by the World Food Programme.
- Identification and listing of questions asked in census, and the survey that *prima facie* are similar enough to be used for small area estimation of poverty incidence, gap and severity, and kilocalorie consumption. This investigation was conducted in conjunction with the Bhutan National Statistics Bureau (NSB) and was based directly on the questionnaires, which were conducted in English.
- The interim report of Phase 1 has been integrated into this report.

Phase Two involved:

- Identification of variables in both survey and census which are potentially useful for small area estimation of poverty incidence, gap, severity, and kilocalorie consumption, in conjunction with NSB.
- Developing and testing preliminary statistical regression models for expenditure (including estimation of variance components at the different geographical levels) for poverty incidence, gap, and severity, plus kilocalories based only on the survey data, supplied by NSB.
- Identification, in conjunction with the Bhutan NSB, of any Administrative Unit (area) code changes that may complicate any later analysis of the statistical relationship between survey and census data. (This analysis, *per se*, was outside the scope of this study).
- Comment on the potential impact of these statistical analyses and boundary changes on small area estimation of poverty.
- Preparation of the final feasibility report.

Completion of Phases 1 and 2 has included consultation and discussion with the following people and organisations:

National Statistics Bureau

Kuenga Tshering, Director
Khandu Dorji, Senior Statistical Officer
Phu Sangay, Senior Statistical Officer
Thinley Jyamtsho Wangdi, Senior Statistical Officer
Cheku Dorji, Statistical Officer
Peden , Assistant ICT Officer
Tshering Choden, Assistant ICT Officer
Nema Deki Sherpa, ICT Technician

Gross National Happiness Commission

Thinley Namgyel, Chief Programme Officer, Development Cooperation Division

United Nations Development Programme

Doley Tshering, Head, Poverty and MDGs, Bhutan

United Nations World Food Programme

Leo van der Velden, Country Director, Bhutan
Udaya Sharma, Programme Unit, Bhutan
Michael Sheinkman, Senior Regional Programme Advisor, Vulnerability Analysis and Mapping (VAM), WFP Bureau for Asia, Thailand

Note that, while additional people were approached, the limited period of the visits to Thimphu, Bhutan during October 2008 meant not all were available. Nevertheless, every effort has been made to ensure a full range of opinion was canvassed and considered in the preparation of this final feasibility report. This effort was aided by the uniformity of opinion that there is need for updated small area estimates of poverty in Bhutan for planning and resource allocation.

2. Background

Small area estimation is a mathematical and statistical method that models data collected from one or more data sources, to produce estimates, for example of poverty, that are more accurate at small area level than using only data collected from each small area. The additional accuracy is achieved in many such models by "borrowing strength" for the estimate for a particular small area by using information from areas to which it is similar. Some small area estimation techniques combine data from different sources. For example, census and new survey information may be combined to update estimates from the original census. Alternatively, and this is more usually the case for poverty estimates, a statistical model is fitted to survey data collected around the same time as the census, and this model is used to predict a variable not collected in the census, based on variables that are collected in both survey and census. In poverty studies, the most usual variable predicted is income or expenditure (or its logarithm) based on a model which includes education, age of household members, number of people in the household and type of house construction, among other variables. The poverty estimates are often mapped in detail, which is why this technique is sometimes given the generic title, poverty mapping. The maps can make interpretation simpler, but the central point is not the maps *per* se, but that poverty can be assessed at a much finer level at a much lower cost than by increasing the sample size sufficiently or rerunning the census. The statistical modelling has a cost, of course, but this can be saved many times over by having better information at a finer level and maps for use in aid allocation.

Numerous small area estimation methods are detailed in Rao (2003). One method, documented, supported and advocated by the World Bank for small area estimation of income or expenditure poverty is that developed by (Elbers, Lanjouw and Lanjouw, 2001, 2003). This is now available as free software (PovMap – Zhao, 2006) from the World Bank website. By fitting a statistical model for expenditure (or income) on the logarithmic scale to sample information, applying the model to the census data to predict expenditure (or income) at household level for all households, and summing back-transformations of the predictions, small area estimates using the World Bank method for poverty incidence, gap and severity can be derived, and mapped at small area level. Variations of the Elbers, Lanjouw and Lanjouw (ELL) method have been implemented for the World Bank in a number of other countries including Thailand (Healy, 2003), South Africa (Alderman et al., 2002), Brazil (Elbers et al. 2001), the Philippines (Haslett and Jones, 2005), and for the World Food Programme in Bangladesh (Jones and Haslett, 2003) and Nepal (Jones, Haslett and Parajuli, 2006)

The Bhutan Population and Housing Census was conducted in 2005, and the Bhutan Living Standard Survey in 2007. This sets the stage for feasibility assessment of small area estimation of poverty. There has been no previous small area estimation of poverty in Bhutan.

There have been development policies in place in Bhutan since the 1960s. In the last ten years the focus on food is illustrated by the WFP publication of Van der Velden (1999) who wrote about the poor in Bhutan and their food requirements. He noted that situation looked well on average, but there were people in situations (eg people in food-insecure areas, in areas of high stunting-malnutrition, in remote areas, the landless) who were recognized as having continuing problems. The FAO (2001) publication outlined the general status of the system of food and agriculture by providing a summary of food and agricultural statistics in Bhutan.

A brief current overview of Bhutan is given in the National Statistics Bureau (2007) publication, *Bhutan at a Glance 2007*, which provides a brief summary of the Bhutan social and economic statistics. An example of Bhutan's recognition that welfare extends beyond the economic is given by Karma Ura and Karma Galay (2004) who edited a volume published by the Centre for Bhutan Studies entitled *Gross National Happiness and Development.* This volume provides a series of essays on national happiness, its philosophy, and its central role in development policy in Bhutan.

While economics is not perceived as primary, it is not however neglected. A more in-depth account (than *Bhutan at a Glance*) of the current situation both economic and in terms of food and agriculture is outlined in national accounts statistics, eg National Statistics Bureau (2007) *National Accounts Statistics 2000-2006*, which provides background on national accounts including economic performance, consumer price index, structure of the economy, sector performance, and gross domestic product.

The link between economic policy and poverty is explored in the 2nd edition of the UNDP publication by Osmani., Bajracharya, Tenzing, and Wangyal (2007) *Macroeconomics of Poverty Reduction: the Case Study of Bhutan.* This contains sections that give an overview of the Bhutan economy, plus information on poverty, human development and employment; fiscal policy; monetary and financial policies; trade policy; macroeconomic policy and poverty reduction; agriculture resources and policies; forest resources prospects and constraints; water resources and hydropower; industrial sector prospects and constraints; and possibilities for a pro-poor development strategy for Bhutan.

At a more detailed level, Togbay and McCullogh (2008) examine linking small farmers in Bhutan with markets and the importance of road access, noting that smallholder farmers remain the backbone of the Bhutanese economy. Exports and imports are primarily to India (95% and 85% respectively). The agricultural exports include oranges, potatoes, cardamom, apples, vegetables and ginger in order of value. Road access and marketing systems are seen as crucial to expansion. They note that rice from India is a major import, but is not generally as nutritious as the locally grown red rice.

This focus on Bhutan's rural areas, where there is greater incidence and severity of poverty, is also the basis of the Planning Commission's (2007) publication *Rapid Impact Assessment of Rural Development*, which considers the effect of development in terms of access to services (education, health, water and sanitation, renewable natural resources, and rural credit), plus impact on livelihoods, income, housing, food sufficiency, environmental conservation, culture, and women, based on a national survey.

The United Nations has a strong and pivotal role in Bhutan, and there are a number of publications reflecting the co-operation between the Royal Government of Bhutan and the United Nations in pursuit of the Millennium Development Goals. In 2003 the Royal Government of Bhutan published *Millennium Development Goals: Progress Report 2002 – Bhutan*, which summarises progress under the headings of eradicating extreme poverty and hunger; achieving universal primary education; promoting gender equality and empowering women; reducing child mortality; combating HIV/AIDS, malaria and other diseases; and ensuring environmental sustainability.

This has been followed in 2007 by the Planning Commission publication *Bhutan Millennium Development Goals: Needs assessment and Costing Report (2006-2015).* This report considers current issues and challenges; major interventions, coverage targets and resource needs estimates; and policy issues across agriculture and rural development; education; gender equality and women's empowerment; health, environment; water and sanitation;

energy; transport; with additional sections on good governance plus capacity building and financing of MDGs.

In 2007 the Royal Government of Bhutan and the United Nations in Bhutan published *Common County Programme Action Plan (cCPAP) 2008-2012*, which provides detailed and integrated objectives for the UN in Bhutan and the RGoB for the period 2008-2012, and covers poverty reduction; health; education; gender; governance; and environment and disaster risk assessment. There are also annual workplans, eg the *2008 Annual Work Plan, Country: Bhutan* which is a document signed by National Statistics Bureau, Centre for Bhutan Studies, Gross National Happiness Commission, UNICEF, UNDP, UNFPA, and WFP outlining the joint work programme for 2008. The small area estimation feasibility study falls under "Gewog socio-economic profiles / poverty mapping with focus on poverty indicators", item 4.

Additional documentation is given in the Royal Government of Bhutan / United Nations in Bhutan 2007 publication *United Nations Development Assistance Framework for the Kingdom of Bhutan 2008-2012*. This provides a framework and a list of specific planned outcomes for 2008-2012, together with estimated resource requirements, implementation strategies and provision for monitoring and evaluation.

The need for links between different United Nations agencies in Bhutan is also recognised. See for example *Common Country Assessment for Bhutan 2006*, which looks at Bhutan's situation in 2006, and outlines an agreed shared analysis by members of the various UN agencies operating in Bhutan. This includes good governance; reducing income poverty and hunger; education and gender equality; child and maternal health; HIV/AIDS and other diseases; environmental sustainability and disaster management; and promoting employment, the private sector and partnerships.

