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of the United Nations

Guidelines for the Enumeration of Nomadic and Semi-Nomadic (Transhumant) Livestock

Publication prepared in the framework of the Global Strategy to improve Agricultural and Rural Statistics

Guidelines for the Enumeration of Nomadic and Semi-Nomadic (Transhumant) Livestock

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Acronyms

ABS	Aerial Block Sampling
AQS	Aerial Quadrat Sampling
CAFF	Conservation of Arctic Flora and Fauna
CARMA	Circum-Arctic Reindeer Monitoring and Assessment Network
CAPRI	Collective Action and Property Rights Initiative
CC	Complete Coverage
CGIAR	Consultative Group for International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIESIN	Center for International Earth Science Information Network (Columbia University)
CPS	Cellule de Planification et de Statistique (Mali)
CSA	Central Statistical Agency/Authority (Ethiopia)
CSI	Consortium for Spatial Information
DDC	Dryland Development Centre (UNDP)
DNSI	Direction Nationale de la Statistique et de l'Informatique (Mali)
DRSRS	Department of Resource Surveys and Remote Sensing (Kenya)
EA	Enumeration Area
EP	Enumeration Point
ERGO	Environmental Research Group Oxford Limited
FAO	Food and Agriculture Organization of the United Nations
FMD	Foot and Mouth Disease
GIS	Geographical Information System
GLPS	Global Livestock Production System
GLW	Gridded Livestock of the World
GPS	Geographical Positioning System
GRID	Global Resource Information Database
GS	Global Strategy to Improve Agricultural and Rural Statistics
GWSM	Generalized Weight Share Method
ICRH	International Centre for Reindeer Husbandry
ICT	Importance of Information Communication Technology
ILCA	International Livestock Centre for Africa (now part of ILRI)
ILRI	International Livestock Research Institute
km2	square kilometres
MLA	Meat and Livestock Australia
NASA	National Aeronautics and Space Administration
NLIS	National Livestock Identification System (Australia)
ODI	Overseas Development Institute
PPR	Pestes des petits ruminants
PSU	Primary Sampling Unit
RIM	Resource Inventory and Management Limited
RGC	Random Geographic Clusters
SRF	Systematic Reconnaissance Flight
SRAT	Stratified Random Aerial Transects
SRT	Stratified Random Transects
SRTM	Shuttle Radar Topography Mission

SSU	Secondary Sampling Unit
TLU	Tropical Livestock Unit
UAV	Unmanned Aerial Vehicles
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

Preface

These Guidelines for the Enumeration of Nomadic and Semi-Nomadic (Transhumant) Livestock have been produced within the framework of the Global Strategy to Improve Agricultural and Rural Statistics (hereinafter, Global Strategy or GS). The Global Strategy is an initiative endorsed in 2010 by the United Nations Statistical Commission that provides a framework and a blueprint to meet current and emerging data requirements, as well as the needs of policymakers and other data users. Its goal is to contribute to greater food security, reduced food price volatility, higher incomes and greater well-being for rural populations, through evidence-based policies. The Global Strategy is centred upon 3 pillars: (1) establishing a minimum set of core data (2) integrating agriculture into National Statistical Systems and (3) fostering the sustainability of the statistical system through governance and statistical capacity building.

The Action Plan to Implement the Global Strategy includes an important research programme, to address methodological issues for improving the quality of agricultural and rural statistics. The research programme seeks to produce scientifically sound and cost-effective methods to be used as inputs in preparing practical guidelines for use by country statisticians, training institutions, consultants, etc.

Given the importance of nomadic livestock in arid and semi-arid areas, and to provide practical guidelines to country statisticians, the Action Plan to Implement the Global Strategy prioritized the revision and finalization of existing preliminary draft guidelines on the Enumeration of Nomadic and Semi-Nomadic (Transhumant) Livestock that was initially prepared by the Statistics Division of the Food and Agriculture Organization of the United Nations (FAO).

These Guidelines for the Enumeration of Nomadic and Semi-Nomadic (Transhumant) Livestock have been prepared with input from specialized senior international and national consultants and experts, and have been reviewed by the Scientific Advisory Committee (SAC)1[1] of the Global Strategy. The draft was also presented and discussed at a dedicated Expert Meeting organized by the Global Office of the Global Strategy held in Accra, Ghana in July 2015 with international, regional and national experts. Detailed comments were made during and after these meetings, and were taken into account in revising the draft.

These Guidelines are intended to be a reference document providing technical and operational guidance on various aspects of the Enumeration of Nomadic and Semi-Nomadic (Transhumant) Livestock in various country conditions, with particular attention being paid to developing countries. It will address an important gap, because the most recent FAO publication on the subject dates back to 1992.

1 The SAC is composed of ten renowned senior experts in various fields relevant to the Global Strategy's Research Programme. The SAC experts are selected for a term of two years. At the time of developing these Guidelines, the SAC members were the following: Vijay Bhatia, Seghir Bouzaffour, Sainte Christine, Jacques Delince, Cristiano Ferraz, Eva Laczka, Dag Maligal, Bakary Sacko, Michael Steiner and Zhu Zenggzuan.

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An initial draft of the Guidelines was prepared from the preliminary draft working paper written by David Bourne, FAO International Livestock Consultant, under the technical supervision and guidance of an FAO team composed of Naman Keita and Giorgi Kvinikadze, FAO Statistics Division (ESS), and Ugo Pica Ciamarra, FAO Livestock Division (AGAL). Mr Bourne also provided guidance to and supervision of the preparation of selected country papers by national consultants[2] in Bolivia, Ethiopia, Jordan, Mali, Mongolia and Niger.

The draft Guidelines were further revised and expanded by Nic Honhold, International Livestock Consultant, who also added other country studies. Mr Honhold worked under the guidance of Naman Keita, Neli Georgieva (Global Office, ESS) and Ugo Pica Ciamarra. To enhance the Guidelines' statistical content, Dramane Bako, International Statistical Consultant, revised the draft and further developed the sections on statistics; Mr Bako also summarized the country case studies. Piero Falorsi (ISTAT), Cristiano Ferraz and Hemilio Fernandez (Federal University of Pernambuco, Brazil), peer-reviewed the sections on statistics.

The Guidelines were finalized by Neli Georgieva, Naman Keita and Ugo Pica Ciamarra. Valuable inputs were received from the SAC members, the participants in the expert meeting held in Accra in July 2015 and the selected peer reviewers[3].

Norah de Falco coordinated the design and communication aspects. The document was edited by Sarah Pasetto.

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2 Carlos Vacaflores (Bolivia), Samia Zekaria (Ethiopia), Fuad Irteimeh (Jordan), Mahady Fofana (Mali) and Ankhzaya Byamba (Mongolia).

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Executive Summary

Agricultural and rural statistics are of great importance, yet it is possible to identify shortcomings in their compilation in several countries. Indeed, the methods of data collection, analysis and reporting vary from country to country, and there is a general need for improvement and for harmonization as advocated by the Global Strategy to Improve Agricultural and Rural Statistics (hereinafter, Global Strategy). Several countries, especially in the developing world, lack the capacity to produce and report even the minimum set of agricultural data necessary to monitor national trends or inform the international development debate (WB/FAO/UNSC, 2011).

In many developing countries, livestock production is one of the fastest growing components of agriculture and, as economic development progresses, is expected to become the largest contributor to the sector. Information on livestock producers and their animals is thus essential to the design, implementation, monitoring and evaluation of socially desirable interventions in the sector, including selective breeding, animal health, improved feeding, processing and marketing policies and investments. However, even the total number of pastoralists around the world cannot be known with any degree of confidence, due to inconsistencies in definitions and uncertain figures. This means that estimations of the number of nomads and semi-nomads are even less reliable.

FAO's previous guidelines on collecting livestock data (FAO, 1992) were published over 20 years ago. Since then, a new awareness of the relative importance of livestock production in rural economies and wealth generation has arisen. New methods of assessing livestock resources and production parameters have also been developed, and new tools have become available for geo-referencing, recording and analysing data. Computer software programs for entering, checking, analysing and displaying data have also greatly improved. Therefore, it is time for FAO's previous guidelines on collecting statistics on nomadic and transhumant pastoralists to be reviewed and revised to reflect these evolutions.

The descriptions and definitions given in the previous FAO publication must be updated, due both to their Afro- and ethno-centric focus, and their failure to draw a clear distinction between nomadism and seasonal transhumance. A more generally applicable definition of the term "nomadism" in its broader pastoral context is required, to avoid confusion and misunderstandings. For operational purposes, the following definitions have been adopted:

- ***Agro-pastoral livestock/pastoralists***: these are permanently settled, with no regular and very limited, local, movement of animals. Their livelihoods depend on both livestock and crops, with livestock being an important but not necessarily the major contributor to household livelihoods. Animals generate cash, food, insurance, manure, transport and hauling services, savings, and other goods and services for the household.
- ***Transhumant livestock/pastoralists***: these are not permanently settled (but are rather generally settled for a certain period of the year). Their movements are regular, cyclical and span short distances. Their livelihoods depend largely on livestock.
- ***Nomadic livestock/pastoralists***: These are not permanently settled. Their movements are irregular, erratic and cover long distances. Their livelihoods depend almost entirely on livestock.

The livestock of permanently settled agro-pastoralists can be enumerated with standard agricultural survey activities. Therefore, these Guidelines focus on the enumeration of nomadic and transhumant livestock, which might otherwise be excluded or partially counted given the particular problems arising due to their mobility.

It is extremely challenging to obtain reliable information on transient livestock populations wandering across extensive rangelands in search of seasonally available pasture. Different countries have adopted a variety of approaches to meet these challenges, depending on local circumstances and requirements; however, there is still no generally accepted method to enumerate nomadic and transhumant livestock.

Generally, two types of surveys can be used to enumerate nomadic and transhumance livestock: (i) ground surveys and (ii) aerial/satellite surveys.

Ground surveys are implemented in two main ways. First, animals can be counted on enumeration points. These are the sites at which animals congregate, such as watering points, vaccination points, dip tanks and spray races; however, they may also include temporary seasonal camps, stock routes and livestock markets. In some situations, it may also be possible to create specific enumeration points specifically for the survey. This requires a complete list and a map to be compiled of all the points of a given type in the enumeration area. Each type of enumeration point has advantages and disadvantages. Watering, vaccination and dipping points have some operational advantages, as animals come to these points so they can be seen and counted. However, not only nomadic livestock may come, and young stock may be excluded. Stock routes provide a good indicator of the number of animals moving from one area to another, but may change from year to year and it is practically difficult to count large herds of moving animals. Livestock markets are good places to meet owners, sellers and buyers for information on market conditions and to collect data on the volumes and prices of livestock. However, the numbers sold may not reflect population size, and not only transhumant and nomadic livestock are sold in such markets.

Second, in some countries nomadism and transhumance are practiced by some specific ethnics groups or clans; in these cases, livestock enumeration may be done with the support of the ethnic group or clan leaders and family networks, and livestock enumerated by identifying and locating temporary seasonal camps of group members. Before using this approach, the following basic conditions must be fulfilled: the prior agreement and full cooperation of all group members must be obtained, especially of the leaders; a list and a map compiled of all camp locations in the enumeration area; advance conduction of an awareness campaign to explain the purpose of the operation.

