

7. METHODS

7.1 SURVEY DESIGN

From the outset, the census was designed to take place on two levels. Level 1 was planned as a complete enumeration. There were no reliable baseline data, and such an effort is required in order to begin a systematic census program needed for designing sector policies, development interventions, and national vaccination programs.

Typically, in national censuses the approach is to develop an appropriate sampling frame for random sampling that allows the creation of 'gold standard' data against which total enumeration data are then evaluated. This was not possible in Afghanistan. Although the comparison was attempted (see Section 7.2), neither level could, in fact, provide 'gold standard' data quality data. However, the results of this census allow the definition of an appropriate sampling frame for the future. Accordingly, the methodology described in Section 7.2 can be considered a reference for future work.

The design of the census on two levels was motivated primarily by two considerations: first, acquire detailed production system data, and second, create a data set that allows consistency checking of Level 1 data where feasible. While the comparison, as discussed, suffered from inherent sampling design problems impossible to avoid, the analysis of production system characteristics was very successful and further supported by data derived in the survey of female livestock owners.

As this report amply documents, data from both levels are intrinsically consistent and provide an excellent summary picture of the Afghan livestock sector. The key problems and most promising intervention routes were identified. Level 2 results allow the application of livestock herd dynamic models (for example Baptist, 1992) to extrapolate herd growth and potential off take data. The impact of the drought on animal numbers was identified by the survey; however, the reasons for the decline of animal numbers are manifold. For example, many farmers in Afghanistan sell livestock when their wheat crop fails. While often this coincides with forage shortages caused by drought, the sale of the animals does not necessarily coincide with the worst state of the pastures in a drought.



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7.2 ANALYSIS METHODOLOGY

Most of the analysis effort was invested in data cleaning. The most critical problem encountered was the separation of true zero answers from missing answers. Many statistics required the computation of ratios (for example, number of certain livestock per species, or number of young per dam, etc.). The frequent inconsistency of data entries as a result of unsatisfactory distinction between true zero and missing answer required considerable verification effort. With the exception of the Level comparison statistics, only basic univariate summary statistics were employed. Additional analysis is conceivable, for example discriminate analysis verifying that the definition of agro-ecological zones adequately reflects important production system characteristics. Further, reproduction data could be used for livestock population dynamics modelling.

7.3 DATA CONSISTENCY

Assumptions and Notation

Comparison of Level I and Level II observations were made at the district level. Level I observations are regarded as census data. We denote ratios of number of livestock per family in a district by:

π_{cattle} = the number of cattle per family,

π_{sheep} = the number of sheep per family,

π_{goats} = the number of goats per family,

$\pi_{donkeys}$ = the number of donkeys per family,

π_{camels} = the number of camels per family.

In our analysis, we take as our null hypothesis that these ratios computed from Level I (census) data are the true district values. For example, if:

$X_{cattle,ij}$ = the number of cattle owned by the j^{th} family in the i^{th} village of the district,

and there are N villages in the district and R_i families in the i^{th} village, then:

$$\pi_{cattle} = \frac{\sum_{i=1}^N \sum_{j=1}^{R_i} X_{cattle,ij}}{\sum_{i=1}^N R_i}.$$

The four other ratios are computed in the same manner.

Level II observations are obtained from sub-samples of families that have been randomly selected from each of n villages. Let r_i denote the number of families selected from the i^{th} village. The n villages were randomly selected from the district. Thus a Level II observation, Y_{ij} , is represented as:

$$Y_{ij} = \mu + \upsilon_i + \varepsilon_{ij}, \quad i = 1, 2, \dots, n, \quad j = 1, 2, \dots, r_i,$$

where

μ = the mean of all Y_{ij} is in the district,

υ_i = the deviation of the mean of all Y_{ij} is in the i^{th} village from μ ,

and

ε_{ij} = the deviation of Y_{ij} from the mean of all Y_{ij} is in the i^{th} village.