Beyond this general background, there have been a series of reports more directly related to small area estimation of poverty. These document the data collections that it is necessary to use and model statistically to produce small area estimates. In general, the National Statistics Bureau and related agencies are the focus for such documents which generally report results of national surveys or the 2005 population and housing census (PHCB2005), or are policy documents or reports derived from such data collections.

Examples include:

- The 2006 Office of the Census Commissioner, Royal Government of Bhutan publication *Results of the Population and Housing Census of Bhutan 2005*, which is a comprehensive document covering census procedure, population characteristics, migration, health, education, labour and employment, and household and housing characteristics from PHCB2005
- The National Statistics Bureau 2008 publication *Socio-Economic and Demographic Indicators 2005*, which summarises the 2005 census looking at population characteristics, fertility, mortality, migration, education, labour and employment, and housing and household amenities. No specific material relevant to small area estimation is included except tabulated summary statistics for the census that provide useful background, especially for education (eg educational status), housing and household amenities (house occupancy status, housing conditions, asset ownership, access to road head, water source, toilet facilities, source of lighting and cooking). These variables are used as predictors of poverty in the survey-based (BLSS2007) regression model, which for final small area estimation will need to be applied to the census data.
- The National Statistics Bureau 2001 publication *Household Income and Expenditure Survey (Pilot)*, which outlines the initial survey of Bhutan household income and

expenditure. This used a stratified cluster design with four strata. The design is clearly specified in "Part I – Presentation of the survey" p1-20. The design was modified for later BLSSs (2003 and 2007).

- The National Statistics Bureau 2004 publication *Bhutan Living Standard Survey 2003*, which details the second national survey of Bhutan household income and expenditure, using a stratified cluster design with seven strata, four urban (Thimphu, West, Central, East) and three rural (West, Central, East). Again the design is clearly specified - see Chapter 1, p7-12 – and was based on the Living Standard Measurement Survey (LSMS) methodology developed and advocated by the World Bank. The design was again later modified for BLSS2007.
- The National Statistics Bureau 2007 publication *Bhutan Living Standard Survey 2007 Report*. This survey, the data collected from it and this report are central to small area estimation of poverty assessments, as it is this survey on which statistical modelling of poverty would need to be based. The BLSS2007 is the third national survey of Bhutan household income and expenditure. The intended sample size was 10,000 households, and actual sample size was 9798 households, sufficient to provide reliable direct estimates from the survey data alone for all twenty districts (dzongkhag) in Bhutan. The design was a stratified cluster design, with forty strata, two (urban and rural) in each dzongkhag, and clusters which are urban-blocks in towns and chiwogs in rural areas. This more sophisticated design was possible in 2007, since it could be based on the results of the first Population and Housing Census of Bhutan (PHCB) undertaken in 2005. As for BLSS 2003, the design was based on the Living Standard Measurement Survey (LSMS) methodology developed and advocated by the World Bank. The design is clearly specified in Chapter 1, "Introduction", p12-18.
- The National Statistics Bureau *Poverty Analysis Report 2007*, which provides an appraisal of poverty patterns in Bhutan down to dzongkhag level, based on BLSS 2007. The report documents the poverty measurement methodology; definitions of food and total poverty lines; regional variations in food prices; poverty incidence for urban / rural and for each dzongkhag; depth and severity of poverty; sensitivity of poverty measures; poverty tables for various subpopulations; average time to exit poverty; Gini index; education, health and fertility indicators; information on amenities, assets and access to services. This survey and report being so central to poverty assessment at small area level is discussed further in consequent sections of this feasibility assessment report.
- The Office of the Census Commissioner, 2006 report *Dzongkhag Level Population and Housing Census Indicator Maps of Bhutan 2005* which contains results of the major mapping exercise that preceded the census (PHCB2005) and was used as the basis of the enumeration for the census. This report contains mostly dzongkhag level information, but also has some gewog level data, eg rural population and population density, drinking water from springs, CGI (corrugated galvanized iron) sheet roofs, owning a radio / tape player, not having toilet facility.
- The National Statistics Bureau, Royal Government of Bhutan 2007 publication *Population Projections Bhutan 2005-2030*, which provides tables of population size projections by sex and age group for each year 2005-2030.
- The Delimitation Commission of Bhutan 2007 report, *Final Delimitation Order for the National Assembly Constituencies of the Kingdom of Bhutan,* which contains maps, listing and commentary of gewogs within each district (dzongkhag) as used for defining political constituencies for the National Assembly. This document is central to delineation of boundaries and boundary changes at dzongkhag, gewog and chiwog level between 2005 when the census was conducted and 2008 when constituency boundaries were finalised. This delineation is also critical to sound small area estimation since this information determines boundaries for small area estimates and their evolution over time.

A general comment about the relationship between small area estimation and mapping is warranted. Small area estimation of poverty, especially if extended from poverty incidence gap and severity, plus kilocalories, to stunting, underweight and wasting in children (as in Jones, Haslett and Parajuli, 2006) provides a detailed perspective on the spatial distribution of poverty. Other variables are also important however (eg health information, rainfall, and other Geographical Information System (GIS) data), even if these cannot be produced as such a fine level except for variables collected in the census. For most users of this information, an atlas of maps is much more useful than a detailed technical report on small area estimation methodology, even if it also contains finer level tabulated detail. A detailed small area estimation report, which would be the next stage after this feasibility assessment report, is however essential, as it provides a clear indication of the methodological foundation for small area maps (often called poverty maps) that are included in the atlas. Without sound use of small area methodology, and publication of the technical report that outlines that methodology, the utility of the more generally-used atlas containing small area estimate maps must remain in doubt.

3. Requirements for and feasibility of small area estimation of poverty in Bhutan

The remainder of this report covers all the assessment phases undertaken by professional statisticians from Massey University, New Zealand to assess feasibility for updated small area estimation of poverty and poverty mapping in Bhutan at constituency and gewog level. It includes preliminary statistical models fitted to the Bhutan Living Standard Survey (BLSS2007).

The particular aspects of poverty considered in this final feasibility report are poverty incidence, gap and severity relative to the national poverty line, with an additional focus on kilocalorie consumption. While the last of these four strongly reflects the food security interests and concerns of the sponsor of the feasibility study, which is the World Food Programme, the feasibility reports also recognise the importance to a wide range international aid agencies of all four measures, and the centrality of the first three to sound economic measurement of poverty.

No poverty estimates using small area estimation techniques are or were intended to be produced in this feasibility study. Such estimates require further research funding. The 2005 census data (PHCB2005), and the 2007 Bhutan Living Standard Survey (BLSS2007) which includes detailed expenditure information, are already available.

Given the two year time difference between survey and census, further detailed work is however required beyond feasibility assessment to make these two data sources fully compatible, with consistent known codes at both gewog / town and the finer chiwog / urban-block level. For this research, release of the information held by the Bhutan National Statistics Bureau will be required. For detailed linking of dzongkhag, constituency, gewog / town and chiwog / urban-block codes, the following are noted:

- the twenty Dzongkhag remained unchanged throughout the relevant period
- PHCB2005 is based on gewog / town and chiwog / urban-block boundaries which were current before the census.
- BLSS2007, in principle, is based on same coding as PHCB2005, except for updates during the two year interval, but there was change that requires that there be detailed checking of all census codes at chiwog / urban-block level.
- constituency boundaries used in 2008 involved changes at gewog / town level to different dzongkhag, chiwogs / urban-blocks to different gewog / towns and dzongkhag, and in some cases splitting of gewogs / towns and chiwogs / urban-blocks with or without reassignment at a higher level, in order to get approximately equal numbers of people in each constituency.
- at all these administrative levels, detailed tracking and checking of all survey and census codes is required, before small area estimation is undertaken, since the 2005 census data must be divided in chiwogs / urban-blocks consistent with the 2007 survey for gewog / town level small area estimates, and if constituency level small area estimates can be derived, consistency of chiwog / urban-block codes in BLSS2007 and PHCB2005 with the constituency boundaries is also required.

For small area estimation of kilocalories, detailed food cost and/or kilocalorie equivalence information for all food types for both urban and rural areas within the twenty dzongkhag has been required in order to estimate kilocalorie consumption per household from the BLSS2007 data. This calculation has been an essential prerequisite to small area estimates of

kilocalorie consumption from expenditure data, whether measured on "per person" or "per adult equivalent" basis. The former measure is simpler since it divides household kilocalories by number of people in each household. The latter requires an adult equivalence scale by age and sex.

Since the poverty line is assessed using required kilocalories, there is necessarily a link via kilocalories to the expenditure needed to avoid being in poverty, as measured by the poverty line. In the National Statistics Bureau *Poverty Analysis Report 2007* the methodology used for calculating the poverty line is based on the nutritional norm, also applied in Nepal, of 2124 kilocalories (Kcal) per person per day. A norm is used because (as in most other countries) no specific food energy requirement is available for the Bhutanese population. Developing specific energy requirements for individuals is difficult, since it depends on age, sex, work type etc. which is why norms are so often used.

For developing Bhutan poverty lines based on expenditure, this kilocalorie requirement is linked to a specific basket of 53 foods with specified amounts of each food. Given price data for each food type in the basket, the equivalent expenditure is derived, after applying dzongkhag by urban / rural level (ie stratum level for BLSS2007) price adjustments which leave the national average expenditure unchanged. See *Poverty Analysis Report 2007* Table 1 p11, “Regional Price Deflator (Median of Household-level Paasche Indices by Dzongkhag and Area”. This method sets the food poverty line as equivalent to an expenditure of Nu. 688.96 (or approximately USD18) per person per month. This is the cost of food only. The total poverty line set at Nu.1096.94 per person per month, which makes allowance for Nu. 407.98 for non-food items, based on the non-food expenditure of households spending close to Nu. 688.96 per person per month on food.