The main advantage of this method lies in the fact that group or clan leaders participate in planning the operation, assist in identifying and locating the group members, and facilitate the collection of information. Some of disadvantages are: the clan leadership may not be aware of the camp site locations of all of the group members; the areas involved may be very large, such that exact locations may not be known; and some pastoral areas may be shared by more than one group or clan, such that more than one set of leaders may have to be involved.

Animals can be enumerated by means of the physical inspection of animals in herds and flocks (direct observation) or from the numbers reported by informants (interviews). Of these, the former option is preferable, as declaration biases may be avoided. The enumerators must count animals themselves, and may use various tools: hand tallies or counters (single or multiple counters), photographs, etc. To avoid double counting, the counted livestock may be marked and an enumeration certificate provided to herders after counting. During the enumeration of large herds, it is very difficult to simultaneously collect data on several variables, such as species, age, sex and breed. It may be appropriate to arrange for one enumerator to call out the species, sex and age of each animal seen, and another enumerator to record the observations. To collect these types of data, it is also possible to select a sample of the herd.

The second enumeration option consists in using questionnaires to collect the number of livestock through herders' declarations. In this case, some issues must be taken into consideration: the recall periods for large ruminants (12 months) and small ruminants (6 months) should be different; the herder is not necessarily the owner; and herders are sometimes reluctant to provide accurate information on the number of their livestock, due to cultural considerations and the fear of taxation or other government policies in some countries. These issues may give rise to significant declaration bias. Therefore, to correct these biases, it is important to select a sample of herds for a supplementary direct counting of livestock.

Aerial surveys can be implemented in various ways. Low level-aerial surveys, which are usually flown at between 300-1,000 feet (100-300 metres) above the ground, are ideal for coverage of extensive and remote areas that are inaccessible by other means. The animals are counted and recorded during flight; for larger herds, photographs are taken, for subsequent verification and correction of observer bias. Instead of teams of people flying in a low-flying aircraft, cameras can be installed and take photographs at regular intervals. However, counting animals from photographs requires training and experience, to ensure that the objects counted are truly livestock and that all livestock are recognized as such. Aerial photographs may be used to check the visual counts and to try to determine and correct observer bias.

Drones and micro-drones may be another way to gather aerial count data without the need to organize manned flights. This equipment is starting to be used for data collection in relatively remote areas and for entities that are difficult to count, such as wildlife animals. The use of larger drones for enumerating livestock is currently not a common practice, because they are expensive and require a high level of technical support. "Micro-drones" or personal drones are more likely to be of use. These are relatively cheap, small, lightweight and easy to operate. They can be fitted with video cameras or still cameras. Currently, their major limiting factor is their very brief flight duration. However, this is likely to increase in a few years, and also depends on the size of battery that the micro-drone can carry.

An additional method of aerial surveys is reliance upon satellite imagery. Today, this is widely available and, in the absence of reliable maps, can be an effective substitute in planning and implementing field data collection for livestock enumeration. A complementary ground survey is however necessary to gain information on variables such as age, sex or breed, as this type of information is difficult to collect from the air.

The survey design used to enumerate nomadic and transhumant livestock depends on the method adopted to conduct the survey. For ground surveys, it is first necessary to create a complete list of all enumeration points for the selected type or ethnic group or clan, to build a reliable national sampling frame for data collection. The second step is to decide between implementing a census or a sample survey. Generally, complete enumeration is easier and more appropriate than a sample survey, especially for cross-border transhumant livestock, as in these cases it is difficult to create and update a reliable sampling frame. Therefore, it is recommended to implement a complete enumeration of all existing enumeration points for the selected type.

If sampling is necessary, due to e.g. operational, financial or timing constraints, stratification may be useful to reduce statistical variation and improve the precision of estimates. The strata may consist in the various categories of enumeration points in the selected type or administrative geographical areas. It is possible for some strata to be surveyed completely and others on the basis of a sample of enumeration points.

Sampling enumeration points for transhumant and nomadic livestock enumeration is rather challenging, due to the mobility of animals at and around enumeration points. Calculating the probabilities of selection (used for weight estimation) may be a complex task and it may be difficult to collect the information required for such computation in the field. In most countries, a stratified simple random sampling may be suitable when enumeration points must be sampled. Calculating the probabilities of selection is straightforward, but it requires knowledge of the number of enumeration points visited by the statistical units (herds, animals) during the year – and this information must be collected in the field.

Depending on the number of enumeration points and their geographical dispersion, a multi- stage sampling approach may be used to reduce survey costs. In this case, estimating each animal's probability of selection is a complex effort. For weight estimation, the Generalized Weight Share Method (GWSM) for indirect sampling (Lavallée, 2007) may be considered. One concern relating to the GWSM is that it requires the enumerator to ask how many sampled enumeration points were visited by the statistical units (herds, animals) during the year. This information may be difficult to collect. To date, no country has tested this approach. Therefore, multi-stage sampling should not be considered when dealing with nomadic livestock unless no other options are available.

There are two main methods to assess livestock populations from the air: (1) a total aerial count or a block count; and (2) a sample count. A total aerial count of the animals in a given area can be obtained by flying a series of closely spaced, parallel flight lines with overlapping observation strips, or by means of a circular "corkscrew" flight path of decreasing radius over the area of interest. These flight patterns should cover the entire area without any gaps arising.

There are four main methods for sampling livestock populations from the air: (1) Systematic Reconnaissance Flights (SRF); (2) Stratified Random Aerial Transects (SRAT); (3) Aerial Quadrat Sampling (AQS); and (4) Aerial Block Sampling (ABS). All these methods derive from procedures that were originally developed to count wildlife populations. Generally, the transect method is more efficient than quadrat or block sampling, in terms of cost, navigation, boundary effects, sample errors and crew fatigue. The total number of animals is calculated by estimating the density of animals in the sampled area and multiplying this density by the total area covered by the survey.

The information collected during a livestock enumeration depends to a great extent on national and local circumstances and the purpose of the enumeration, which in any case should be clearly stated at the outset. In recent years, the tools that can be used in livestock enumeration, field data collection, and the analysis and presentation of results have greatly improved, especially due to the advent of hand-held navigation devices, more powerful computers and overall advances in Information Communication Technology (ICT). To collect data on livestock, Computer-Assisted Telephone Interviewing (CATI)/Computer-Assisted Personal Interviewing (CAPI) tools are increasingly used. For surveys conducted on a one-off basis, applications running on smartphones and tablets may be used; these are relatively simple and inexpensive tools in terms of both operational and investment costs. The location can be recorded manually, using either dedicated Geographical Positioning System (GPS) devices, a smartphone mapping app or an additional GPS app.

Electronic identification devices (ear tags, boluses, injectables) may be among the best solutions to obtain a reliable estimate of livestock (whether nomadic, transhumant or sedentary) in a short period of time. The main issue relating to this method may be its cost. Indeed, the cost per animal of electronic identification devices appears to be much greater than that relating to aerial or ground surveys.

An analysis has been conducted of the costs of the various field data collection methods implemented in different countries. The costs were adjusted for inflation and converted to Purchasing Power Parity (PPP) values. The highest cost per animal counted was USD 0.74, registered in Jordan, and could be explained by the fact that facilities were specifically built for counting the animals. The next highest cost was USD 0.47, relating to Ethiopia's aerial surveys; this was certainly due to the fact that aircrafts were used, and thus specialized equipment and highly trained staff were required. For the remaining enumerations, where costs were available, the cost per animal counted was much lower, ranging between USD 0.06 and USD 0.02.

1

Introduction

Methods for evaluating agricultural resources date back more than five thousand years to the very origins of counting and writing systems, first adopted in West Asia's Fertile Crescent. The widespread use of Sumerian clay tokens and tablets depicting the type and quantity of various commodities, including grain, oil and sheep, mark the beginnings of urbanization and state formation (Schmandt-Besserat, 1991), as well as the start of formal agricultural accounting. Today, in a rapidly changing world, responsible governments must regularly assess and monitor their human populations and natural resources. Most governments conduct national censuses of their human populations approximately every ten years, to assess changes in population structure and distribution, and for a wide range of planning purposes. Several governments also conduct periodic censuses of agriculture, for the same reasons. Between censuses, sample surveys are often undertaken, such as Household Budget Surveys (HBS), Living Standards Measurement Studies (LSMS) and livestock production surveys. However, the methods of data collection, analysis and reporting vary from country to country, and there is a general need for improvement as well as of harmonization, as advocated by the Global Strategy (see Box 1.1).

BOX 1.1. THE NEED FOR BETTER DEVELOPMENT STATISTICS

In developing countries, three upon four poor people live in rural areas. Most rely on agriculture directly or indirectly for their livelihoods. Agricultural development is therefore vital to achieving the Millennium Development Goals (MDGs), particularly those relating to poverty and food security and to environmental sustainability. Agriculture contributes to development as an economic activity, as a source of livelihoods, and as a provider of environmental services – roles described in substantial detail in the 2008 World Development Report entitled "Agriculture for Development" (World Bank, 2008).

Recognition of its importance has led to a renewed commitment to agriculture within the international development community – a commitment that has assumed increasing urgency given the global context of skyrocketing food prices and falling food reserves. Globally, food prices have doubled between 2006 and mid-2008, a trend driven in part by droughts in grain-producing regions, increased oil prices, and sales of corn to produce biofuels. In the future, food prices are expected to remain higher than their 1990s level and to be more volatile. The role of agriculture as a source of greenhouse gas emissions and other environmental problems has also assumed prominence, given the need to raise production, but with little latitude to expand it into new areas. The need to measure agricultural performance and the results of agricultural investment has therefore become an increasingly pressing priority.

Many countries, especially in the developing world, lack the capacity to produce and report even the minimum set of agricultural data necessary to monitor national trends or inform the international development debate. The Independent External Evaluation of the Food and Agriculture Organization (FAO, 2006) argued that "the time has come for a total re-examination of the statistical needs for the 21st century and how they can best be met." The Evaluation concluded that "the quantity and quality of data coming from national official sources has been on a steady decline since the early 1980s, particularly in Africa." It also found that "official data submissions from countries in Africa are at their lowest level since before 1961, with only one in four African countries reporting basic crop production data." The Evaluation also recognized the increasing demands for new statistics and the need to integrate data on agriculture, fisheries, and forestry to understand their effects on the environment and climate change, and on the use of biofuels to deal with policy issues effectively.

The Global Strategy provides a blueprint for a coordinated and long-term initiative to address the difficulties faced by agricultural statistics systems.

Source: World Bank, FAO & United Nations, 2010. *Global Strategy to improve Agricultural and Rural Statistics.*

1.1. GLOBAL LIVESTOCK PRODUCTION SYSTEMS

The most recent snapshot of Global Livestock Production Systems (GLPS) (see Figure 1 below) is based on an integration of five data sets each having a resolution of 1 km. The data sets are the following: land cover types; length of plant-growing period; temperature characteristics of highland and temperate areas; human population density; and the extent of irrigated areas (Robinson et al., 2011).