Because both the number of villages and the number of families in the Level II data are generally quite small relative to the corresponding numbers in the population (Level I data), we ignore the use of finite

population correction factors in our analysis and regard υ_i is and ε_{ij} is as random components in our representation of Y_{ij} . [Aside: Use of finite population correction factors in our analysis likely would have the effect of slightly decreasing our standard error estimates for Level II estimates of district means. This would result in slight strengthening of the conclusions that we present.] Thus, we assume that:

$$\upsilon_i \text{ is } \square \text{ iid } \left(0, \sigma_{\upsilon}^2\right) \text{ and } \varepsilon_{ij} \text{ is } \square \text{ iid } \left(0, \sigma_{\varepsilon}^2\right),$$

Comparisons of Level I and Level II Observations

We outline the basic analysis for cattle data only, and then present results of our analyses for cattle, sheep, goat, donkey and camel data. Under the null hypothesis that

$$\pi_{cattle} = \frac{\sum_{i=1}^N \sum_{j=1}^{R_i} X_{cattle, ij}}{\sum_{i=1}^N R_i}$$

is the true ratio of cattle per family in a given district, we compute:

$$t_{cattle} = \frac{\hat{\pi}_{cattle} - \pi_{cattle}}{s.e.(\hat{\pi}_{cattle})},$$

where

$$\hat{\pi}_{cattle} = \frac{\sum_{i=1}^n \sum_{j=1}^{r_i} Y_{cattle, ij}}{\sum_{i=1}^n r_i},$$

is an unbiased estimator of π_{cattle} computed from the Level II data. Derivation and computation of the standard error of $\hat{\pi}_{cattle}$, $s.e.(\hat{\pi}_{cattle})$, follows.

Derivation of Standard Error

Letting $m = \sum_{i=1}^n r_i$ (and dropping the subscript 'cattle' for notational convenience), we have that:

$$\hat{\pi}_{cattle} = \frac{\sum_{i=1}^n \sum_{j=1}^{r_i} Y_{ij}}{\sum_{i=1}^n r_i} = (1/m) \left(\sum_{i=1}^n Y_{i.} \right),$$

where replacement of a subscript by a dot indicates summation over that subscript. Because observations from different villages are independent due to the random sampling of villages:

$$Var(\hat{\pi}_{cattle}) = Var(\bar{Y}_{..}) = (1/m^2) Var\left(\sum_{i=1}^n Y_{i.}\right) = (1/m^2) \sum_{i=1}^n Var(Y_{i.}).$$

Using our mixed model representation of Y_{ij} :

$$\begin{aligned} Var(Y_{i.}) &= Var\left(\sum_{j=1}^{r_i} Y_{ij}\right) + \sum_{\substack{j=1 \\ j \neq j'}}^{r_i} \sum_{j'=1}^{r_i} Cov(Y_{ij}, Y_{ij'}) \\ &= r_i \left(\sigma_{\upsilon}^2 + \sigma_{\varepsilon}^2 \right) + r_i (r_i - 1) \left(\sigma_{\upsilon}^2 \right) \\ &= r_i^2 \sigma_{\upsilon}^2 + r_i \sigma_{\varepsilon}^2. \end{aligned}$$

Therefore:

$$\begin{aligned} \text{Var}(\bar{Y}_{..}) &= \left(\frac{1}{m^2}\right) \sum_{i=1}^n \text{Var}(Y_{i.}) \\ &= \left(\frac{1}{m^2}\right) \sum_{i=1}^n [r_i^2 \sigma_v^2 + r_i \sigma_\varepsilon^2] \\ &= \left(\frac{\sum_{i=1}^n r_i^2}{m^2}\right) \sigma_v^2 + \left(\frac{1}{m}\right) \sigma_\varepsilon^2 \end{aligned}$$

We note that for the special case in which equal numbers of families are sub-sampled in each (say)

village, i.e., $r_1 = r_2 = \dots = r_n = r$, so that $m = nr$, then:

$$\text{Var}(\bar{Y}_{..}) = \left(\frac{1}{n}\right) \sigma_v^2 + \left(\frac{1}{nr}\right) \sigma_\varepsilon^2 .$$