In principle, reversing the process would give the required translation of expenditure (collected in BLSS2007) to kilocalories (not collected in BLSS2007) for small area estimation of kilocalories, but only for a household using only those items in the exactly the same proportion as in the food basket. Estimating kilocalories from each household’s actual food consumption based on their unit prices is possible in principle but Table A-30, p61 “Food Bundle and Costs of Nutritionally Adequate Food Bundle Per Person Per Day” only provides prices for units of each food type in the basket, not all food types, and then only to one significant figure. This information is insufficient to estimate kilocalories for each household in BLSS2007 based on its expenditure, even putting aside statistical and nutritional issues which (on the statistical side) include structure (eg bias) of the measurement error from such calculations.

Research by the FAO, WFP, and others has focused instead on quantities of food consumed (which is also collected in BLSS2007) and its link to kilocalories. It is this translation of food quantity consumed to kilocalories estimates at household level for the BLSS2007 that has yielded the kilocalorie consumption per household data supplied by FAO, and which is the basis for the assessment of feasibility of small area estimation of kilocalories for Bhutan that forms part of the current feasibility assessment report.

One aim of the feasibility study is to find the variables that *prima face* are sufficiently similar that they have clear potential to be used as the explanatory part of a statistical model for the logarithm of average per capita household expenditure and for another separate statistical model for kilocalories consumed per person per day, based on BLSS2007 data. Such models are required after the feasibility phase to predict household expenditure for each (and every) household in the census based on that household’s measured characteristics leading to small area estimates of poverty incidence, gap and severity, and to predict kilocalorie consumption for small area estimates of undernourishment.

The BLSS2007 data has been used for this initial modelling. Note that the modelling used in the feasibility study focuses on logarithm of per capita expenditure, since it is this model from which poverty incidence, gap and severity are derived, and on kilocalorie consumption for undernourishment.

Explicit details of this statistical modelling are included in Sections 4 to 9 below. In the initial part of this report, the focus is limited to establishing whether variables collected in the 2005 census are also collected in the 2007 BLSS, and if so, exactly how the relevant questions are structured in both data sources. Ideally, exactly the same question with exactly the same categories is asked in the survey and census, but in practice internationally there are usually differences. For Bhutan, these differences are given in detail in the material detailed for each potential matching variable (ie question) in Appendix A in Tables A1-A18.

The feasibility study does not complete the matching of variables between census and survey, since this would also require detailed analysis of the 2005 census data. What is provided in these "matching tables" A1-A18 however, taken in conjunction with the preliminary statistical modelling based on BLSS2007 data alone, is the best available indication currently available of whether small area estimation is likely to work for Bhutan. Given this conclusion is positive, funding should be sought immediately from a variety of international donors for a full scale small area estimation study in Bhutan based on the 2005 census and BLSS2007 data.

Note there is a two year time difference between survey and census, which will have an effect on interpretation of small area estimates, although not on the estimates themselves. The small area estimates will apply to some period between census and survey dates, which will still be useful for planning purposes, but will not allow a particular date within the 2005-2007 period to be assigned.

Assessing the resources required for the full poverty mapping exercise after the feasibility phases are beyond the scope of this study. As noted previously, additional international funding beyond the feasibility stage is required. These additional resources are primarily to fund time and expertise. Both dedicated Bhutan National Statistics Bureau staff and international experts in small area estimation are needed. NSB expertise remains critical in the questionnaire matching exercise, and when considering area code changes, as well as for interpreting local details within a variety of small area models. The international expertise required consists of staff with a strong theoretical understanding of small area estimation methods, including but not limited to the World Bank method, and with experience applying such methods in a range of developing countries. The additional component is equipment. Small area estimation is computationally intensive, since even full scale checking a single statistical model can take three days of computation time using a fast PC. Long term sole access to a machine with a minimum memory size of 4GB, and preferably rather more, will be required. Software is not so much an issue at NSB, since NSB already have licenced copies of Stata 10 for statistical analysis, and software for mapping.

The dedicated NSB staff to take the collaborative small area research beyond feasibility stage are required for:

- area code linking in different years at dzongkhag, gewog / town and chiwog / urban-block level
- statistical modelling and checking using local knowledge
- specialised programming where necessary
- ensuring the expertise required for feasibility assessment of small area estimation is transferred
- mapping of poverty estimates, in conjunction with WFP staff

Although small area estimation is not and cannot be part of this feasibility study, we were aware from our initial discussions with the Bhutan Gross National Happiness Commission (GNHC) on arrival in Bhutan in late-September 2008 that poverty incidence estimates at a finer level than the twenty dzongkhag were required in late 2008 as an aid to and input for resource allocation. A separate analysis was carried out using the BLSS2007 data only to assess whether such information could be made available, although this did not form part of the WFP – Massey University contract specification for the small area estimation feasibility study. The results are summarised in Appendix B.

The BLSS2007 has a rather unusual and useful characteristic. Because it sampled nearly 10000 households, it has sample households in nearly all of Bhutan's gewogs. Even at chiwog level (which corresponds to primary sampling units or clusters in BLSS200) the sampling fraction is high especially for urban areas. The published analysis for BLSS2007 follows the usual international protocol for national surveys, and treats sampling as through clusters were sampled with-replacement. With-replacement sampling assumes that primary sampling units (psus) could in principle be sampled more than once. For surveys with large numbers of psus in the population, and in the strata used in the survey design, this is a good approximation. For Bhutan however, there were forty strata at design stage, and the sampling fractions within them were often high, so that specifying the sampling fractions and the design as a without-replacement design, for which sampled psus cannot be reselected, can considerably reduce the estimated standard error by adjusting for the upward bias in accuracy (ie standard error) from treating the without-replacement design as a with-replacement one.

Using estimation of standard errors based on with-replacement sampling, and using the 47 constituencies, which is a level intermediate between dzongkhag and gewog, direct estimates of poverty incidence and standard error were calculated based on the BLSS2007 alone. These are tabulated in Table B1 in Appendix B of this report. Generally standard errors at constituency level for poverty incidence (but not the poverty estimates themselves) are satisfactory, being below 5%, and the poverty incidence measures, in conjunction with population counts in constituencies, can be used as a guideline for resource allocation, subject to recognising that the estimates are subject to an error determined by their estimated standard errors

While these poverty incidence estimates at constituency level may be useful for immediate planning, given the limited time available for analysis between October and December 2008, the need for small area estimation of poverty at a finer level, and estimates of poverty gap and severity and kilocalories, remains. Unlike small area estimation, using survey data alone no direct estimate at all is possible in gewogs that were not sampled in BLSS2007. Consequently it will still be necessary to consider statistical modelling and small area estimation techniques beyond the feasibility assessment stage to derive gewog level small area estimates of poverty.

4. Introduction – Phase 3: Analysis

The second phase of the feasibility study involved statistical modelling of Bhutan sample survey data (BLSS2007). The modelling used the variables identified in the first phase of the feasibility study, which had examined data sources and identified variables contained in both the survey and the census which were suitable for small area estimation of expenditure poverty (and hence poverty incidence, gap and severity) and undernourishment.

These variables comprise:

- a target variable, here denoted *y*, recorded for each household in the survey and from which household-level poverty, undernourishment status or malnutrition can be inferred; this variable is log-transformed household per capita consumption expenditure (for poverty), household per adult equivalent daily calorie intake (for undernourishment) or height-for-age and weight-for-height (for malnutrition). Malnutrition is not considered directly in this report, because the required information was not collected (and was not intended to be collected) in the BLSS2007;

- a set of auxiliary variables, denoted x_1, x_2, ..., x_p, either recorded at household level in both survey and census or else missing from the survey but available from the census or another external source as an average over a geographic area; for example household size (`hhsize`) is a household-level variable available in both PHCB2005 and BLSS2007; gewog- or chiwog-level averages have not yet been included because of coding inconsistencies between survey and census;

- a set of regional indicators common to the survey, census and other external data sources; these are required so that area-level information can be merged appropriately with the survey and census databases, and so that small area estimates can be produced at appropriate geographic levels; for Bhutan these are indicators for dzongkhag, constituency, gewog / town, and chiwog / urban-block.

The ELL (Elbers, Lanjouw and Lanjouw 2003) method uses the auxiliary data to infer the value of the target variable *y*, and hence poverty, malnutrition or undernourishment status, for every household in the census via a statistical model

$$y_{vh} = \beta_0 + \beta_1 x_{1vh} + \beta_2 x_{2vh} + \cdots + \beta_p x_{pvh} + \eta_v + \varepsilon_{vh} \qquad (1)$$

where y_{vh} denotes the value of the target variable in the *h*th household of the *v*th cluster. Clusters are defined as the primary sampling units (psus) from the survey design – here the chiwogs / urban-blocks. The unknown parameters $\beta_0, \beta_1, \cdots, \beta_p$ are estimated using the survey data. The disturbance terms η_v, ε_{vh} represent unexplained variation at chiwog and household level respectively; these are treated in the modelling as random effects with mean zero and variances $\sigma_\eta^2, \sigma_\varepsilon^2$. These variance components are also estimated from the survey data. There can be merit in considering an additional variance component at small area level.

The quality of the small area estimates produced by the ELL method, measured in terms of the standard errors of the estimates, depends crucially on the quality of the model linking the target and auxiliary variables. In this phase of the report we examine this issue in detail by identifying, from existing datasets, useful auxiliary variables for the model (1), fitting the model to the BLSS2007 data and summarizing the performance of the model statistically.