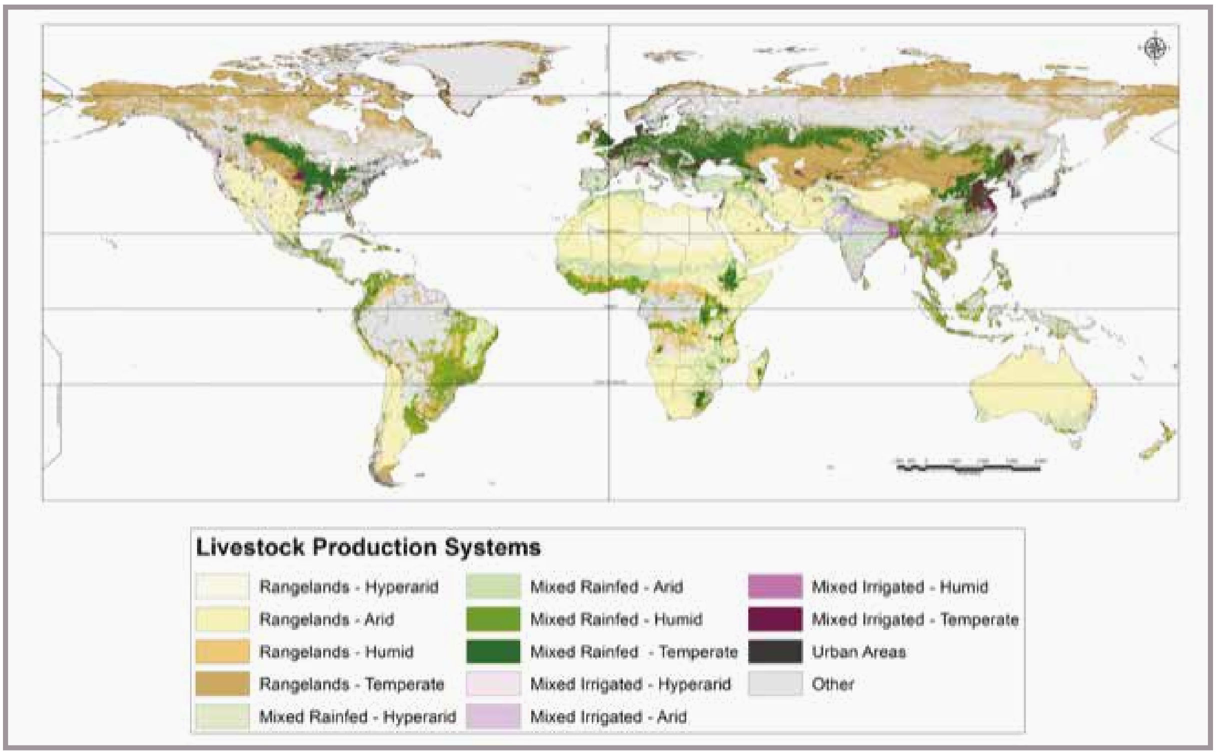
GLPS land areas are shown in Table 1. Rangeland production systems extend over approximately 60 million km2, or 45 per cent of the Earth's land surface. Dryland production systems, including all arid and hyper-arid systems, expand over 45 million km2, or 34 per cent of the Earth's land surface.

TABLE 1. THE LAND AREAS OF GLOBAL LIVESTOCK PRODUCTION SYSTEMS

Livestock Production System	km^2	%
Rangelands Hyper-arid	3,840,000	2.9
Rangelands Arid	32,171,800	24.4
Rangelands Humid	4,602,670	3.5
Rangelands Temperate	19,240,200	14.6
Mixed Rain-fed Hyper-arid	15,468	0.0
Mixed Rain-fed Arid	7,592,820	5.8
Mixed Rain-fed Humid	8,561,070	6.5
Mixed Rain-fed Temperate	8,237,040	6.2
Mixed Irrigated Hyper-arid	6,101	0.0
Mixed Irrigated Arid	1,547,020	1.2
Mixed Irrigated Humid	853,514	0.6
Mixed Irrigated Temperate	1,121,770	0.8
Urban	3,778,140	2.9
Other	40,443,600	30.6
TOTAL	**132,011,213**	**100.0**
All Rangelands	59,854,670	45.3
All Arid and Hyper-arid Systems = Drylands	45,173,209	34.2
All Rangeland and Mixed Systems	87,789,473	66.5

GIS data source: Global Livestock Production Systems, FAO and ILRI (http://www.fao.org/geonetwork/srv/en/main.home).

FIGURE 1. GLOBAL LIVESTOCK PRODUCTION SYSTEMS



GIS data source: Global Livestock Production Systems, FAO and ILRI (http://www.fao.org/geonetwork/srv/en/main.home).

1.2. HOW MANY MOBILE PASTORALISTS ARE THERE?

As extensively documented by several authors (de Haan et al., 1997; Niamir-Fuller, 1999; Blench, 2001; Thornton et. al., 2002; CGIAR-CAPRI, 2005; Rass, 2006; Kerven et al., 2011; and Catley et al., 2012), both nomadic and transhumant forms of pastoralism are widely practiced in many countries and regions of the world. Adaptability and mobility are proven sound strategies for using unpredictable, seasonal fodder and water resources that vary from year to year and from place to place. In light of the increasing climatic variability predicted for the years ahead, nomadic and transhumant pastoralism are set to continue for the foreseeable future.

The total number of pastoralists in the world cannot be known with any degree of confidence, due to inconsistencies in the relevant definitions and uncertainty in the figures computed. However, some estimates have been made, ranging from 20 million pastoral households (de Haan et al., 1997, referred to in Blench, 2001); to 180.7 million pastoralist individuals (Thornton et. al., 2002); and 200 million pastoralist individuals (Rota and Sperandini, 2009).

TABLE 2. BREAKDOWN OF REGIONAL PASTORALIST POPULATIONS IN THE DEVELOPING WORLD

Region		Millions (of individuals)	%
West Asia		31.1	17
East Asia, including China		21.6	12
South Asia, including Pakistan and India		19.3	11
Former Soviet Union (excluding Russia)		8.2	5
South-East Asia		1.4	1
	Subtotal	81.6	46
Sub-Saharan Africa		61.9	34.3
North Africa		5.1	2.8
	Subtotal	67	37
Central and South America		32.1	18
	TOTAL	180.7	100

Source: Thornton et al. (2002).

As noted by Kerven and Behnke (2011), however, the regions listed in Table 2 do not include the developed rich countries of Western Europe, Russia, North America, Australia, Japan, etc. Therefore, the global total is likely to be considerably greater than the figure of 180.7 million given as a total in the table.

While estimates of the total number of transhumance pastoralists are inaccurate at best, estimates of the number of nomads are even less certain. For the latter, a figure of 30-40 million individuals is commonly quoted. However, this appears to be based on an estimate made no later than 1995, and numbers are likely to have fallen since then[1]. Estimates for semi-nomads (i.e. those practicing transhumance) are also difficult to compute, although it is likely that more people practice this system than full nomadism. It is safe to estimate that at least 100 million people depend on nomadic or transhumance production systems worldwide[2].

1 "Nomads: the facts". New Internationalist. Oxford, UK. 5 April 1995.
Available at: http://newint.org/features/1995/04/05/facts/) Accessed on 12 July 2016.

2 Chambers, R. 2013. Nomadic pastoralists - Who are they?
Available at: http://nomadicpeoples.net/wp-content/uploads/2013/04/Defining_Nomadic_Pastoralists.pdf. Accessed in June 2015.

As with the estimates of the number of transhumant pastoralists, considerable uncertainty surrounds the actual geographical distribution of nomadic populations. However, a good indication of the potential distribution of nomadic pastoralists may be inferred from the distribution of rangelands and drylands, with which they are closely associated.

1.3. THE IMPORTANCE OF LIVESTOCK AND NOMADIC LIVESTOCK STATISTICS AND ISSUES TO BE ADDRESSED

Agricultural and rural statistics are of great importance for several reasons. First and foremost, by providing the necessary baseline information on the number of agricultural producers and on productivity, overall production and changes over time, they are a critical input to national and subnational policy formulation, investment design and implementation, as well as monitoring and evaluation activities.

In many countries, livestock production is one of the fastest-growing components of agriculture and, as economic development progresses, is expected to become the largest contributor to the sector. Information on livestock producers and on their animals is thus essential for designing, implementing, monitoring and evaluating socially desirable interventions in the sector, including those relating to selective breeding, animal health, improved feeding, processing and marketing policies and investments.

Where agricultural households are settled and farm specific areas of land, the locations of towns, villages and farms are known and mapped. In these areas, the implementation of agricultural censuses or surveys – including on livestock – is a relatively straightforward process of defining the census area, deciding on an appropriate enumeration frame (usually farming households), mobilizing and training enumerators and then administering one or more standard questionnaires at the farmers' homesteads. Some measurement issues, however, must be addressed, such as: defining what types and breeds of livestock are to be recorded; estimating feed intake from roadside verges; and allocating labour input for different animal species when the herder manages a mixed herd. These can be challenging decisions, but the first step of identifying and interviewing livestock keepers is usually not a major issue.

Where livestock producers are transient pastoralists, standard survey methods of agricultural enumeration cannot be easily applied. Nomadic and transhumant pastoralists move their animals according to the availability of fodder resources and tend to inhabit relatively remote and inaccessible areas, which are major constraints on the conduct of conventional field surveys. The production and consumption decisions of pastoralists also differ from those of settled farmers, because the groups do not necessarily have the same priorities and management strategies. Special attention is therefore required to devise appropriate methods for both enumerating nomadic and transhumant livestock, and assessing the multiple contributions made by livestock to rural households, farming enterprises and local economies.

FAO's previous guidelines on collecting livestock data (FAO, 1992) were published over twenty years ago. Since then, a new awareness of the relative importance of livestock production in rural economies and wealth generation has arisen. New methods of assessing livestock resources and production parameters have also been developed; and new tools have become available for geo-referencing, recording and analysing data. Computer software programmes for entering, checking, analysing and displaying data have also greatly improved. In light of its importance for countries, and to reflect new methods and tools, the Global Strategy has included the development of new guidelines on collecting statistics on nomadic and transhumant livestock as a priority topic in its research programme.

1.4. DEFINITION OF TERMS

According to FAO's previous guidelines on collecting livestock data (FAO, 1992):

- A nomad "*is identified not as belonging to a particular locality, province or other delimited territory but belonging to a tribe which is a group of nomadic people usually having the same ancestral origin*."
- "*Nomadism is broadly defined as a movement of tribes or clans and/or herd keepers with their herds*."

The descriptions and definitions provided in the previous FAO publication should now be updated, due both to their Afro- and ethno-centric focus, and their failure to draw a clear distinction between nomadism and seasonal transhumance.

A more generally applicable definition of the term "*nomadism*" in its broader pastoral context is required, to avoid confusion and misunderstanding.

1.4.01. Pastoralism

According to the Oxford English Dictionary (11th edition), the term "*pastoral*" relates to the use "*of land for the keeping or grazing of sheep or cattle*".