Restricted maximum likelihood (REML) estimates of σ_v^2 and σ_ε^2 , which we denote by $\hat{\sigma}_v^2$ and $\hat{\sigma}_\varepsilon^2$ respectively, were obtained using the VARCOMP Procedure of SAS Version 9.0. The estimated variance of $\bar{Y}_{..}$ (or $\hat{\pi}_{cattle}$) was computed as:

$$\hat{\text{Var}}(\bar{Y}_{..}) \equiv \hat{\text{Var}}(\hat{\pi}_{cattle}) = \left(\frac{\sum_{i=1}^n r_i^2}{m^2}\right) \hat{\sigma}_v^2 + \left(\frac{1}{m}\right) \hat{\sigma}_\varepsilon^2 ,$$

and the standard error of $\bar{Y}_{..}$ (or $\hat{\pi}_{cattle}$) then was computed as:

$$s.e.(\bar{Y}_{..}) = s.e.(\hat{\pi}_{cattle}) = \sqrt{\left(\frac{\sum_{i=1}^n r_i^2}{m^2}\right) \hat{\sigma}_v^2 + \left(\frac{1}{m}\right) \hat{\sigma}_\varepsilon^2}$$

Example Calculation of t_{cattle} :

We use observations from the Qadis district of Badghis province to illustrate the calculation of t_{cattle} . The Level I (census) value for π_{cattle} in the Qadis district is:

$$\pi_{cattle} = 0.5105 .$$

Families from six ($n=6$) villages in the Qadis district were randomly sub-sampled for Level II observation. The numbers of families selected were (in no particular order):

$$r_1 = 5, r_2 = 4, r_3 = 1, r_4 = 5, r_5 = 5 \text{ and } r_6 = 5 .$$

The Level II estimated ratio of cattle per family was $\hat{\pi}_{cattle} = 2.4000$. REML estimates of the variance components were:

$$\hat{\sigma}_v^2 = 1.35743 \text{ and } \hat{\sigma}_\varepsilon^2 = 6.41973 ,$$

so that the standard error of $\hat{\pi}_{cattle}$ was computed as:

$$\begin{aligned}
s.e.(\bar{Y}_{..}) &= s.e.(\hat{\pi}_{cattle}) = \sqrt{\left(\frac{\sum_{i=1}^n r_i^2}{m^2}\right) \hat{\sigma}_v^2 + \left(\frac{1}{m}\right) \hat{\sigma}_\varepsilon^2} \\
&= \sqrt{\left(\frac{5^2 + 4^2 + 1^2 + 5^2 + 5^2 + 5^2}{25^2}\right) (1.35743) + \left(\frac{1}{25}\right) (6.41973)} \\
&= 0.71477 .
\end{aligned}$$

Finally, we compute t_{cattle} as:

$$t_{cattle} = \frac{0.51050 - 2.4000}{0.71477} \approx -2.644 .$$

Summary of Results :

The following table presents values of t_{cattle} (t_{sheep} , t_{goats} and $t_{donkeys}$ are given in the Tables A - A). If the ratios π_{cattle} , π_{sheep} , π_{goats} and $\pi_{donkeys}$ computed using the Level 1 (census) data are the true district values, then corresponding values of t_{cattle} , t_{sheep} , t_{goats} and $t_{donkeys}$ should behave approximately like independent standard normal random variables based on Central Limit Theorem arguments. As a rule of thumb, approximately 95 percent of the values should fall between minus two and plus two, and essentially all values should fall between minus three and plus three. Further, values should be distributed somewhat symmetrically about zero. All four tables exhibit, to varying degrees, the following tendencies:

1. An excess (relative to our rule of thumb) of large $|t|$ values.
2. Most t values are positive, i.e., values tend to be greater than zero.