5. Measures of Model Performance

There are two aspects of model performance commonly used to evaluate linear models like (1). The first measures the proportion of the variability in the target variable (y) explained by the predictors (x); this is commonly denoted R^2. The second, the mean squared error (MSE), measures the overall size of the unexplained variation. In the ELL method however there is no direct link between these and the precision of the final small area estimates; this is partly because the variable of interest at small area level is not y itself but a nonlinear function of y (for example *poverty incidence* is the proportion of households in an area for which y is below a poverty line). Nevertheless, previous experience with the ELL method, combined with theoretical considerations, enable some statements linking the two to be made.

In successful applications of the ELL method to poverty estimation, the R^2 value of the model for log-transformed per capita expenditure tends to be about 50% or higher. R^2 always increases as more x variables are added to the model, but a point of "diminishing returns" sets in after which an increase in model complexity gives only a negligible improvement in R^2. Such apparent improvements in the predictive power of the model may also be spurious, holding for the estimation data but not for census-based predictions. The target, of around 50% for consumption poverty, should be achieved with a modest number p of auxiliary variables in relation to the size of the estimation dataset. Calorie intake and anthropometric measurements (height-for-age, weight-for-height) tend to be harder to predict than consumption expenditure (perhaps, in part, because of measurement errors); internationally, some reasonably successful small area estimates have been produced using models with an R^2 around 30%, because cluster-level variation is small compared to household level variation.

In (1) the unexplained variation is decomposed into psu-level (η_v) and household-level (ε_{vh}) effects. When the model is used to predict y for the census households, simulated values of these random effects are included to incorporate the uncertainty in these predictions. When the household-level predictions are amalgamated to small area (gewog) level to produce the final estimates, these effects will tend to "average out", reducing the variability at small area level; the extent to which this happens depends on the number of census households, and the number of census psus, in the small areas. Since the number of households is generally much larger than the number of psus, the crucial factor affecting precision is usually the size of the psu-level effects. Thus while both σ_ε^2 and σ_η^2 should preferably be small, it is particularly important that the latter should be as small as possible.

Table 1: Summary measures for expenditure models from recent SAE exercises.

	p	R^2	σ_η^2	σ_ε^2
Cambodia2002 PPenh	38	0.48	0.099	0.359
Cambodia2002 urban	40	0.70	0.034	0.354
Cambodia2002 rural	58	0.54	0.141	0.236
Bangladesh2003	31	0.59	0.025	0.107
Philippines2004	68	0.74	0.039	0.113
Nepal2005	37	0.55	0.027	0.194

Table 1 gives the values of these summary measures for the models used in some recent small area estimation / poverty-mapping exercises. In Cambodia, different models were fitted in each stratum; note that in the rural stratum, the proportion of unexplained variance at psu (village) level was relatively high and the estimates for rural areas were found to be significantly less precise than the others (Fujii, 2002). The technique works best when the average number of psus in a small area exceeds thirty.

6. Modelling Strategy

There is typically a large set of auxiliary variables available for inclusion in the model (1). It is not good practice to include all of these x variables as the complete set would be highly multicollinear, with low precision in the estimates, and possibly many spurious relationships leading to bias. A model selection procedure is needed to decide which variables to include and to avoid this "over-fitting". We want to achieve a reasonably high R^2 and low $\sigma_\eta^2, \sigma_\varepsilon^2$ with only a moderate number p of variables.

We first distinguish between two kinds of variables: numerical (eg household size with numerical values 1, 2, 3, ...) and categorical (eg cooking fuel with values electricity, lpg, wood, ...). Numerical x variables each contribute one to the total model size p; however if the effect is nonlinear we might want to add quadratic (x^2), cubic (x^3) or other terms to capture the relationship. Categorical variables increase the model size by the number of categories in the variable; here it may be possible to simplify the model by combining categories with a similar effect. One "default" category is omitted, so effects are measured relative to this default.

The model may also include "interactions", allowing the effect of one variable to change with different values of another variable. For example the effect of household size may vary between urban and rural strata; to accommodate this we would include an `hhsize×rural` interaction term.

Some approaches to the model selection problem have first created a maximal pool of potential x variables by adding quadratic and cubic terms for all numeric variables and all possible two-way (sometimes even three-way) interactions, then running an automatic model selection method (stepwise regression) that lets the computer choose the model. The result can be over-complicated and hard to interpret; it also increases the possibility of spurious relationships in the model. We tend to prefer a more cautious approach, starting with a relatively simple and interpretable model and judiciously adding nonlinear and interaction terms where they seem necessary and where the results seem to be plausible.

Some implementations of the ELL method have used different models in different strata, these strata being defined by the survey sample design or, in the case of a survey design with many small strata, as accumulations of geographically contiguous strata. Our approach is to first investigate the possibility of fitting a single country-wide model, with differences between strata accommodated by interaction terms where necessary. This allows for the possibility that the effect of some variables is consistent across the different strata.

Since the psu-level error component plays the largest part in the precision of the final small area estimates, we try to get σ_η^2 as small as possible. This is often aided by using area-level variables such as GIS data and census means.

7. Estimation Methods

The data used to estimate the model (1) typically comes from a two-stage survey design: in the first stage primary sampling units (psus) are randomly sampled within each stratum, after which individual households are selected at random within each sampled psu. The psus usually represent natural clusters of households within the population; in BLSS2007 the psus are urban-blocks (urban) or chiwogs (rural). One consequence of this design is that individual households can have different representational values within the population; this is reflected in the different "survey weights" given to each household. Statistical methods exist for taking into account the survey weights and the two-stage structure of the sample.

Early implementations of ELL used ordinary least squares (OLS) regression (ie ignoring the clustering and the weights) when selecting the variables. The chosen model was then re-estimated using a form of generalized least squares (GLS) in which estimated variance components (for $\sigma_\eta^2, \sigma_\varepsilon^2$) were used to re-weight households within clusters. This GLS estimation is included in the PovMap software provided by the World Bank. An alternative is to perform the model selection using a survey regression method specifically designed for the purpose and available in some common statistical programs such as Stata. It is sometimes found that variables which seem to have a significant effect in OLS estimation lose their significance when the survey design is accounted for. There are other, more sophisticated technologies available (eg Rao, 1999; You and Rao, 2002; You, Rao and Kovacevic, 2003) for estimating the final model and its variance components. The differences obtained from these various methods do not seem to be great. Because the present exercise is exploratory, we consider here only Stata's survey regression method to investigate model choice and evaluation.

8. Results for Modelling Expenditure

Table 2 gives the results for a model fitted to the BLSS2007 survey data with log-transformed per capita consumption expenditure as the target variable. The **Coef** column gives the estimated effect of each variable on log expenditure. For example the model estimates that those who cook with electricity have on average 0.0432 lower log expenditure (ie about 4.4% lower expenditure) than those who cook with gas, assuming that all other variables stay the same. Household size has both quadratic and interaction effects – these are best understood graphically, as shown in Figure 1 below.

Note that there are a number of interaction terms which differentiate between the urban and rural areas. For example, in urban areas the possession of a TV is associated with an average increase of 0.1023 in log expenditure (ie about 10.7% higher expenditure) whereas in rural areas the increase is only 0.1023 – 0.0521 = 0.0502 (ie about 5.1% higher expenditure).

The education variables `hnosch, hedlevel, htraded htradyrs` did not enter into the model. This is not to say that education level does not influence expenditure; rather that its effect is accounted for by other variables in the model.

The **Std Err** column in Table 2 measures the uncertainty in the estimated effects. Roughly speaking we would expect the true values to be within two standard errors of the estimates. The **t** and **P>t** columns are tests of whether the true effect size might be zero. Often a threshhold of 0.05 is used for **P>t**, the "p-value", to decide whether a particular variable should be included in the model, so that variables with p-values above 0.05 would be considered for elimination. We have relaxed this somewhat in the present situation, as we are interested in screening for potentially useful variables, particularly where they represent possible urban / rural differences. The model presented here should not be thought of as a "final model". Much further work would be required to identify such a model, after careful statistical checking of the equivalence (ie matching) of the survey and census variables. This work does not form part of the present feasibility study; the current model should be regarded only as giving an indication of the likely performance of the final model adopted in a small area poverty mapping exercise.

This model has 54 variables and achieves an R^2 of 0.665, with estimated variance components of 0.123 for σ_ε^2 and 0.028 for σ_η^2. These results seem to be comparable with those of previous poverty-mapping models, so we can be reasonably optimistic regarding the performance of a final model for per capita expenditure. The second important requirement is that there should be enough census psus in the small areas for which estimates are required, ie that there should be enough chiwogs in each gewog, so that the unexplained variation at chiwog level is "averaged out".