Pastoralism can thus be defined as the husbandry of grazing animals and the use of naturally occurring fodder resources for the production of livestock and maintenance of livelihoods. Pastoralism is widely practiced in many regions around the world where there are marked seasonal variations in the availability of fodder resources, especially in extensive, dry, tropical rangelands and savannahs, but also in temperate and arctic regions.

Pastoral production systems may take many forms and are adapted to particular natural, political and economic environments. The types of livestock kept by pastoralists vary according to climate, environment, water and other natural resources, and geographical location. The types include: alpaca, camels, cattle, horses, goats, llamas, reindeers, sheep and yaks.

Identifying nomadic or semi-nomadic/transhumant producers is possible in the field, on the basis of a less ambiguous and more directly observable criterion, such as the producers' type of dwelling: in particular, whether this is permanent or temporary (sedentary, or mobile). The identification may also occur by asking producers to describe their production practices, to ascertain whether they involve frequent but varying movements during the year (nomadism) or a clear and relatively fixed annual pattern of movements, often towards remote summer pastures (transhumance).

These Guidelines follow the classification adopted in Blench (2001), whose broad review of global pastoralism, commissioned by FAO's Animal Production and Health Division, identified and described three main forms of pastoralism: agro-pastoralism, nomadism and transhumance.

1.4.02. Agro-pastoralism

Agro-pastoralists can be described as settled pastoralists who cultivate sufficient areas to feed their families from their own crop production. Agro-pastoralists usually hold land rights and use their own or hired labour to cultivate land and grow staples. While livestock remains valued property, agro-pastoralists' herds are usually smaller than those found in other pastoral systems, possibly because they no longer rely solely on livestock and depend on a finite grazing area that can be reached from their villages within a day. Agro-pastoralists invest more in housing and other local infrastructure and, if their herds become large, they often send them away with more nomadic pastoralists (Blench, 2001).

For current operational purposes, the following definition will be used:

Agro-pastoralists and agro-pastoral livestock: Agro-pastoralists are permanently settled and the movement of agro- pastoral livestock is local, irregular and very limited. The livelihoods of agro-pastoralists depend on both livestock and crops, with livestock being an important but not necessarily the major contributor to household livelihoods. Animals generate cash, food, insurance, manure, transport and hauling services, savings, and other goods and services for the household.

1.4.03. Nomadism

The Oxford English Dictionary (11th edition) defines the terms "*nomad*", "*nomadic*" and "*nomadism*" as relating to people who travel from place to place to find fresh pasture for their animals and have no permanent home. Nomads are exclusive livestock producers, who grow no crops and depend solely on the sale or exchange of animals and their products to obtain foodstuffs. Their movements are opportunistic and follow pasture and water resources in a pattern that varies from year to year. This type of nomadism almost directly reflects the availability of forage resources; the patchier these are, the more likely an individual herder is to move in an irregular pattern (Blench, 2001).

For operational purposes, the following definition will be used:

Nomadic pastoralists and nomadic livestock: Nomadic pastoralists are not permanently settled and the movements of nomadic livestock are irregular, erratic, and long-distance. The livelihoods of nomadic pastoralists depend almost entirely on livestock.

1.4.04. Transhumance

The term "*semi-nomadic*", meaning partially nomadic, is sometimes used, although it is difficult to define precisely. In recent decades, the tendency has grown for "*transhumant*" to be used in its place.

Transhumance presents regional differences, depending on the climate, landscape and level of economic development.

The following features apply mainly to countries with a temperate climate, mountainous landscape and with a certain level of economic development in Europe, Latin America and Asia.

According to the Oxford English Dictionary (11th edition), transhumance is "the action or practice of moving livestock from one grazing ground to another in a seasonal cycle, typically to *lowlands in winter and highlands in summer.*" In technical terms, this is sometimes called vertical transhumance.

According to Blench (2001), "*[t]ranshumant pastoralists often have a permanent homestead and base at which the older members of the community remain throughout the year. Transhumance is often associated with the production of some crops, although primarily for herders' own use rather than for the market. In many temperate regions, where snow is likely to block animals' access to pasture, haymaking is an important component of the system.*

A characteristic feature of transhumance is herd splitting; the herders take most of the animals to search for grazing, but leave the resident community with a nucleus of lactating females. There are many variations on this procedure, and the development of modern transport has meant that in recent times households are not split so radically; members can travel easily between the two bases. Whether milking females, weak animals or work animals are left behind depends *substantially on the system being followed, and may even vary within an individual system on a year-by-year basis.*

Transhumance has been transformed by the introduction of modern transport in many regions of Eurasia. For example, in the United Kingdom, the transhumance of sheep between the lowlands and highland areas for rough grazing is now conducted entirely by trucks that carry the animals from one grazing point to another. Many pastoralists in North Africa send their animals on transhumance by truck or train. Wealthier countries in the Persian Gulf, such as Oman and Saudi Arabia, make vehicles available at subsidized rates to assist pastoralists with animal transport. It seems likely that this pattern will become more and more frequent, especially as the problem of controlling animals in increasingly densely settled environments worsens."

In other regions, such as in Sahelian countries or in East and southern Africa, transhumance is somewhat different.

Indeed, in these countries, transhumance is characterized by the coexistence of herders and crop farmers, who often compete for resources such as land and water. Many of these countries are entirely organized around the practice of transhumance. For example, in Sahelian countries, "*the difference between the dry north with higher levels of soil-nutrients and the wetter south is utilized so that the herds graze on high quality feed in the north during the wet season, and trek several hundred kilometers down to the south, to graze on more abundant, but less nutritious feed during the dry period. Increased permanent settlement and pastoralism in fertile areas has been the source of conflicts with traditional nomadic herders*[3]" . Some of these countries have both internal transhumance, between different regions of the country, and external transhumance to neighbouring countries.

For operational purposes, the following definition will be used:

Transhumant pastoralists and transhumant livestock: transhumant pastoralists are not permanently settled, although they are usually settled for a part of the year. The movements of transhumant livestock are regular, cyclical and short-distance. The livelihoods of transhumant pastoralists depend largely on livestock.

1.5. PURPOSE OF THESE GUIDELINES

These Guidelines are targeted at statisticians, administrators and decision-makers responsible for collecting data on nomadic and semi-nomadic/transhumant livestock, and are intended to contribute to strengthening and harmonizing data collection. They provide a general review of the literature and methods relating to the enumeration of nomadic and transhumant livestock. The Guidelines present and build on various practical examples of why and how such information has been collected in various countries around the world.

Given the diversity of circumstances prevailing in different countries, these Guidelines should not be regarded as definitive or universally applicable, but rather as providing general guidance on various key issues that must be considered by national practitioners, as well as some examples of how they have been addressed in other countries.

The livestock of permanently settled agro-pastoralists can be enumerated during standard agricultural survey activities. Therefore, these Guidelines focus on the enumeration of nomadic and transhumant livestock, which might otherwise be excluded or partially counted due to their mobility.

3 **New World Encyclopedia**. 2012. *Sahel*. Available at: http://www.newworldencyclopedia.org/entry/Sahel. Accessed 12 July 2016.

2

Review of Enumeration Methods

2.1. OVERVIEW

As evident from the foregoing review, various forms of nomadic and transhumant livestock production are still widely practiced around the world, and are likely to persist for the foreseeable future. It should also be clear that there are many challenges to obtaining reliable information on transient livestock populations wandering across extensive rangelands in search of seasonally available pasture.

Various approaches to these challenges have been adopted by different countries, depending upon local circumstances and requirements. However, there is still no generally accepted method of enumeration of nomadic and transhumant livestock (see Box 2.1).

BOX 2.1. LIVESTOCK ENUMERATION METHODS

There is no best method that is better in all situations but whatever method used, it is necessary first of all to have a good knowledge of the tribal family groups (where applicable), their customs and habits, pattern and time of movements, grazing grounds, including maps of the routes used by each tribe. This kind of information provides useful guidance in choosing the appropriate time and place of survey operations. Information on livestock management practices as well as on the size of the population of each tribe and on the size of its herds are also important, and can be utilized for stratification purposes and other improvements in the sample design.

Source: FAO (1992).

This section provides a systematized review of the existing enumeration methods, to give general guidance to planners, survey designers and policy advisers as they consider the available options and select the most appropriate method for their particular circumstances.

2.2. GENERAL CONSIDERATIONS

Whatever method is used to enumerate livestock populations, it is essential that field activities are coordinated with broader agricultural surveys, that the data collected are in line with the integrated survey framework and that international classifications and definitions (in particular, those endorsed by the Global Strategy) are used. In addition, in the case of nomadic and transhumant livestock, particular attention should be given to avoiding double counting, a factor that poses a major risk. For example, the agricultural survey area may be divided into agricultural and pastoral zones, and each zone dealt with separately using a different methodology. However, the reality is rarely demarcated this straightforwardly, and there is usually considerable overlap between settled agro-pastoral and nomadic/transhumant zones, such that special care is required in the design and implementation of ground surveys to prevent double-counting and to ensure that the animals counted are actually part of nomadic or transhumant production systems.

Ideally, the timing of crop and livestock enumerations should be coordinated to take place at the same time and within as short a period of time as possible. Enumerated livestock should be identifiable and can be permanently marked (i.e. branded or ear-notched), although this may be impractical for large numbers of animals. Alternatively, herders may be provided with an enumeration certificate as proof that their animals have been counted.

The information collected should be standardized and clearly defined compatibly with national agricultural statistics standards and requirements. In particular, the following characteristics should be collected: livestock species name; breed name (where this information is collected); and herd/flock composition (young animals not yet of breeding age, mature females and mature males). The latter information is particularly relevant to any changes arising in the nomadic/transhumant livestock in between surveys.

Deciding how to enumerate nomadic and transhumant livestock requires careful consideration of four separate but interrelated questions, the answers to which differ from country to country, depending on local circumstances and on the human and financial resources available to collect the information required. The questions are:

1. What is the most appropriate way of finding animals and/or their keepers? In statistical terms, of identifying the most suitable frame for locating animals?
2. Should all or only some animals be counted? In statistical terms, should there be a complete census or a sample survey enumeration?
3. How should sample surveys be designed?
4. What is the most appropriate way of counting animals in the field, once the animals or their keepers have been located?

The options available are reviewed in the following sections. The methods for collecting data on livestock are grouped into two main categories: on one hand, those involving ground surveys; and on the other, those involving aerial surveys. However, a combination of the two approaches is generally necessary if reliable data is to be obtained.

2.3. GROUND SURVEYS

The most appropriate way of locating nomadic and transhumant livestock and/or their keepers depends on the national and local circumstances, and may vary in different parts of the same country. For logistical reasons, ground surveys often use enumeration frames targeted at sites where animals congregate, such as watering points, vaccination points, dip tanks and spray races; however, these may also include temporary seasonal camps, stock routes and livestock markets, as discussed in the following sections. In this connection, two issues arise. The first is how to locate the animals, i.e. which enumeration points to select (watering points, dip tanks, etc.). Generally, preference is given to enumeration points that are somewhat independent of governments' policies and programmes: thus, for example, a stock route should be preferred to a vaccination point. This is because the former usually involve all animals, while policies and programmes do not necessarily target all livestock-keeping households nor are they often successfully implemented. The second issue is how to collect data on the number of live animals (through questionnaires for herders or by means of direct observations and count), once the enumeration points have been agreed. In some countries, another option in conducting ground surveys is the use of ethnic groups or clans.