Conclusions and Discussion

If Level 2 data are randomly selected sub-samples from districts, then the distributions of the t values are inconsistent with the hypothesis that Level 1 (census) values are true values. However, Level 2 observations were sampled mostly from families with livestock, and no sampling frame could be developed based on the distribution of livestock wealth from Level 1 data. In total, only 29 respondents in Level 2 (of 1284) had no livestock at all. Therefore, we should expect the distributions of the t values to exhibit the tendencies noted in the table above. This, of course, is because Level 2 ratios are estimating the ratios of number livestock to number of families, given that the family has livestock, whereas Level 1 data are global averages of number of animals per family, definitely including all families that had no livestock. Thus, there are three potential sources of bias in the Level 2 data: one is the fact that the number of families without livestock in the sample is likely not representative of the number of families without livestock in the population. This bias could be corrected if the number of families without livestock (for each specific species in question) could be reliably estimated from Level 1 data. However, this is not possible since the questions about number of families without livestock in Level 1 were not species-specific. The next source of bias is wealth distribution. Level 1 data are global community averages per family – not allowing to derive a frequency distribution of livestock ownership according to wealth classes as discussed above. If we know the proportion of families in each district who possess no livestock of a given type, then bias-correction adjustments can be made to our Level 2 ratios. The bias-corrected Level 2 ratios can then be reanalyzed using the procedures outlined herein to assess accuracy of the Level 1 (census) observations. The third source of bias is the selection of villages for Level 2 sampling. Although enumerators were asked to not intentionally select villages for sampling, systematic sampling based on convenience criteria is of course likely. However, since no village list was available at the start of Level 2, randomized sampling of villages was not possible.

Table 131 Comparison of cattle numbers in selected districts from Level 1 and Level 2 observations

Obs	Province	District	π_{cattle}	$\hat{\pi}_{cattle}$	s.e. ($\hat{\pi}_{cattle}$)	t_{cattle}
1	Badghis	Qadis	0.511	2.400	0.715	2.644
2	Baghlan	Baghlan	1.805	3.849	1.045	1.956
3	Baghlan	Dushi	1.718	4.344	0.493	5.325
4	Baghlan	Khinjan	2.477	5.563	0.675	4.571
5	Balkh	Dawlat Abad	0.350	2.250	0.201	9.463
6	Bamyan	Kamhard	2.001	2.571	0.869	0.656
7	Bamyan	Saighan	1.534	2.321	0.437	1.804
8	Bamyan	Shibar	1.050	1.100	0.307	0.164
9	Bamyan	Yakawlang	1.708	3.214	1.120	1.345
10	Farah	Anar Dara	0.446	1.432	0.352	2.802
11	Faryab	Dawlat Abad	0.291	1.821	0.345	4.434
12	Ghazni	Dih Yak	0.997	2.231	0.320	3.855
13	Ghazni	Zana Khan	0.429	1.936	0.690	2.184
14	Ghor	Tulak	0.851	2.640	0.668	2.680
15	Hilmand	Nad Ali	1.961	4.000	0.811	2.514
16	Hirat	Ghoryan	0.380	1.600	0.537	2.270
17	Hirat	Kohsan	0.289	0.611	0.224	1.441
18	Hirat	Obe	0.936	2.449	0.317	4.774
19	Jawzjan	Qurghan	0.105	1.379	0.445	2.864
20	Kabul	Chahar Asyab	1.121	4.067	0.496	5.939
21	Kabul City	Nahya 14	0.060	6.375	1.235	5.113
22	Kapisa	Hisa Awal Kohistan	3.020	4.200	1.321	0.894
23	Kunduz	Dasht Archi	1.628	8.100	3.065	2.112
24	Kunduz	Imam Sahib	3.764	15.900	6.623	1.832
25	Laghman	Alingar	2.211	4.036	0.314	5.812
26	Logar	Baraki Barak	1.256	4.807	1.234	2.877
27	Logar	Charkh	0.725	4.474	0.589	6.362
28	Nangarhar	Kama	5.053	4.515	0.554	-0.970
29	Nangarhar	Khogyani	2.235	3.278	0.531	1.965
30	Nangarhar	Muhmand Dara	2.654	5.359	0.460	5.887
31	Nangarhar	Pachir Wa Agam	2.515	4.191	0.746	2.246
32	Nimroz	Khash Rod	0.667	2.600	0.568	3.403
33	Paktika	Mata Khan	2.345	5.917	1.965	1.818
34	Paktika	Sharan	2.214	3.000	1.025	0.767
35	Paktya	Chamkani	3.409	4.923	0.970	1.560
36	Paktya	Dandi Patan	3.432	8.526	3.359	1.516
37	Parwan	Bagram	1.404	4.037	0.405	6.505
38	Parwan	Jabalusaraj	1.306	5.200	1.126	3.457
39	Samangan	Kaldar	1.078	3.750	0.751	3.555
40	Samangan	Khulm	0.416	3.875	2.048	1.689
41	Sari Pul	Sayed Abad	1.750	2.000	0.730	0.342
42	Takhar	Ishkamish	1.561	7.800	2.681	2.327
43	Takhar	Yangi Qala	2.087	7.100	2.029	2.471
44	Zabul	Shahjoy	0.777	3.148	0.695	3.413
45	Zabul	Shahr-e-Safa	0.965	3.087	0.789	2.688