Table 2: Model for log-transformed per capita consumption expenditure

lpcexp	Coef.	Std. Err.	t	P>t	Meaning
_cons	8.3159	0.0613	135.73	0.000	constant term
hhsize	-0.1348	0.0058	-23.28	0.000	# person in hh
hhsq	0.0079	0.0016	5	0.000	quadratic effect: (hhsize-5)^2
sawomen	0.0604	0.0319	1.89	0.059	proportion in hh of adult women
selder	-0.1769	0.0391	-4.53	0.000	proportion in hh of elderly (aged 65+)
skids6	-0.5038	0.0331	-15.22	0.000	proportion in hh of kids under 7
rural	-0.2912	0.0399	-7.3	0.000	rural area
skids714U	-0.1880	0.0520	-3.61	0.000	proportion in hh of kids aged 7-14, urban only
hage	-0.0016	0.0004	-3.55	0.000	age of household head
hfem	0.0454	0.0121	3.74	0.000	female head of household
hlit	0.0272	0.0114	2.39	0.017	literate head of household
nrooms	0.0478	0.0037	12.91	0.000	number of rooms in household
ownd	0.0485	0.0202	2.4	0.017	household owns their dwelling
ownlvstk	-0.1396	0.0349	-4	0.000	household owns livestock
computer	0.0771	0.0257	3	0.003	household owns a computer
fridge	0.0391	0.0148	2.64	0.008	household owns a refrigerator
mphone	0.1502	0.0123	12.2	0.000	household owns a mobile phone
phone	0.1148	0.0175	6.56	0.000	household owns a phone (landline)
radio	0.0308	0.0164	1.88	0.060	household owns a radio
tv	0.1023	0.0245	4.17	0.000	household owns a tv
vehicle	0.1580	0.0208	7.6	0.000	household owns a vehicle
washmach	0.1266	0.0304	4.16	0.000	household owns a washing machine
_lcooking_2	-0.0432	0.0137	-3.15	0.002	cooking by electric (default = gas)
_lcooking_3	-0.1773	0.0182	-9.76	0.000	cooking by wood (default = gas)
_lcooking_4	-0.2996	0.0649	-4.62	0.000	cooking by kerosene (default = gas)
_lcooking_5	-0.0974	0.0356	-2.74	0.006	cooking by other (default = gas)
_ldwater_2	-0.0680	0.0340	-2	0.046	drinking water from well
_lhempstat_2	0.0446	0.0188	2.37	0.018	hoh paid employee (default = unemployed)
_lhempstat_3	-0.0594	0.0188	-3.16	0.002	hoh unpaid family worker (default = unemployed)
_lhempstat_4	0.0415	0.0158	2.63	0.009	hoh own account worker (default = unemployed)
_lincsourc_2	0.0890	0.0168	5.31	0.000	income from business (default = wages)
_lincsourc_4	-0.0539	0.0344	-1.57	0.118	income from remittance (default = wages)
_lincsourc_6	0.1126	0.0703	1.6	0.110	income from property (default = wages)
_lincsourc_7	-0.3226	0.0255	-12.63	0.000	income from stipend (default = wages)
_lincsourc_8	0.0445	0.0237	1.88	0.061	income from other (default = wages)
_llighting_2	0.0326	0.0180	1.81	0.070	lighting from kerosene/gas (default = electricity)
_llighting_4	0.0834	0.0310	2.69	0.007	lighting from others (default = electricity)
_lnroad_7	-0.0946	0.0383	-2.47	0.014	5-6 hrs from nearest road
_lnroad_8	-0.0907	0.0292	-3.11	0.002	> 6 hrs from nearest road
_lrooftype_4	-0.1342	0.0245	-5.47	0.000	roof thatch (default = metal)
_lrooftype_6	-0.1490	0.0246	-6.07	0.000	roof other (default = metal)
_ltoilet_2	-0.0422	0.0227	-1.86	0.064	toilet shared flush (default = independent flush)
_ltoilet_3	-0.0759	0.0153	-4.95	0.000	toilet pit latrine (default = independent flush)
_ltoilet_4	-0.1113	0.0310	-3.59	0.000	toilet none (default = independent flush)
_ltoilet_5	-0.3026	0.0536	-5.65	0.000	toilet other (default = independent flush)
_lwalltype_3	0.0564	0.0157	3.6	0.000	walls mud (default = brick/stone)
_lwalltype_4	-0.0314	0.0180	-1.74	0.081	walls wood (default = brick/stone)
_lwalltype_5	-0.0514	0.0184	-2.79	0.005	walls other (default = brick/stone)
hhsizeXR	0.0135	0.0066	2.05	0.041	interaction of hhsize with rural area
hhsqXR	-0.0026	0.0017	-1.53	0.126	interaction of hhsq with rural area
ownlvstkXR	0.0926	0.0389	2.38	0.018	interaction of ownlvstk with rural area
phoneXR	0.0775	0.0258	3	0.003	interaction of phone with rural area
radioXR	0.0576	0.0199	2.89	0.004	interaction of radio with rural area
tvXR	-0.0521	0.0290	-1.8	0.073	interaction of tv with rural area
washmachXR	-0.1406	0.0607	-2.32	0.021	interaction of washmach with rural area

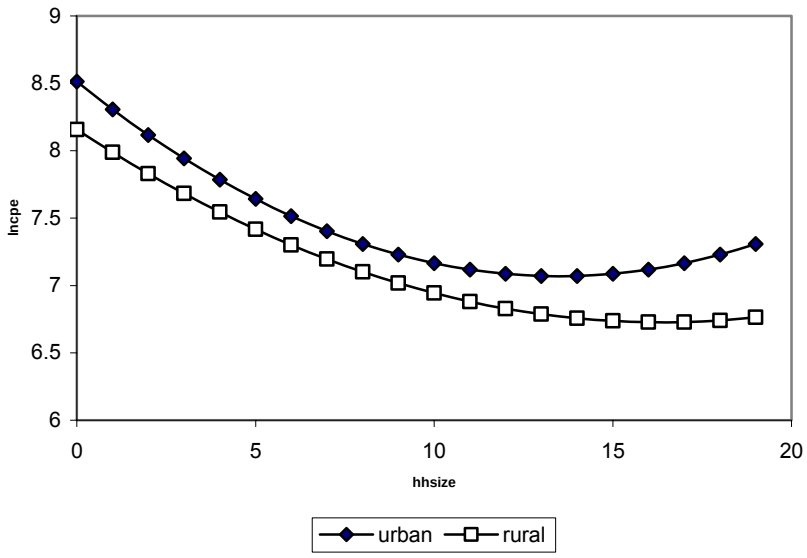

Figure 1. Effect of household size on log per capita expenditure

9. Results for Modelling Kilocalories

Table 3 gives the results for a model fitted to the BLSS2007 survey data with log-transformed daily kilocalorie consumption per adult equivalent. The adult equivalent size of a household was calculated by FAO based on tables of kilocalorie requirements by age and gender.

We note that many, but not all, of the variables in the earlier expenditure model also have a significant effect on kilocalorie consumption. Here we have used household size as an explanatory variable. An alternative and perhaps preferable approach would be to use adult equivalent household size instead. The model here should not be regarded as a final model but as indicative of the level of explanatory power we can expect from such a model.

This model has 30 variables and achieves an R^2 of 0.480, with estimated variance components of 0.113 for σ_ε^2 and 0.015 for σ_η^2. These results are very encouraging as our previous experience with modelling kilocalorie consumption is that it is difficult to achieve an R^2 in excess of 30%. They may reflect a good choice of food-related questions in BLSS2007, among other factors. We can be reasonably optimistic about the performance of a final model for kilocalories, provided unexplained variation at chiwog level is "averaged out" sufficiently.

Table 3: Model for log-transformed per capita consumption expenditure

lpaekcal	Coef.	Std. Err.	t	P>t	Meaning
_cons	8.2611	0.0346	238.77	0.000	constant term
hhsize	-0.1452	0.0047	-30.92	0.000	# person in hh
hhsq	0.0056	0.0005	10.64	0.000	quadratic effect: (hhsize-5)^2
sawomen	0.2734	0.0277	9.87	0.000	proportion in hh of adult women
selder	0.3384	0.0348	9.72	0.000	proportion in hh of elderly (aged 65+)
skids6	0.5411	0.0568	9.52	0.000	proportion in hh of kids under 7
rural	0.0979	0.0365	2.68	0.008	rural area
skids714	0.2487	0.0248	10.02	0.000	proportion in hh of kids aged 7-14
hlit	0.0146	0.0092	1.59	0.113	literate head of household
ownlvstk	-0.0615	0.0284	-2.17	0.030	household owns livestock
mphone	0.0661	0.0182	3.63	0.000	household owns a mobile phone
radio	0.0398	0.0089	4.48	0.000	household owns a radio
_lcooking_2	0.0323	0.0107	3.02	0.003	cooking by electric (default = gas)
_lhempstat_4	0.0620	0.0097	6.37	0.000	hoh own account worker (default = unemployed)
_lincsourc_3	-0.0417	0.0111	-3.76	0.000	income from farming (default = wages)
_lincsourc_6	-0.0934	0.0420	-2.22	0.026	income from property (default = wages)
_lincsourc_7	0.4138	0.0240	17.24	0.000	income from stipend (default = wages)
_llighting_2	0.0498	0.0142	3.51	0.000	lighting from kerosene/gas (default = electricity)
_llighting_4	0.0447	0.0264	1.69	0.091	lighting from others (default = electricity)
_lnroad_7	-0.1166	0.0359	-3.25	0.001	5-6 hrs from nearest road
_lnroad_8	-0.1102	0.0216	-5.11	0.000	> 6 hrs from nearest road
_lrooftype_2	-0.0525	0.0284	-1.85	0.064	roof concrete/cement (default = metal)
_lwalltype_3	-0.1107	0.0155	-7.14	0.000	walls mud (default = brick/stone)
_lwalltype_4	-0.0473	0.0133	-3.56	0.000	walls wood (default = brick/stone)
_lwalltype_5	-0.0939	0.0151	-6.20	0.000	walls other (default = brick/stone)
hhsizeXR	-0.0126	0.0053	-2.38	0.018	interaction of hhsize with rural area
skids6XR	0.1438	0.0647	2.22	0.027	interaction of skids6 with rural area
ownlandXR	0.0513	0.0172	2.98	0.003	household owns land, rural area only
ownlvstkXR	0.1283	0.0324	3.96	0.000	interaction of ownlvstk with rural area
fridgeXR	-0.0704	0.0185	-3.80	0.000	interaction of mphone with rural area
mphoneXR	-0.0548	0.0226	-2.42	0.016	interaction of mphone with rural area

10. Structure of Survey and Census

Tables 4 and 5 give information on the number of households and number of psus (chiwogs) at different levels of the survey and census, based on the regional codes for district (dzongkhag), gewog / town and psu (chiwog / urban-block) in the datasets. These codes are not entirely consistent between the census, conducted in 2005, and the survey conducted in 2007, as there were some changes to regional boundaries during this time. Nevertheless the figures can be taken as indicative of the actual patterns.