2.3.01. Enumeration points

Several types of enumeration points may be used for this survey.

2.3.01.1. Watering points

In arid and semi-arid areas, livestock surveys are usually conducted during the late dry season, when animals concentrate in areas around water points – wells, boreholes, rivers and lakes – and accessing these points is relatively easy. In the dry season, watering points are very useful locations for counting, as almost all animals will have be brought there fairly regularly. However, it is important to consult the local population to learn the location of all watering points, or to use maps, GPS and satellite imagery to locate them. A classification of watering points by category is sometimes necessary to use a data collection approach that is suitable to each category (see Box 2.2).

The frequency with which animals are watered varies between species; also, some smaller species may be taken to smaller, more local, locations that cattle would find inadequate. For example, camels are characterized by infrequent watering. Again, local knowledge should be sought on this. In any case, counting all the animals that frequent a single water point requires several days at the same location and introduces the possibility of double counting. Enumerators are positioned at all water points to record visiting livestock over a predetermined period of time, depending on the frequency with which animals are watered. To avoid double counting, some form of marking or certifying that animals have already been counted should be used.

Before conducting livestock enumeration based on water points, it is essential to:

- Obtain reliable information on the names and locations of all water points in the target area. If the existing information is obsolete or otherwise unreliable, it should be updated and consolidated into a comprehensive list of all known water points.
- Conduct an initial survey to determine the watering frequency of each livestock species, so that appropriate corrective factors can be applied.
- Identify the period of maximum livestock concentration around water points; and
- Plan and budget for effective coverage and enumeration, with adequate human and financial resources.

TABLE 3. USE OF ENUMERATION POINTS – PREREQUISITES, ADVANTAGES AND DISADVANTAGES

Prerequisites	Advantages	Disadvantages
Complete list and map of all water points in enumeration area (EA).	• Animals come to water points where enumerators, can be positioned • Animals can be easily seen and counted • Logistically simple and easy to organize	• Watering frequency varies with species and location, and must be determined for each species to estimate population sizes • Animals brought are not necessarily nomadic/ transhumant (some may be sedentary) • Depending on how watering is organized, may be difficult to avoid double counting; • Young stock may not visit water point, and may thus be excluded • Small ruminants may be watered at smaller water points than cattle • Additional information/surveys required to determine watering frequencies and proportion of nomadic/ transhumant animals, to estimate population size.

BOX 2.2. USE OF WATER POINTS IN MALI AND NIGER

Mali: Census of transhumant and nomadic livestock (2001)

A preliminary list of the concentration areas of livestock in the dry season was compiled and mapped by the Bureau of Agricultural Census, based on the local knowledge of field staff from the Ministry of Rural Development. The list and map identified the main areas to be enumerated and provided the basic information necessary for planning and implementing the census.

The census was conducted during the late dry season (March, April, May 2001), when livestock congregated in concentration areas around watering points. The concentration areas were classified into two types:

- Type I Concentration Areas, with deep water or isolated pools, boreholes, wells or small isolated ponds. Usually, there were relatively few points in each concentration area.
- Type II Concentration Areas, with surface water (perennial ponds, large lake, rivers and tributaries) and no specific convergent points where all animals were taken to drink. These areas are typical of concentration areas in the Inland Delta and along the Niger River.

In Type I Concentration Areas, enumerators were stationed at each water point and recorded all animals coming to drink over a two-day period. The maximum period between watering for cattle is two days; however, it is much longer for camels.

The watering frequency of camels was determined by means of interviews, and the number of camels observed watering over the two-day enumeration period was adjusted accordingly.

For Type II Concentration Areas, as many enumerators as possible were mobilized to enumerate all livestock within each area as comprehensively and quickly as possible. To minimize double counting, they were then moved on to the next area as quickly as possible.

Field survey teams were equipped with hand counters and Global Positioning System (GPS) locators, to enhance the accuracy of livestock enumeration and recording of the geographical coordinates of concentration areas and water points.

To avoid double-counting sheep during the livestock census and the general agricultural census, herdsmen were issued with an enumeration certificate.

Niger: General census of agriculture and livestock in Niger in 2004/5 (RGAC, 2007)

The survival of livestock in dry-season concentration areas depends critically on the availability of water. In Niger, during the dry season, animals are watered at least once every three days and can be counted at watering points with relative ease. First, the location and type of all known water points was surveyed. To reduce statistical variation and improve the precision of estimates, three types were identified:

I. Boreholes, including all drilled boreholes and pumped water sources;
II. Wells, including all cemented and traditional wells; and
III. Other watering points, permanent ponds and rivers.

Enumerators were posted at water points for three to five days, to record all animals drinking. To avoid double counting, certificates were issued to herders for all herds enumerated. A total of 1,223 water points were included in the census.

2.3.01.2.Stock Routes

In many countries, nomadic and transhumant livestock are moved from one seasonal area of grazing to another along well-established stock routes. Records of the species and numbers of animals passing through can be obtained by strategically placing enumerators at key points along the routes during the main migration periods.

Depending on specific local circumstances, this may provide a good indication of overall livestock numbers. Where, for example, there is only one route or mountain pass through which all animals must go to enter a specific area, it should be possible to count all the animals entering or leaving. However, such cases are relatively rare. Stock routes are often composed of numerous tracks, which are not well-defined and may change from one year to another. There may also be many different routes between seasonal grazing areas, as in the major seasonal movements of livestock occurring each year between Mali and Burkina Faso, and between Niger and Nigeria.

It is important to note, however, that counting animals in large herds that move on the ground is not easy and is prone to error unless special provisions are made, and herders are willing to cooperate and channel their herds into holding pens and through counting gates, using different channels for large and small stock. This too is relatively unusual. Any delay in movement may make it harder for the animals to keep together, which usually makes herders reluctant to accept any delay. However, there may be specific locations for overnight stops during journeys taking more than one day. These specific locations can be useful if it is possible to identify them.

Stock routes are often used in combination with other secondary enumeration points located on these routes, and where enumerators must interview herders. Box 2.3 below presents some examples of the use of stock routes combined with other enumeration points: strategic spots on the trails used by herders and control posts established on the principal cattle routes (Bolivia), and water points located on the principal cattle corridors (Niger)

Before attempting to assess livestock numbers from the passage of animals along stock routes, it is essential to:

- Compile a list and map of all main stock routes in the area of interest;
- Identify key points (mountain passes, river crossings) where all herds must pass, to select the location of checkpoints;
- Consider the practicality of constructing temporary holding pens and channels at strategic locations on stock routes, to enumerate large and small stock; and
- Mount an advance awareness campaign to explain the purpose of the enumeration and facilitate herder cooperation.

TABLE 4. USE OF STOCK ROUTES – PREREQUISITES, ADVANTAGES AND DISADVANTAGES

Prerequisites	Advantages	Disadvantages
• Complete list and map of all stock routes in EA • Cooperation of herders to channel animals through/past checkpoints.	• Can be good indicator of numbers moving from one area to another • Animals pass along stock route where enumerators can be located	• There may be many routes that are not always well-defined • Often, there are multiple tracks • Routes may change from year to year • Not all animals use the same route • It is difficult to count large herds of moving animals

BOX 2.3. USE OF STOCK ROUTES IN BOLIVIA AND NIGER

Bolivia

Animal registry conducted by the National Agricultural Health and Food Safety Service (SENASAG), 2010.
The approach used in this survey was to identify the principal routes and roads used by cattle and establish a number of control posts along them. Three technicians worked in each control point to register livestock, animal products and plant movement.

The survey does not cover secondary cattle trails. SENASAG technicians estimated that their control covered most of the area's livestock movement, approximately 80 per cent of total cattle movement.

The survey is carried out a permanent basis. The registry thus constructs a time series that shows the behaviour over time of transhumant movement through the control post, illustrating the following information: animal quantity, direction, time of the year, owner, place of origin, place of destination, herd age structure and sanitary conditions.

Data is collected from both enumeration points every day of the year, on a permanent basis. This makes it is possible to observe the exact date when cattle from a certain place and/or belonging to a certain owner passes by the control post. Since transhumance movements occur only during certain months, the rest of the year the animals moving will only be registered cattle for slaughter.

Niger

General Census of Agriculture and Livestock, 2007

The census of transhumant animals (both within Niger and to neighbouring countries) required a preliminary survey to establish a comprehensive list of water points and transhumance corridors. Enumerators were located at selected water points along these routes for internal transhumance, to count animals being watered. For external transhumant livestock, enumerators were located at the end of corridors leading to neighbouring countries. During the survey period, enumerators were positioned between Niger and all neighbouring countries.

Once the animals were counted, herders were issued with an enumeration certificate, to avoid double counting and ensure that all herds were counted.

2.3.01.3. Dip tanks and vaccination posts

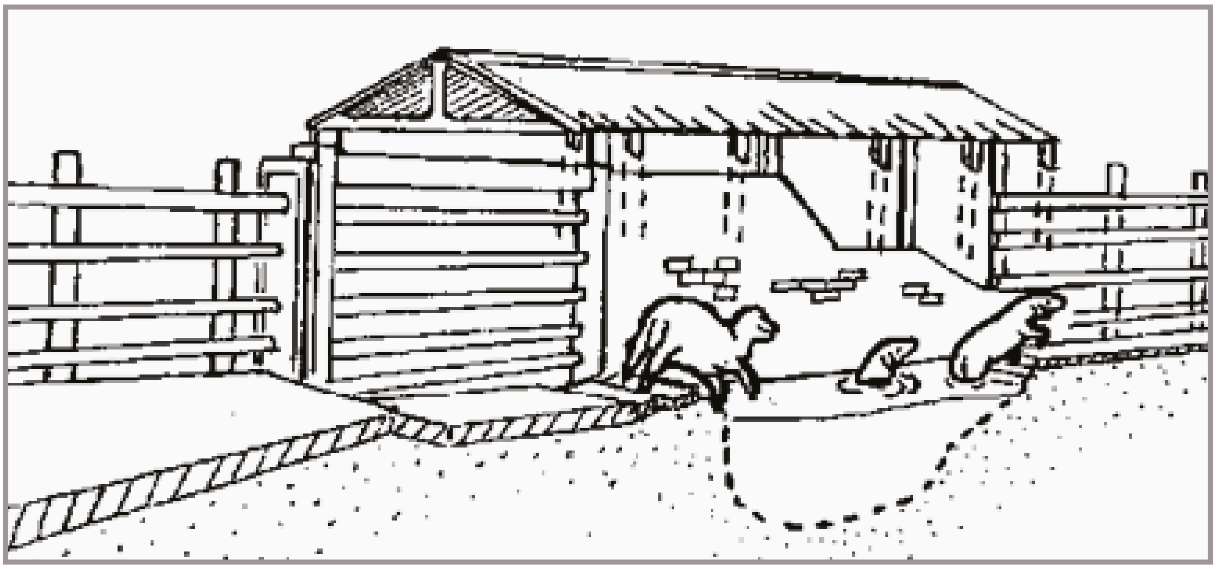
Dip tanks and vaccination posts (which are often at the same place) usually have the advantage of being well-known and recorded on a complete official list. This means that there is already a sampling frame from which a random sample can be drawn or a census made. Also, there will already be data on the numbers of animals being dipped or vaccinated, as records of these should be kept.