While the exact comparison between Levels 1 and 2 ultimately proved impossible, we should comment on general tendencies exhibited in the data. The production system data from Level 2 appear to be plausible and coherent. Likewise, summary statistics from Level 1, for example on age structure, are compatible with expert opinion about levels of reproduction typical for the extreme low input conditions of Afghanistan. No systematic bias could be detected. Thus, we arrived at the conclusion that the census data provide a reliable picture of the Afghan livestock sector.

7.4. KEY LESSONS LEARNED

“Statistical inference, properly interpreted, can be misleading. But the nature of statistical evidence is such that we cannot observe strong misleading evidence very often.” (Chambers and Skinner, 2003; p. 60)

Important lessons were learned in the Afghan National Livestock Census. They fall into the categories of Methodology, Organization and Supervision, Logistics, and Analysis.

Methodology

The Census was designed to be conducted on two levels of sampling intensity (in terms of amount of information asked from farmers). Level 1, or total enumeration, had the explicit objective of visiting every community in Afghanistan and enumerate livestock numbers by species, relating it to number of families. Level 2, or sub sampling, had the objective to gather detailed production system information and data that could assist in the interpretation of the general stock inventories gathered in Level 1 and inform the design of interventions in the livestock sector.

A survey requires a sampling frame. A frame is an operational representation of the population units of interest (in the case of the Afghanistan National Livestock Census, all farmers). A frame could be for example a list of all farmers. Typically, there would be various steps involved in developing a sampling frame for general populations. In any case, at some point a list of all objects in the area to be sampled must be available. This was obviously not possible for the Census. Accordingly, the only feasible solution for the estimation of livestock populations in Afghanistan was total enumeration. However, information on a more detailed level was required, given the near-total lack of information about production system characteristics, markets, and producer problems and preferences. Accordingly, a much more detailed questionnaire had to be designed and administered to a sub sample of farmers in Afghanistan. However, since it was not possible to develop a sampling frame because of the total enumeration survey being conducted almost concurrently, certain aspects of the Level 2 survey data may be biased. Sources of bias include omission of provinces (due to security and logistics issues), non-random selection of villages within districts and provinces and non-random selection of farmers (because no frame was available). Accordingly, Level 2 violated one of Dalenius’s required prerequisites of a survey (as cited and discussed in Biemer and Lyberg, 2003, p. 4) – the sampling of units from the frame in accordance with a sampling design specifying a probability mechanism and a sample size. This critical issue affected certain aspects of Level 2 results, in particular composite statistics on number of livestock per family, as discussed above. However, the consistency of data on production system properties and farmer preferences clearly demonstrates that even a survey impacted by (in our case unavoidable) design deficiencies can produce valuable and trustworthy data, if conducted by a responsible field team. In fact, given the enormous logistics problems typically faced by survey teams in developing countries, it is arguable if the rigorous conditions theoretically required are ever met. What is needed, however, is an assessment and discussion of possible sources of error. Unfortunately, this seems to be very rarely accomplished in practice. As the key lesson learned we conclude that a more rigorous description of methods for survey design and analysis of data gathered under conditions not meeting ‘ideal’ requirements would be useful for practitioners.

The methodology problems encountered in the Afghanistan National Livestock Census had two major sources:

- (1) The time restrictions implied by the donor
- (2) The security problems restricting access to parts of the country

The implications of these restrictions, which seem to be frequently encountered in similar survey scenarios, will be discussed next.