Table 4: Structure of BLSS2007

SURVEY	District	Strata	Gewogs	Psus	Households
Number	20	38	250	853	9798
Mean hh	490	258	39.2	11.5	
Min hh	217	20	8	2	
Max hh	1344	1220	1220	80	
Mean psu	42.7	22.4	3.4		
Min psu	18	2	1		
Max psu	86	69	62		

Table 5: Structure of PHCB2005

CENSUS	District	Strata	Gewogs	Psus	Households
Number	20	40	262	2177	126115
Mean hh	6306	3153	481	58	
Min hh	727	84	6	1	
Max hh	19689	15728	15728	978	
Mean psu	109	54.4	8.3		
Min psu	30	1	1		
Max psu	287	274	72		

Note that some of the strata (district×urban/rural) in the survey data were combined to avoid estimation problems when only one psu was sampled in a stratum. Of particular interest is the number of census psus in a gewog / town: this ranges from 1 to 72, with an average of 8.3. It would appear that the number of psus in the targeted small areas is lower, and more variable, than is commonly encountered in small area poverty mapping. Table 6 gives the complete distribution for the census, showing that 29 of the gewogs / towns consist of only one psu.

Table 6: Distribution of gewog / town sizes (number of psus) in PHCB2005

Psus	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Freq.	29	9	13	24	24	21	22	20	19	9	11	11	10	6
Psus	15	16	17	18	19	20	22	23	24	25	33	35	72	
Freq.	5	3	9	2	5	1	1	3	1	1	1	1	1	

11. Conclusions

Our modelling exercise, based on the currently available data, suggests that for predicting log-transformed per capita consumption expenditure an R^2 of around 0.65 should be achievable, and that the unexplained variation at psu-level should be reasonably small, or at least comparable with its value in other such analyses. Similarly for predicting log-transformed kilocalorie consumption per adult-equivalent at household level, an R^2 of more than 0.50 should be achievable, with again a reasonably small fraction of unexplained variation occurring at psu-level. We can therefore be cautiously optimistic about the performance of a future small area mapping exercise for both poverty incidence and incidence of undernourishment, assuming that the final statistical checks on the matching of survey and census do not eliminate too many variables.

One important factor governing the precision of the small area estimates is the number of psus (chiwogs / urban-blocks) within each small area (gewog). From previous poverty-mapping exercises in which we have been involved, the average has been 20 or more: for Bhutan it appears to be 8.3 based on the 2005 census. This means that unexplained chiwog-level random effects will typically be averaged over only a modest number of values, leading possibly to a lack of precision in many of the gewog-level estimates.

We might want to combine geographically adjacent gewogs in some cases in order to achieve sufficient precision. However, we would expect that in the modelling exercise beyond feasibility phase to have available census means at chiwog level, which were not available to us at feasibility assessment. These should reduce further the chiwog-level variation and hence the standard errors of the small area estimates of expenditure poverty and undernourishment.

Cautious optimism is warranted that updated small area estimation of expenditure poverty and undernourishment in Bhutan are possible. However, we must stress that poverty mapping from the resulting small area estimates will relate to the period of the survey (BLSS2007) and census (PHCB2005). We appear to be entering a period of extreme volatility in both oil and food prices internationally; the effects of these, particularly on the poorest members of a society, are sure to be considerable. In particular, the relationships being examined in this study are almost certainly changing to some extent. Nevertheless, small area methods have the potential to provide a finely grained yardstick against which both changes since 2005/7 and future progress can be usefully gauged.

The population size in Bhutan is less than one million. This too is likely to have an effect on the accuracy of small area estimates if the small areas are not sufficiently large (in terms of population size). This limits the number of small areas into which the population can be divided. Nevertheless, sound small area estimates at gewog level seem feasible (at least for the larger gewogs), and almost certain at constituency level.

The completion of this report follows extensive consultation with the Bhutan National Statistics Bureau (NSB), the Bhutan Gross National Happiness Commission (GNHC), UNICEF, UNDP, and the World Food Programme (WFP) - which commissioned this research - in Thimphu, Bhutan, 29 September to 8 October 2008. The authors are grateful for these extensive contributions. Viewpoints and opinions expressed in this report do not however necessarily reflect those of all or any of the organisations consulted.

Bibliography

Alderman H., Babita M., Demombynes G., Makhata N. and Ozler B. (2002) "How low can you go? Combining census and survey data for mapping poverty in South Africa", *Journal of African Economics*, **11**, 169-200.

Central Statistical Organization (2001) *Household Income and Expenditure Survey (Pilot)*, Central Statistical Organization, Planning Commission, Royal Government of Bhutan, October 2001, 165 pages.

Delimitation Commission of Bhutan (2007) *Final Delimitation Order for the National Assembly Constituencies of the Kingdom of Bhutan*, Delimitation Commission of Bhutan, Royal Government of Bhutan, March 2007, 52 + 7 pages.

Elbers, C., Lanjouw, J.O. and Lanjouw, P. (2001) *Welfare in villages and towns: micro-level estimation of poverty and inequality*, unpublished manuscript, The World Bank.

Elbers, C., Lanjouw, J. and Lanjouw, P. (2003) "Micro-level estimation of poverty and inequality", *Econometrica*, **71**, 355-364.

Elbers, C., Lanjouw, J.O., Lanjouw, P. and Leite, P.G. (2001) *Poverty and inequality in Brazil: new estimates from combined PPV-PNAD data*, unpublished manuscript, The World Bank.

Fujii, T. (2002) *Estimation of Poverty Rates at Commune-Level in Cambodia – using Small-Area Estimation Technique to Obtain Reliable Estimates*, Ministry of Planning and the United Nations World Food Programme, October 2002, vi+62 pages+CD of estimates.

Food and Agriculture Organization (2001) *General Status of the System of Food and Agriculture Statistics in Bhutan*, Food and Agriculture Organization of the United Nations, Bangkok, GCP/RAS/171/JPN , Field Document No 2/BHT/1, 20 pages.

Haslett, S. and Jones, G. (2005) *Estimation of Local Poverty in the Philippines*, Philippines National Statistics Co-ordination Board / World Bank, November 2005.

Healy A.J., Jitsuchon S. and Vajaragupta, Y. (2003) "Spatially disaggregated estimation of poverty and inequality in Thailand", preprint.

Jones, G. and Haslett, S. (2003) *Local Estimation of Poverty and Malnutrition in Bangladesh*, Bangladesh Bureau of Statistics and United Nations World Food Programme.

Jones, G., Haslett, S. and Parajuli, D. (2006) *Local Estimation of Poverty, Undernourishment and Malnutrition in Nepal*, The Central Bureau of Statistics of His Majesty's Government of Nepal / United Nations World Food Programme.

National Statistics Bureau, Royal Government of Bhutan (2007) *Population Projections Bhutan 2005-2030*, National Statistics Bureau, Royal Government of Bhutan, July 2007, 38 pages.

National Statistics Bureau, Centre for Bhutan Studies, Gross National Happiness Commission, UNICEF, UNDP, UNFPA, and WFP (2007) *2008 Annual Work Plan, Country: Bhutan*.

National Statistics Bureau, Royal Government of Bhutan (2007) *Bhutan Living Standard Survey 2007 Report*, National Statistics Bureau, Royal Government of Bhutan, December 2007, 127 pages.

National Statistics Bureau, Royal Government of Bhutan (2007) *Poverty Analysis report 2007*, National Statistics Bureau, Royal Government of Bhutan, December 2007, 67 pages.

National Statistics Bureau, Royal Government of Bhutan (2007) *Bhutan at a Glance 2007*, National Statistics Bureau, Royal Government of Bhutan, 6 pages.

National Statistics Bureau, Royal Government of Bhutan (2007) *National Accounts Statistics 2000-2006*, National Statistics Bureau, Royal Government of Bhutan, October 2007, 43 pages.

National Statistics Bureau, Royal Government of Bhutan (2004) *Bhutan Living Standard Survey 2003*, National Statistics Bureau, Royal Government of Bhutan, July 2004, 108 pages.

Office of the Census Commissioner, Royal Government of Bhutan (2006) *Results of the Population and Housing Census of Bhutan 2005*, Office of the Census Commissioner, Royal Government of Bhutan, x + 492 pages, ISBN 99936-688-0-X.

Office of the Census Commissioner, Royal Government of Bhutan / UNFPA (2006) *Dzongkhag Level Population and Housing Census Indicator Maps of Bhutan 2005*, Office of the Census Commissioner, Royal Government of Bhutan, 86 pages.

Osmani, S. R., Bajracharya, B. B., Tenzing, S. Wangyal, T. (2007) *Macroeconomics of Poverty Reduction: the Case Study of Bhutan*, 2nd edition, UNDP Bhutan, August 2007, 286 pages.

Planning Commission, Royal Government of Bhutan (2007) *Rapid Impact Assessment of Rural Development*, Planning Commission, Royal Government of Bhutan, November 2007, 112 pages.

Planning Commission, Royal Government of Bhutan (2007) *Bhutan Millennium Development Goals: Needs Assessment and Costing Report (2006-2015)*, Planning Commission, Royal Government of Bhutan, November 2007, 104 pages.

Rao, J. N. K. (2003) *Small Area Estimation*, Wiley, New York.

Rao, J. N. K. (1999). Some recent advances in model-based small area estimation, *Survey Methodology* 25, 175-186.

You, Y. and Rao, J. N. K. (2002). A pseudo-empirical best linear unbiased prediction approach to small area estimation using survey weights, *Survey Methodology* 30, 431-439.

You, Y., Rao, J. N. K. and Kovacevic, M. (2003). Estimating fixed effects and variance components in a random intercept model using survey data, *Statistics Canada International Symposium Series - Proceedings*.