The dipping and vaccination registers can also be used to estimate population size, although they are unlikely to give any information on population structure. However, it has long been the case that not all animals are presented for dipping or vaccination, for various reasons, which leads to possible underestimates. In addition, it is unusual for small ruminants or equids to be dipped or vaccinated, meaning that these locations are mostly useful only for enumerating cattle.

Dipping/spraying points

Networks of dip tanks or spray points? to control ticks and biting flies – the vectors of various animal diseases – have been established in many countries in East and Southern Africa, including: Botswana, Kenya, Mozambique, United Republic of Tanzania, South Africa, Zambia and Zimbabwe.

FIGURE 2: EXAMPLE OF DIPPING POINT.



Where such facilities are still maintained and livestock are required to be dipped or sprayed at regular intervals, the records of the numbers treated may be indicative of the population within treatment range. However, much depends on local circumstances and the system's underlying assumptions. The animals treated may include a mix of sedentary and nomadic/transhumant stock. Some animals may not be brought for treatment, because they are too young or – if charges are made – due to the expense.

Dip tanks and spray points work during certain routine periods between treatments, depending on the local needs. Counting all the animals that come to a dip tank requires daily attendance over that period, which usually comprises a number of weeks. A disadvantage is that in many areas where nomadic and transhumant animals are kept, dipping is either not required or there are long intervals between dippings due to the climate. This is less frequent in Africa, although there too, dipping frequencies are being reduced or keepers increasingly apply insecticidal dips themselves.

TABLE 5. USE OF DIPPING/SPRAYING POINTS – PREREQUISITES, ADVANTAGES AND DISADVANTAGES

Prerequisites	Advantages	Disadvantages
Complete list and map of all dipping/spraying points in EA	• Animals come to dipping/spraying points where enumerators can be positioned • Animals can be easily seen and counted • Relatively simple and easy to organize	• Not all animals are brought for dipping/spraying • The animals brought are not necessarily nomadic/transhumant – some may be sedentary • Young animals may not be included • Additional information/surveys may be required to determine the proportion of dipped/sprayed animals and the proportion of nomadic/transhumant livestock, to estimate population size

Vaccination posts

Some countries run periodic vaccination campaigns, which require livestock to be brought to pre-arranged points for vaccination against various diseases, such as: anthrax, foot and mouth disease (FMD), haemorrhagic septicaemia, pestes des petits ruminants (PPR) and brucellosis. The number of animal species vaccinated are recorded at each site, and animals are also usually marked, such as ear notching, so that they can be distinguished from those that have not been vaccinated.

Vaccination campaigns are targeted to specific areas and designed to provide maximum coverage in as short a period of time as possible. The campaigns are usually well-received by herders, who are aware of the benefits. Thus, turnout is typically good, even if there may be charges for the vaccination. The total number of animals vaccinated at all vaccination points in a specific area can therefore be a good indicator of population size. Nevertheless, some herds are likely to be missed and not included in the counting.

There are several issues with using vaccination records. First, as indicated above, not all herds may be presented; even for herds that brought, not all animals may be sent for vaccination. This may be due to the desire to withhold animals, particularly where vaccination is not free or if not all age groups must be vaccinated every year. For certain vaccines, only the young replacement stock is vaccinated in most years. This may be corrected by means of sample surveys, to determine the percentage of animals with vaccination marks, and adjusting the population total accordingly. However, this may require almost as much effort as carrying out a specific sample survey that will also enable a great deal of other information to be gathered on herd structure and reproduction.

Second, most vaccinations are administered to cattle. PPR vaccinations are only for small ruminants and are increasing, but are not yet particularly common in most of the world. Equines are rarely vaccinated against any diseases. Thus, vaccination records are most likely to be useful mainly for cattle, and not for other species.

In other words, vaccination records can be a useful first source of information for nomadic and transhumant livestock. When using them, it is important to understand the specific vaccination protocol applied, to enable appreciation of how many animals are likely to be presented.

Before attempting to assess livestock numbers from vaccination campaigns, it is essential to:

- Compile a comprehensive list of the names and locations of all vaccination points in the target area; the species vaccinated; the type of vaccination given; the date of vaccination; and the mark given to vaccinated animals; and to
- Conduct an extensive post-vaccination survey of livestock herds within the target area, to assess the percentage of animals vaccinated.

TABLE 6. USE OF VACCINATION POSTS – PREREQUISITES, ADVANTAGES AND DISADVANTAGES

Prerequisites	Advantages	Disadvantages
Complete list and map of all vaccination points in EA	• Animals come to vaccination points, where enumerators can be positioned • Animals can be easily seen and counted • Relatively simple and easy to organize	• Different vaccinations are administered to different species • Not all animals are brought for vaccination • The animals brought are not necessarily nomadic/ transhumant – some may be sedentary • Additional information/surveys may be required to assess the proportions of vaccinated and nomadic/ transhumant animals, to estimate population size

2.3.01.4. Specific enumeration points

Considering each country's socioeconomic context, specific enumerations points can be created to ensure reliable livestock data collection. Box 2.4 presents the example of Jordan, where special counting centres were established to facilitate data collection.

BOX 2.4. USE OF COUNTING CENTRES IN JORDAN

Jordan

Census of nomadic and semi-nomadic livestock, 1991

To facilitate data collection, specific counting centres were established. Counting centre listing committees were formed in each of the 26 geographical EAs, to organize and unify the listing process. The committees were also tasked with listing potential counting centres; estimating the number of livestock in surrounding areas by interviews of local specialists, notables, mayors and heads of municipal and village councils; and identifying counting centres for the census.

The criteria for selecting locations suitable for counting livestock were the following:

- The area of land adjacent to the location must be large enough to accommodate the anticipated number of herds brought for counting;
- The counting area's topography should be relatively flat; and
- The sites should be accessible and as close as possible to towns or villages, with a preference for those sites capable of serving more settlements.

It was recommended that counting centres be constructed in the form of fenced triangles, with wire mesh fixed by iron bars; thus, having entered through its wide base, an animal could only exit though a narrow gate at its apex, where it could be marked and counted.

Security personnel have been hired in badiya (desert) areas for the census. Their role and responsibilities were:

1. Thorough guarding along the borders with neighbouring countries for 48 hours prior to the census day, to prevent cross-border movement of sheep that were to be included in the census.
2. Erecting, 24 hours in advance, at least two tents in each counting centre to be utilized by the workers, and providing each team with food and drinks.
3. Providing transport to ensure the punctual arrival of enumerators at their duty stations.
4. Listing of mobile nomadic communities and guiding the enumerators there.
5. Providing a rapid means of communication between work sites and the census operation room at Jordan's Department of Statistics (DoS), relaying instructions or information on the progress of field operations.

2.3.01.5. Livestock markets

Livestock markets are good places to meet owners, sellers and buyers, and to obtain information on market prices for the animals sold. However, the information depends to a great extent on individual respondents' points of view, which naturally cannot be representative of the entire population. Livestock markets tend to hold certain classes of animals, which are usually sold for breeding or slaughter. In addition, only the animals for sale are present, and these may be put up for sale by agro-pastoralist as well as nomadic and transhumant systems.

In addition, such information may be regarded as confidential, and is not always willingly shared. Long-term records of volumes and prices are required to assess seasonal patterns and inter-annual trends.

To determine off-take rates, it is necessary to conduct separate field surveys of representative herds. A crude estimate of livestock population size can be obtained by dividing total annual sales by mean herd off-take. However, assessing this will require a similar amount of work as carrying out a sample survey at those locations. Thus, using livestock markets as a significant source of data on livestock populations is likely to be difficult.

Information from livestock markets should be used in cases when no enumeration points can be used, or to complement existing information on livestock population with some elements on prices. Before attempting to assess livestock numbers from market records, it is essential to:

- Prepare a complete list of all markets in the frame area and assess the extent of their catchment;
- Compile and review long-term records over at least one year (preferably longer) for seasonal and inter-annual comparison.

TABLE 7. USE OF LIVESTOCK MARKETS – PREREQUISITES, ADVANTAGES AND DISADVANTAGES

Prerequisites	Advantages	Disadvantages
• Complete list and map of all markets in EA • Long-term records over at least a year (preferably longer for seasonal and inter-annual comparison)	• Good places to meet owners, sellers and buyers for information on market conditions • Long-term records of volumes and prices can provide useful insight on seasonal patterns and inter-annual trends	• The numbers sold may or may not reflect population size – this depends on other circumstances • Not necessarily all nomadic/transhumant stock is present • Market sales and prices are sensitive/confidential information, that is not always willingly shared • Sellers (middlemen) may have recently bought stock from previous owners who are not present, such that the animal history may not be known • Additional surveys of herd structure are required to determine off-take percentage for the purpose of estimating population size

2.3.02. Ethnic groups or clans

In some circumstances, it may be appropriate to enlist the support of ethnic group or clan leaders and family networks to locate and enumerate livestock by identifying and localizing temporary seasonal camps of group members. This method clearly depends to a great extent upon the willingness of ethnic leaders to cooperate and participate in the enumeration; their knowledge of campsite locations; and the willingness of group members to have their animals counted.

Before attempting to assess livestock populations through ethnic group or clan leaders and family networks, it is thus essential to:

- Ensure that ethnic leaders are willing to cooperate and participate in the enumeration and that they are indeed aware of the locations of their group members;
- Compile a list and map the locations of all camps in the area of interest;
- Mount an advance awareness campaign to explain the purpose of the enumeration and facilitate group member cooperation.

TABLE 8. USE OF ETHNIC GROUPS OR CLANS – PREREQUISITES, ADVANTAGES AND DISADVANTAGES

Prerequisites	Advantages	Disadvantages
• Prior agreement and full cooperation of all group members • List and map of all camp locations in EA	• Group/clan leaders: • Participate in planning • Assist in identifying and locating all members • Explain the purpose of enumeration • Facilitate information collection	• Requires an assumption that the clan leadership is aware of the camp site locations of all its members • The areas may be very large, such that the exact locations may not be known • Some pastoral areas are shared by more than one group/clan; thus, more than one set of leaders may have to be involved

2.4. How are animals counted?

Assessing livestock numbers in the field is not as straightforward as may appear to the uninitiated. Quite to the contrary, careful consideration, standardization and guidance are required before any large-scale enumeration may be conducted.

First of all, it is necessary to establish which species and types of livestock are to be recorded. Are only species totals required, or should the breed, sex and age of animals also be recorded? If the breed and other, more detailed, data are to be collected, enumerators must be provided with guidance on recognizing different breeds and cross-breeds, and on classifying animal into sex and age classes.

There are essentially two options for obtaining this data: (1) physical inspection of animals in herds and flocks (direct observation); or (2) from the numbers reported by informants (interview).