Logistics

One of the most critical problems encountered when reviewing previous FAO livestock surveys in Afghanistan was the proper identification of location. As detailed in this report, considerable confusion persists about delineation of districts. As a result, unique identification of sampling units (typically mosque communities within village) for Level 1 (total enumeration) data collection was expected to be difficult. To remedy the problem of non-unique identification of sampling units, it was proposed to equip all surveying teams with GPS units for the recording of geographical coordinates that would ensure unique identification. However, the timeline set by the donor made it impossible to wait until all equipment had arrived. As a result, a major effort had to be invested in unique identification of locations (communities visited for total enumeration). This was a key problem in preparing the data for comparison with Level 2 data. Obviously, the translation from and into Dari and operational difficulties in maintaining translation standards compounded the problem. Nevertheless, the key lesson learned is that census quality is a direct function of available time for preparation and execution. In the preparation of a livestock census operation, all logistical problems must be analysed carefully and their impact on data quality assessed as conservatively as possible. It is critically important to maintain good and direct communications between the donor and the census team to ensure that spending deadlines do not impinge upon survey quality. If a census begins without the necessary preparation, delays in data analysis are unavoidable if minimal standards of data quality, integrity and utility are to be maintained.

Organization and Supervision

The number of people employed in the Afghanistan National Livestock Census indicates the scope and intensity of a task of this magnitude. Given the extraordinary difficulties accessing communities in Afghanistan, the extent to which farmers were reached constitutes a major achievement by itself. The organization scheme employing enumerator teams and supervisors in all provinces worked well for the data collection process. However, a critical problem that could have been prevented to a certain degree by reallocation of personnel resources became apparent during the data analysis process. As described above, one of the most difficult, and in some cases almost intractable problems is the differentiation between true zero responses, and no or missing responses. In particular in the calculation of summary statistics such as livestock per family, or number of young per adult female the confounding of true zeros and missing observations causes enormous problems that require considerable time to resolve. An important lesson learned in the Afghanistan National Livestock Census, therefore, is that consistency checking of data sheets and data entry should begin as soon as the first field data arrive at the census headquarters. As long as enumerators are in the field, corrections are possible with manageable effort. Post hoc data corrections are very difficult, time consuming and costly. Thus, not only is it necessary to employ a data entry team that facilitates consistency checking, there should be an additional team that interfaces between the enumerator – supervisor teams and the data entry teams. The task of this team should be the immediate checking of data sheets and identification of all instances of inconsistent information. It is necessary to develop a special manual for this team that facilitates this task. This manual should be developed during the testing phase of the survey.

Although an effort was made to ensure spelling consistency, the level of preparation of the data entry team was not consistent, especially in terms of knowledge of English. If language problems of the level of complexity encountered in Afghanistan are to be expected, data files should be checked by an additional group of personnel trained specifically to identify spelling consistency problems. Especially if multi-level surveys are conducted, comparisons between survey levels will be extremely time-consuming or even impossible if spelling problems have been resolved post-hoc.

Investment in adequate personnel support during data collection and data entry is the key factor in timely execution and analysis of livestock surveys.

Analysis

Most problems encountered in the analysis of the Afghanistan National Livestock Census data were caused by a few, well defined issues. Chief among them were: differentiation between true zeros and no/missing response, proper identification of location, and spelling inconsistency.

While the methods needed for census data analysis are not very sophisticated, comparison between levels or analysis of triangulated questions can be very involved, as the above section on comparison methodology suggests. More sophisticated methods will be useful only, however, if the quality of data matches their requirements. The most critical issue in survey statistics is the definition of the sampling frame and the appropriate definition of sampling size. As discussed above, this was not possible for Level 2 within the time frame set by the donor.

Livestock surveys are often necessary in post crisis situations, where very little if any tangible information needed for the construction of a sampling frame is available. In such cases, total enumeration should be considered as a first step, focusing on livestock numbers, number of families and, if it all possible, data that allow to derive a distribution of livestock wealth classes so that this important factor can be considered in subsequent survey work. After the analysis of total enumeration data, the next step for the development of a sampling frame for more detailed analyses would be the selection of villages/communities within district and province. For detailed Level 2 type surveys, a sampling frame can be developed based on the randomized selection of villages. In other words, the selection of survey units (farmers) following a national census would be a two step process, first developing a sampling frame for villages, and then for farmers (respondents) within villages.

The analysis of Level 2 data produced evidence of some questions not properly understood by respondents and enumerators. Although training was conducted, a manual was written and the survey was tested, few survey results are free of such problems. Accordingly, the important lesson learned is that extensive testing and in-depth analysis of test survey data pays high dividends in national census programs.

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