Royal Government of Bhutan - National Statistics Bureau (2008) *Socio-Economic and Demographic Indicators 2005*, Royal Government of Bhutan - National Statistics Bureau, August 2008, 60 pages.

Royal Government of Bhutan / United Nations in Bhutan (2007) *Common County Programme Action Plan (cCPAP) 2008-2012*, December 2007, 73 pages.

Royal Government of Bhutan / United Nations in Bhutan (2007) *United Nations Development Assistance Framework for the Kingdom of Bhutan 2008-2012*, June 2007, 38 pages.

Royal Government of Bhutan (2003) *Millennium Development Goals: Progress Report 2002 – Bhutan*, Royal Government of Bhutan, February 2003, 49 pages.

Togbay, S. and McCullogh, E. B. (2008) Linking small farmers in Bhutan with markets: the importance of road access, in McCullough, E., Pingali, P., and Stamoulis, K. *The*

Transformation of Agrifood Systems: Globalization, Supply Chains and Smallholder Agriculture, Earthscan, London.

United Nations Bhutan (2006) *Common Country Assessment for Bhutan 2006*, United Nations, Bhutan, 91 pages.

Ura, K. and Galay, K, eds. (2004) *Gross National Happiness and Development*, Centre for Bhutan Studies, Thimphu, Bhutan, ISBN 99936-14-19-X, 755 pages.

Van der Velden, L. (1999) *The Hungry Poor of Bhutan*, WFP Thimphu.

Zhao, Q. (2006) *User Manual for PovMap*, The World Bank.

http://siteresources.worldbank.org/INTPGI/Resources/342674-1092157888460/Zhao_ManualPovMap.pdf

Appendix A

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

General Notes for Tables A1-A18:

1. Tables A1-A18 below provide the detail necessary for preliminary matching of variables in the 2005 census and the Bhutan Living Standard Survey 2007.

2. Questionnaire details have been compared in these tables via their English versions, the language in which both were written. The tables below list agreement or otherwise in principle. Further statistical checking that similar proportions of people in survey and census respond to each apparently equivalent category will be required after the small area estimation feasibility assessment, and before fitting the final small area models.

3. Standardising by using the same categories and identical questions in census and survey is highly recommended in future, if further small area estimation using a combination of both data sources is planned.

4. The majority of the BLSS2007 survey questions are not collected in the census. With the exception of expenditure related information, such non-matching questions are irrelevant to small area estimation using variants of the World Bank methodology for small area poverty estimation, which model expenditure using survey data and use variables that match between survey and census for prediction of expenditure at household level, and which are then combined to small area level.

5. Tables A1-A18 below are organised by categories within variable type.

Table A1:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Household size, Head of household - Household level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Household size	Form 2B: Household members list, derivable as sum of number of entries (ie names) in col 2.	Numeric: 1, 2, 3,…..	Household roster	Numeric: 1, 2, 3,…..	Usually need to watch during modelling for household sizes in census that are very much in excess of those in the survey, especially if a 'household size squared' term is included in the survey-based model.
Household head	Form 2B, Household members list, col 3.	"Relationship to head of household" is coded, with "01" for "Head".	Household roster column 3 "Relationship to the head"; also Block1.1 Demographics q2.	Code '01' denotes head of household	This variable is useful for deriving personal characteristics of the head as household-level variables. There are possible inconsistencies in the treatment of an absent head.

Table A2:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Sex, Age – Individual level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Sex	Form 2B, Household members list, col 3.	1. Male 2. Female	Household roster column 4 and Block1.1 Demographics q1.	1. Male 2. Female	Combine with age, head of household to give proportion of adult females, female head.
Age	Form 2B, Household members list, col 3.	Numerical values: Age in completed years.	Household roster column 5 and Block1.1 Demographics q3.	Numerical values: Age in completed years.	Used to derive age-related variables such as proportion of children under 7, proportion aged 7 to 14.

Table A3:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Marital Status – Individual level

Topic	***2008 Census Question***	***2008 Census Categories***	***2003/4 CSES Question***	***2003/4 CSES Categories***	***Notes***
Marital Status	Form 2C Individual member details part A: General demographic characteristic and migration, col 3.	1. Single 2. Married 3. Widowed 4. Divorced 5. Separated 6. Living together	Block1.1 Demographics q3.	1. Married 2. Never married 3. Widowed 4. Divorced 5. Separated 6. Living together	Categories are identical, except for interchange of "Married" and "Single/Living together"..

Table A4:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Literacy – Individual level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Literacy	Form 2C Individual member details part B: Education and employment, col 16.	Can read or write in any language 1. Yes 2. No.	Block1.2 Education q10.	Can read or write a short text in: 1. Dzongkha 2. Lotsham 3. English 4. Other 1. Yes 2. No.	Need to combine survey answers to get overall literacy. Use to derive household level variables: literacy of head, proportion literate (aged 6+)

Table A5:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Education – Individual level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Schooling	Form 2C Individual member details part B: Education and employment, col 17.	Attending school 1. Now 2. Past 3. Never	Block1.2 Education q11.	Attending school 1. Now 2. Past 3. Never	Equivalent categories. Use to derive whether head has no schooling.
Education level	Form 2C Individual member details part B: Education and employment, col 18.	Highest grade completed - Never attended 00 No grade 01 Grade 1 …. 12 Grade 12 13 Diploma 14 Undergraduate 15 Graduate 16 > Degree 17 Others	Block1.2 Education q20.	Highest grade completed - Never attended 00 Pre-primary 01 Grade 1 …. 12 Grade 12 13 Diploma 14 Batchelors degree 15 Masters 16 > Masters 17 Others	Despite differences in nomenclature, these are considered to be equivalent for Bhutan. Use to derive education level of head.
Traditional learning	Form 2C Individual member details part B: Education and employment, col 19.	Numerical – number of years of traditional/nonformal education.	Block1.2 Education q22.	Numerical – number of years of traditional/nonformal education.	Use to derive whether head had traditional learning, and how much.

Table A6:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Employment – Individual level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Worked in the past week	Form 2C Individual member details part B: Education and employment, col 20.	1. Yes 2. No	Block1.4 Employment q37, q38.	Farming, fishing, hunting, gathering: 1. Yes 2. No Work for money or profitable business: 1. Yes 2. No	Census has "worked for cash or kind at least one hour in past week". This may not match with the survey answers: further investigation will be required using statistical summaries.
Employment status	Form 2C Individual member details part B: Education and employment, col 24.	1 employer 2 paid employee 3 own-account worker 4 unpaid family worker 5 others	Block1.2 Education q20.	1 regular paid employer 2 casual paid employee 3 unpaid family worker 4 own account worker 5 employer 6 other	1 -> 5 2 -> 1+2 3 -> 4 4 -> 3 5 -> 5 Missing denotes unemployed

Table A7:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Income Source – Individual/Household level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Main source of income	Form 2C Individual member details part B: Education and employment, col 28.	01 salary/wage 02 own enterprise 03 farming 04 property 05 pension 06 stipend 07 remittances 08 livestock 09 weaving 10 other sources 11 no income	Block7 Main sources of income q1(1).	01 wages 02 own business 03 own farm enterprise 04 remittances 05 pensions 06 rental/real estate 07 inheritance 08 charity 09 scholarships 10 selling of assets 11 others	Census has individual level, survey household level with 1st, 2nd and 3rd most important sources. Could use response of head for census, and 1st source from survey. Some recoding also necessary; the validity of this will need checking by statistical comparisons.

Table A8:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Distance to road – Household level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Distance to nearest road	Form 2D Household information part A: Housing conditions and facilities, col 1.	Distance from nearest motorable road head: 1 < 30 minutes 2 30 minutes - 1 hour 3 1 -2 hours 4 2 - 3 hours 5 3 - 4 hours 6 4 - 5 hours 7 5 - 6 hours 8 > 6 hours	Block 4 Access and distance to services: tarred road q8, q8h, q8m; feeder road q9, q9h, q9m.	q8/9 how do you go: 1 foot 2 bicycle 3 motorcycle 4 bus 5 car 6 foot+vehicle 7 other 8 not applicable q8h/9h hours taken q8m/9m minutes taken	Examination of survey responses suggests that it would be reasonable to take the minimum time given for q8 and q9 and categorize as in the census. Need to check statistical summaries.

Table A9:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Wall material – Household level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Wall material	Form 2D Household information part A: Housing conditions and facilities, col 2.	1 concrete/brick/stone 2 cgi/metal 3 mud 4 wood 5 straw/leaves 6 bamboo 7 others	Block 2 Housing q7.	1 mud-bonded bricks/stones 2 cement-bonded bricks/stone 3 concrete 4 mud 5 wood/branches 6 other	Some but not all categories are identical; amalgamation of categories likely to be required to match census and survey information

Table A10:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Roof material – Household level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Roof material	Form 2D Household information part A: Housing conditions and facilities, col 3.	1 concrete/brick/stone 2 cgi/metal 3 mud 4 wood 5 straw/leaves 6 bamboo 7 slate 8 others	Block 2 Housing q8.	1 metal sheets 2 concerete/cement 3 tiles/slate 4 thatch 5 plank/shingles 6 other	Some but not all categories are identical; amalgamation of categories likely to be required to match census and survey information

Table A11:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

House occupation status – Household level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Occupation status	Form 2D Household information part A: Housing conditions and facilities, col 4.	1 owner occupied 2 rented government house 3 rented private house 4 rent free private house 5 rent free government house 6 others	Block 2 Housing q2, q3, q4.	Own the dwelling: 1 yes 2 no Pay rent: 1 yes, in cash 2 yes, in kind 3 no Rent/obtain from whom: 1 public corporation 2 employer 3 private person 4 other	Rental categories difficult to match. Can derive a variable for owner-occupied or not.