2.4.01. Direct observation

It is not necessarily easy to physically inspect and count large herds of livestock visiting e.g. water points or passing along stock routes, unless there is infrastructure, such as a crush, to separate and channel animals through given counting points. In certain situations, it may be possible to arrange for high-resolution digital photography or video coverage to be recorded for subsequent counting. This two-stage process is advantageous in that a permanent record exists and the numbers can be counted and double-checked; however, it is time-consuming and depends upon the reliability of the camera operation.

The simplest, most reliable and least expensive tool currently available is the hand tally or counter, that can be clicked once for each animal counted and thus provide an incrementing total of the animals counted. Hand tallies can be obtained with single or multiple counters, so that different types or species can be counted at the same time.

FIGURE 3. EXAMPLE OF A HAND TALLY

During the inspection of large herds, it may be appropriate to arrange for one observer to call out the species, sex and age of each animal seen, and for another to record the observations. Hand-held computerized data loggers can also be used for standardized data collection in the field, although these require specialist training.

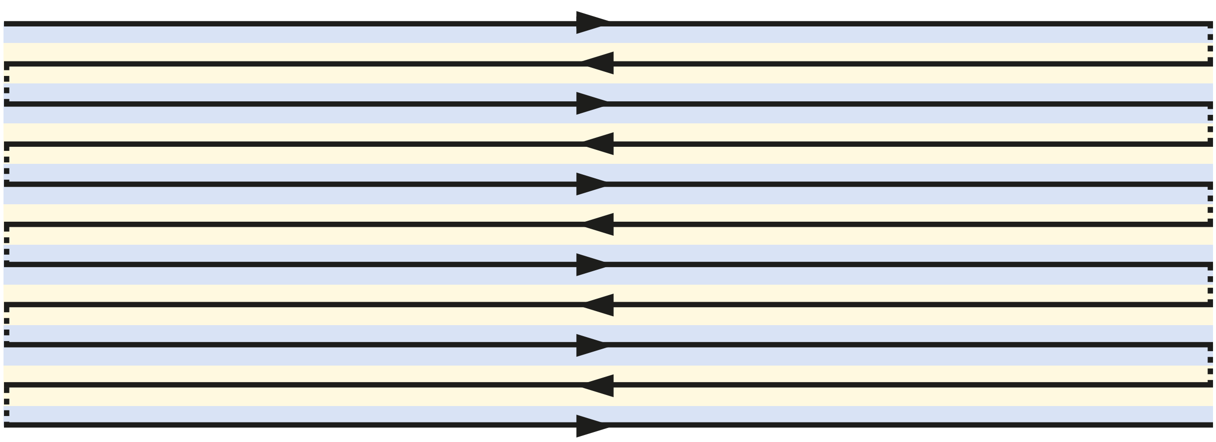
It can be very difficult – if not impossible – to individually count animals in a large, moving herd. In such circumstances, the herd could be visually subdivided into groups of e.g. ten animals, and the number of groups thus counted to provide an estimated total. This estimate is clearly subject to observer bias; however, this can be corrected if there is a vantage point from which the groups or the entire herd can be appropriately photographed. The photographs can subsequently be projected or printed; all the animals may be individually counted from them to obtain a total count. A digital camera with a zoom lens can thus be useful in recording and counting animals in large herds, as are binoculars for viewing distant herds.

2.4.01.1. Counting livestock on foot

An alternative to counting at fixed locations is to randomly select locations and count a fixed area starting from that point. The advent of low-cost GPS machines and of GPS capabilities in smartphones and tablet computers makes it possible to select and walk over an area with some degree of accuracy, as well as with the ability to record it. To cover an area of 1 km2 would require walking back and forth across the area along paths having a regular and pre-established distance between one another. The point of origin can be randomly selected and a north/south aligned area can be chosen. A GPS machine displays position within approximately 10m of accuracy and can also show compass bearings. This makes it possible to cover a 1-km2 area with fairly accurate pathways. An example of such a pathway is shown in Figure 4 below, with 1-km tracks walked 100m apart. All livestock seen during this walk can be recorded. The total distance to be walked is 12km – which should be feasible in a day. The advantage of this type of track (compared to walking a certain distance and counting the livestock on either side of the track) is that enumerators need not be trained to estimate the width of the track that they should count. However, it may increase the risk of double counting.

Other designs creating a 1-km2 count can be used, such as a triangle with equal sides of 3.3 km each, and all livestock located at a distance not greater than 50 m on either side of the track are counted. A square shape could also be used, the sides of which measure 2.5km; again, all livestock found within a distance of 50m of either side of the track would be counted. These would both have the advantage of starting and finishing the enumeration at the same point.

FIGURE 4. SCHEMATIC DIAGRAM OF WALKING A 1-KM2 AREA TO COUNT LIVESTOCK



The diagram is for an area measuring 1 km x 1 km and shows the tracks that must be walked to count all the livestock in the area, using 100m wide strips (the blue and yellow stripes), 50 m either side of each track and tracks that are 100 m apart from each other. Counting is required only along the solid lines; the dotted lines are the route linking the two tracks' end and start points. For the first and last tracks, only the livestock on one side of the track are counted.

2.4.01.2. Marking counted livestock

For vaccination programs, animals are often marked permanently with one of several possible methods, such as ear notching, ear tagging or tattooing. It is not recommended to use a permanent marking system for enumeration purposes, for several reasons. First, it requires animals to be handled, which may not always be possible. Second, it is likely to cause resistance. Animals can be marked with a temporary marker such as a colour stick or spray. It may be possible to mark only a few animals in the group, to indicate that the group has been included. If a colour is used, care should be taken to avoid colours having negative connotations; preference should be given to colours with positive association, if possible (for example, red thread is used in many parts of the world to ward off disease; therefore, a red marker may be popular). The enumerator should explain that the marker is temporary and will not cause any damage to the animals; if necessary, the enumerator should be ready to mark him/herself.

2.4.01.3. Issuing enumeration certificates

Instead of marking livestock, it is preferable to issue, to the keeper or herder accompanying the animals, a brief certificate with the date, location, the name of the project and the name of the enumerator. The number of livestock counted should not be included on it. The enumerator should make sure that the person receiving the certificate understands what is written on it and why; care should be taken to explain the enumeration process and its purpose, that the certificate does not involve money and that it should be kept to show that their animals have already been counted already. The enumerator should explain that after the counting period is over, they can dispose of the certificate.

2.4.01.4. The Pictorial Evaluation Tool for livestock

The Pictorial Evaluation Tool for livestock (PET-Livestock) enables livestock to be assessed by comparing observations with photographs taken of animals – in particular, of a recorded body condition (i.e. using one site on their body). PET-Livestock has essentially two objectives:

- to help assessors to rapidly estimate the most common body condition of groups of domestic animals seen on ranges, in fields, in backyards, by the roadside and in markets and without touching their bodies;
- to quantify and standardize evaluations of livestock body conditions, and monitor changes arising in the same herds and flocks over time, as well as between similar herds and flocks in different locations.

Detailed information on PET-Livestock is available at: http://www.aainternational.co.uk/content/view/78/85/.

2.4.02. Use of informant declarations

If information is to be obtained from respondents, the best people to ask are probably those who manage the animals on a regular basis, because these are accountable to the animals' owners. However, those people may not be willing to provide information without the owner's consent – and the owner may very well not be present. The animals may also be collectively managed on behalf of multiple owners living elsewhere.

It is also important to note that in many societies, it is considered improper to count or declare the numbers of animals owned, for cultural reasons or fear of taxation. Therefore, public awareness campaigns should be held in advance to explain the purpose of enumeration and allay concerns.

When individuals are interviewed, additional issues arise:

I. Different recall periods should be established for large ruminants (12 months) and small ruminants (6 months);

II. Questions must be included on the animals currently owned and those owned at the beginning of the recall period, as this enables estimation of the growth rate of the livestock population, on which information is rarely available;

III. In semi-nomadic production systems, some animals may not be moved and may remain at the homestead (e.g. cows in milk; heifers);

IV. When the herder is also the owner of the animals, he may have incentives to under-report or over-report the number of animals (depending on the government policies in place); on the contrary, herders who are not also owners should have no incentives to misreport.

Correcting declaration bias

If data recorded by enumerators is based on figures provided by respondents, that data must be validated by a physical inspection of a sample of the herds or flocks recorded, to assess the accuracy of the information reported. This validation should be performed independently and as soon as possible after data has been collected by someone other than the enumerator, such as his or her field supervisor.

A subsample of the herd may also be used to correct any declaration bias in data relating to the number of animals. In this case, a selection of herds is randomly chosen from the full sample. The sample size need not necessarily be large, as long as it permits the stochastic convergence of statistical tests[1]. However, the measurement-error sample should be selected with the same sampling design applied for the full sample; this ensures better representativeness of the declaration bias and the consideration of all kinds of biases in the correction process.

The estimator

Let us suppose that the full sample is stratified into H strata. In each stratum, a minimum of 30 herds may be selected for the measurement-error sample.

Let us consider:

- x_{ih} to be the number of animals of herd i of stratum h declared by the herder to the enumerator;
- $x_h = (x_{1h}, x_{2h}, \dots)$ as the vector of the declared sizes of herds in stratum h;
- x^*_{ih} as the number of animals of herd i of stratum h that were effectively counted by the enumerator; and
- $x^*_h = (x^*_{1h}, x^*_{2h}, \dots)$ to be the vector of the real sizes of herds in stratum h.

The declaration bias correction factor in stratum h (β_h) can be estimated with a simple linear regression model:

$$x_h = \beta_h x^*_h + \varepsilon$$

The ordinary least-squares estimator of β_h is:

$$\hat{\beta}_h = \frac{\sum_{i=1}^{n_h}(x^*_{ih} - \overline{x^*_h})(x_{ih} - \overline{x_h})}{\sum_{i=1}^{n_h}(x^*_{ih} - \overline{x^*_h})^2},$$

where n_h is the measurement-error sample size in stratum h; and $\overline{x^*_h}$ and $\overline{x_h}$ are, respectively, the means of vectors x^*_h and x_h.

Numerical example

Let us suppose that in a given stratum h, a sample of 35 herds has been selected to correct declaration bias. For each herd selected, the herder was asked questions on the number of animals. The number of animals was then actually counted.

1 There is no consensus on the minimum sample size; however, approximately 30 observations are generally admitted.

TABLE 9. SAMPLE OF HERDS

Herd ID	Number of animals declared (x_h^*)	Number of animals counted (x_h^*)
H.102436	552	624
H.83617	1,195	1,016
H.141204	942	1272
H.24787	215	243
H.51787	925	675
H.148569	558	631
H.25654	1,081	1,038
H.107337	340	245
H.78328	301	256
H.19963	243	292
H.55098	741	993
H.6967	1,320	990
H.45094	947	1,260
H.31816	643	476
H.89928	1,019	1,274
H.12559	165	183
H.33512	1,322	1,150
H.18245	1,277	1,417
H.71359	579	428
H.89033	855	616
H.94516	161	187
H.15829	1,295	1,140
H.40459	1,133	974
H.127523	304	319
H.99307	684	780
H.95258	1,345	1,533
H.160444	1,165	1,165
H.47413	293	243
H.128248	231	171
H.57497	349	255
H.99500	946	1,154
H.22994	209	253
H.121703	762	907
H.24463	1,388	1,152
H.111332	1,304	1,239
Mean	**765**	**759**

Here,

$\overline{x_h} = 765$

and

$\overline{x_h^*} = 759$.