Table A12:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Housing conditions: Number of rooms occupied by household - Household level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Number of rooms occupied by household	Form 2D Household information part A: Housing conditions and facilities, col 5.	1 One room 2 Two rooms 3 Three rooms 4 Four rooms 5 Five rooms 6 Six rooms 7 Seven rooms 8 Eight rooms or more	Block 2 Housing q6.	Coded as number of rooms	Census excludes bathroom, toilet and storeroom. Survey excludes kitchen, toilet and balconies. Code values >8 as 8. Need to check statistical comparisons.

Table A13:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Housing conditions: Source of lighting – Household level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Main source of lighting	Form 2D Household information part A: Housing conditions and facilities, col 6.	1 electricity 2 kerosene 3 firewood 4 solar 5 lpg 6 personal generator 7 candle 8 others	Block 2 Housing q20.	1 electricity 2 kerosene or gas lamps 3 candles 4 others	Some amalgamation of categories likely to be required to match census and survey information; need to check statistical summaries.

Table A14:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Housing conditions: Main cooking fuel – Household level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Main cooking fuel	Form 2D Household information part A: Housing conditions and facilities, col 7.	1 electricity 2 kerosene 3 firewood 4 solar 5 lpg 6 others	Block 2 Housing q21.	1 gas 2 electricity 3 wood 4 coal 5 kerosene 6 dung cake 7 other	Census asks for two answers to be circled. It is not clear at present whether the first recorded is the main fuel; statistical matching could resolve this.

Table A15:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Housing conditions: Toilet facility – Household level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Toilet facility	Form 2D Household information part A: Housing conditions and facilities, col 8.	1 independent flush toilet inside house 2 independent flush toilet outside house 3 shared flush toilet outside house 4 vidp latrine outside house 5 long drop latrine inside house 6 pit latrine 7 no toilet facility 8 others	Block 2 Housing q16, q17.	1 flush toilet 2 pit latrine+septic tank 3 pit latrine/no septic tank 4 none 5 other Shared? 1 yes 2 no	1 and 2 in census can be derived from 1 and q17 in survey. Some amalgamation of other categories likely to be required to match census and survey information; need to check statistical summaries.

Table A16:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Housing conditions: Main source of drinking water – Household level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Main source of drinking water	Form 2D Household information part A: Housing conditions and facilities, col 9.	1 piped water within house 2 piped water outside house 3 spring/river/pond 4 rain water 5 tube well 6 others	Block 2 Housing q12.	1 pipe in dwelling or compound 2 neighbours pipe 3 public outdoor tape 4 protected well 5 unprotected well 6 spring 7 river/lake/pond 8 other	Probably: 1+2 -> 1+2+3 3 -> 6+7 4+6 -> 8 5 -> 4+5 Need to check statistical comparisons.

Table A17:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Asset ownership and communications/media facilities – Household level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Communications facilities available in household	Form 2D Household information part A: Housing conditions and facilities, col 11.	Yes/no to ownership of: radio/tape player TV/video telephone(landline) mobile phone computer ... and others	Block 3 Assets ownership q1. [Block 2 Housing q11]	Yes/no to ownership of: radio TV, vcr/vcd/dvd [phone] mobile phone computer ... and others	Some facilities, listed here, are common to both census and survey. Phone ownership is asked in a separate question in the census
Ownership of assets	Form 2D Household information part A: Housing conditions and facilities, col 12.	Yes/no to ownership of: vehicle fridge washing machine ... and others	Block 3 Assets ownership q1.	Yes/no to ownership of: family car, other vehicles refrigerator washing machine	Need to check statistical summaries, particularly for "vehicle" since the survey has other categories (bicycle, tractor, motorbike) that might be classed as vehicles.

Table A18:

Links between Population and Housing of Bhutan (PHCB) 2005 and Bhutan Living Standard Survey (BLSS) 2007

Land and livestock ownership – Household level

Topic	***PHCB 2005 Question***	***PHCB 2005 Categories***	***BLSS 2007 Question***	***BLSS 2007 Categories***	***Notes***
Ownership of land	Form 2D Household information part A: Housing conditions and facilities, col 12.	land/plot: Yes/no	Block 3 Assets ownership q3.	Number of acres in: wet land dry land orchard sokshing pasture seri	Positive amounts for any of survey categories should match with "yes" for census. But need to check on statistical matching.
Ownership of livestock	Form 2D Household information part A: Housing conditions and facilities, col 12.	livestock: Yes/no	Block 3 Assets ownership q2.	Number of head of: pigs horses cattle sheep yaks goats buffaloes poultry	Positive amounts for any of survey categories should match with "yes" for census. But need to check on statistical matching.

Appendix B

Bhutan Constituency-level Rural Poverty Incidence Estimates

General Notes for Tables B1

1. Table B1 below provides poverty incidence estimates directly from the Bhutan Living Standard Survey (BLSS2007) for 2008 Bhutan Constitutions, without use of small area estimation methods. These estimates are for rural areas within electorates only.

2. Standard errors have been estimated using standard errors from Taylor Series linearisation with finite population corrections.

3. While finite population corrections reduce standard errors, they are usually not important for standard error estimation from national sample surveys because their effect is small. However, for BLSS2007 they are important because the proportion of urban-blocks / chiwogs (which are the survey's primary sampling units – psus) that are sampled is very high (especially for towns). Finite population corrections have consequently been incorporated in Table B1 below.

4. Constituency definitions are provided in full in *Final Delimitation Order for the National Assembly Constituencies of the Kingdom of Bhutan*, March 2007, Delimitation Commission of Bhutan.: Table 1: "Dzongkhag-wise Allocation of the National Assembly Seats".

5. The size of the standard errors estimated directly from BLSS2007 allowing for the finite population correction within strata, and tabulated in Table B1, also provide additional evidence of feasibility for small area estimation of poverty incidence.

Table B1

Bhutan Constituency-level Poverty Incidence Estimates

Code	Constituency	Mean	Std. Err.	[95% Confidence	Interval]
111	Chhoekhor-Tang	0.1895	0.0472	0.0969	0.2821
112	Chumey-Ura	0.0565	0.0271	0.0034	0.1097
121	Phuentsholing	0.3944	0.0521	0.2921	0.4966
122	Bongo-Chapcha	0.2779	0.0398	0.1998	0.3561
131	Drujeygang-Tseza	0.2866	0.0473	0.1938	0.3794
132	Lhamoy Zingkha-Trashiding	0.3567	0.0576	0.2436	0.4697
141	Goenkhatoe-Laya	0.0841	0.0209	0.0432	0.1251
142	Goenkhamey-Lunana	0.0092	0.006	-0.0025	0.021
151	Bji-Katsho-Uesu	0.0724	0.0208	0.0315	0.1132
152	Sombaykha	0.2687	0.1006	0.0712	0.4661
161	Gangzur: Minjay	0.4958	0.0713	0.3558	0.6358
162	Menbi-Tshenkhar	0.4119	0.063	0.2881	0.5356
171	Monggar	0.2493	0.0481	0.1549	0.3436
172	Dremitse-Ngatshang	0.6355	0.0291	0.5783	0.6926
173	Kengkhar-Weringla	0.5634	0.0612	0.4432	0.6836
181	Lamgong-Wangchang	0.0427	0.0173	0.0086	0.0767
182	Doga-Shaba	0.0421	0.0106	0.0214	0.0629
191	Nganglam	0.2741	0.0338	0.2077	0.3404
192	Khar-Yurung	0.2661	0.0281	0.2109	0.3213
193	Nanong-Shumar	0.3259	0.038	0.2512	0.4006
201	Lingmukha-Toewang	0.2009	0.0392	0.1239	0.2779
202	Kabji-Talo	0.1469	0.0227	0.1024	0.1914
211	Deothang-Gomdar	0.426	0.0535	0.3209	0.531
212	Jomotshangkha-Martshala	0.5929	0.0568	0.4814	0.7044
221	Pagli-Samtse	0.5126	0.0522	0.41	0.6152
222	Sipsu	0.479	0.0597	0.3618	0.5963
223	Dorokha-Tading	0.6263	0.0489	0.5304	0.7222
224	Ugentse-Yoeseltse	0.5893	0.0478	0.4955	0.6831
231	Shompangkha	0.3338	0.0477	0.2401	0.4274
232	Gelephu	0.2007	0.0511	0.1003	0.3011
241	North Thimphu Throm-Kawang-Lingshi-Naro-Soe	0.155	0.0694	0.0188	0.2912
242	South Thimphu Throm-Chang-Dagala-Genye-Mewang	0.0649	0.0394	-0.0124	0.1423
251	Radhi-Sakteng	0.2122	0.0359	0.1416	0.2827
252	Bartsham-Shongphu	0.2243	0.0434	0.1391	0.3095
253	Thrimshing	0.5783	0.0846	0.4123	0.7444
254	Kanglung-Samkhar-Uzorong	0.3416	0.0652	0.2137	0.4696
255	Wamrong	0.4236	0.0494	0.3268	0.5205
261	Bumdeling-Jamkhar	0.1315	0.0224	0.0876	0.1754
262	Khamdang-Ramjar	0.1601	0.0321	0.097	0.2231
271	Nubi-Tangsibji	0.1378	0.0526	0.0346	0.241
272	Drakteng-Langthel	0.3417	0.0501	0.2434	0.44
281	Pataley-Tsirangtoe	0.1569	0.0384	0.0816	0.2323
282	Kikhorthang-Mendrelgang	0.1388	0.0471	0.0464	0.2312
291	Nyisho-Sephu	0.1572	0.03	0.0983	0.216
292	Athang-Thedtsho	0.2339	0.0353	0.1646	0.3032
301	Bardo-Trong	0.4631	0.0598	0.3457	0.5805
302	Panbang	0.7991	0.0501	0.7008	0.8975