The declaration bias correction factor is:

$$\hat{\beta}_h = \frac{(552-765)(624-759)+(1195-765)(1016-759)+\cdots+(1304-765)(1239-759)}{(624-759)^2+(1016-759)^2+\cdots+(1239-759)^2}.$$

After calculation, $\hat{\beta}_h = 0.896$

Thus, each number of animals declared can be corrected by dividing it by 0.896 (or multiplying it by 1.12).

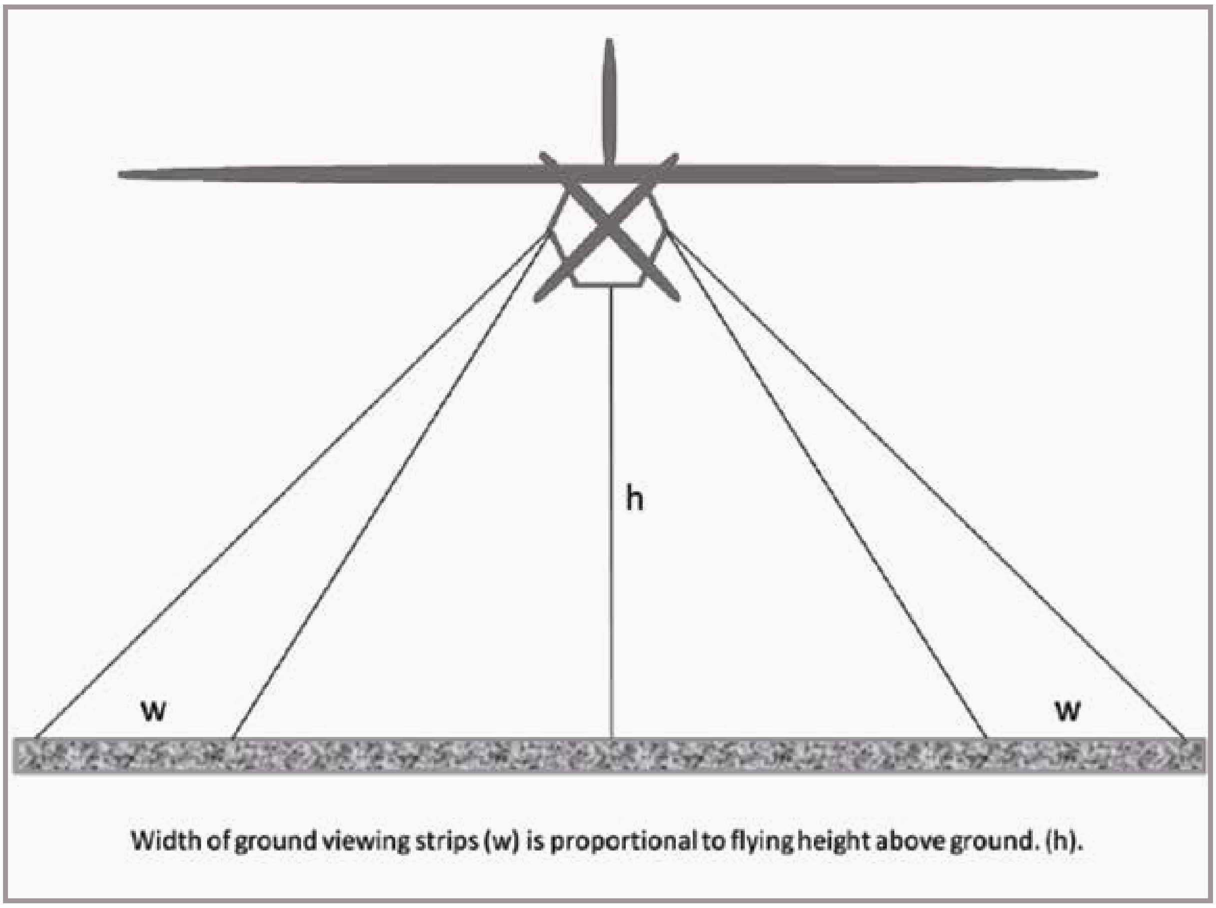
2.5. AERIAL SURVEYS

2.5.01. Low-level aerial surveys

Grazing animals are easier to see, count and photograph from the air than they are on the ground. Low-level aerial surveys are usually done from aircraft flying between 300 and 1,000 feet (100-300 metres) above the ground, and are ideally suited for coverage of extensive, remote areas, inaccessible by other means. Livestock can be seen in thick woodland vegetation, because they tend to frequent relatively open areas therein and are often disturbed by the noise of the passing aircraft. Their oblique passing view enables aerial observers to see under and around trees that may impede ground viewing. Animals are counted and recorded during flight, and photographs are taken of larger herds for subsequent verification and correction of observer bias.

High-wing light aircraft – such as the Cessna 186, Cessna 206, or Patenavia P68 – are usually used for aerial monitoring and low-level aerial surveys (Norton-Griffiths, 1978; ILCA, 1981; Anon, 1986). Helicopters are sometimes used, although they are more expensive to operate. Survey aircraft are equipped with an on-board, programmable autopilot and satellite navigation system for accurate navigation, and a radar altimeter to maintain safe and consistent low-level flight above ground. The aircraft are also fitted with external viewing frames to delineate ground sampling strips on both sides of the aircraft, as shown in Figure 5 below.

FIGURE 5. AERIAL SURVEY GROUND VIEWING STRIPS



The air crew comprises a team of four: the pilot, the navigator (front-seat observer) and two rear-seat observers. The pilot and the navigator are responsible for accurate navigation along a predetermined flight plan and maintaining a consistent height above the ground. The rear-seat observers count and record the number of animals and dwellings seen within ground sample strips on either side of the aircraft, and take photographs of herds and settlements counted whenever possible. The width of these ground-viewing strips is proportional to the flying height above ground. Accurate counts can be made from these photographs at a later stage. The counting bias for each observer is then determined, so that their visual records can be corrected if no clear photographs were available. An important prerequisite to the implementation of aerial surveys is to clearly define the boundaries that are visible from the air, e.g. coastlines, mountain ranges, rivers and roads.

2.5.02. Counting livestock from specially-taken aerial photographs

Instead of arranging for teams of people in a low-flying aircraft, cameras can be installed on aircraft to automatically take photographs at pre-established regular intervals. The cameras could be installed on a low-flying aircraft, but could also be fitted on a drone (see Section 2.5.03. below). To ensure full coverage, the plane or drone should fly at a uniform speed with a regular time interval between exposures; alternatively, the camera could be set to take photographs using GPS co-ordinates. Once on the ground, the livestock would be counted from these photographs. However, it would probably be impossible to achieve a complete census count with this method, even of a relatively small area. Comparatively, it would be simpler to install cameras on the aircraft and set them to take photographs at pre-established distance intervals (using GPS or other location equipment). This could be used to check the visual counts.

However, counting from photographs requires training and experience to ensure that all livestock are recognized as such and only livestock are counted. Counting things in real time is easier, as the brain's visual capacity to recognize objects in real life is greater than its ability to do the same on the basis of photographic images. In any case, as noted above, aerial photographs can be used to verify the visual counts and to determine and correct for observer bias.

2.5.03. Drones and micro-drones

Also known as Unmanned Aerial Vehicles (UAVs), drones and micro-drones may enable the gathering of aerial count data without the need to arrange manned flights. UAVs are starting to be used for data collection in relatively remote areas and for objects that are difficult to count, such as wildlife.

The larger and better known drones, currently used mostly – and most prominently – by armed forces, are expensive and their use requires high levels of technical support. They have a wingspan of several metres and they need an airfield to take off and land. The potential duration of their flight is long, and they are capable of carrying a broad range of advanced instruments on a single platform. These drones may be available through international agencies or perhaps some large non-governmental organizations (NGOs). However, currently, they are unlikely to be used to enumerate livestock. Some law enforcement agencies have started using them to identify illicit crops or to check forest cover; in these cases, they are likely to be dedicated to these purposes alone. Their use by military organizations has given them a generally negative reputation, which may give rise to problems with local populations. The use of such vehicles would certainly require licensing by the national government, as well as military clearance.

"Micro-" or personal drones are more likely to be useful in counting livestock. These are relatively cheap: current prices are in the range of a few hundred dollars, and will probably fall over time. In addition, they are small, lightweight and can be easy to fly; they can be transported in ordinary vehicles or even in backpacks. Many of these drones are multi-rotor helicopter-type vehicles, and can thus take off from and land upon from any flat location. Others are fixed-wing designs and are launched by hand. Some can be programmed to fly a pre-established pattern from an initial starting point and to return to that point automatically. These drones can be fitted with videocameras or still cameras. The former enable counting livestock in real time, similar to aerial flights; alternatively, the flight can be recorded by means of video footage or still photographs, which are used at a later stage to count livestock in a given area. Currently, the major limiting factor is the duration of these vehicles' flight, which tends to be approximately 30 minutes for helicopter-type drones, and slightly longer for fixed-wing drones. The duration also depends on the size of the micro-drone's battery, which – given technological advances in the field – will probably increase in the near future.

In several countries, these small drones are used to monitor and/or count livestock and wildlife [2]. This area of expertise is rapidly expanding, as is the relevant technology. At the time of writing, some systems have the ability to analyse images in real time, on board the drone itself, and transmit the results to the base station. A recent publication by Chamoso et al. (2014) provides further details on the current situation. In light of the speed at which this technology is developing, it is likely that even only five years from now, these semi-automated systems will be more easily available, and at lower costs.

2.5.04. Satellite imagery

Satellite imagery is now widely available on the Internet and – in the absence of reliable maps – can be a valid substitute in planning and implementing field data collection for the purpose of livestock enumeration. Satellite

2 See e.g. the Wikipedia webpage on UAVs for a good set of examples (http://en.wikipedia.org/wiki/Unmanned_aerial_vehicle).

imagery provides a broad overview of the landscape and land cover, and can be useful in locating tracks, settlements and water sources and updating existing maps.

Currently, the highest resolution of commercially available satellite images is of 40-inch pixel size, approximately 1.1 m x 1.1 m. At this resolution, adult cattle can be counted. Interested parties such as Google have used these images to observe the orientation of standing cattle in certain areas. However, it appears unlikely that small ruminants or young cattle can be counted with any real confidence. Also, to cover an area measuring 1 km2, a large image would be required to ensure that individual animals can be seen clearly. Interpreting such images is likely to pose several challenges; in addition, obtaining them may be expensive.

If the resolution improves, commercially available satellite imagery may become an option, although weather conditions (absence of cloud cover) will always be decisive. For the time being, such imagery is limited in terms of enabling animals to be counted; however, if necessary, it may enable the location of watering points and transit routes.

2.6. COMBINING AERIAL AND GROUND SURVEYS

Aerial surveys are more suitable and effective for large survey areas and in desert environments. They are not so appropriate for surveying forest areas, because the trees may conceal livestock and houses. Aerial surveys are also useful in areas that are difficult to access.

Generally, when implementing aerial surveys, it is necessary to conduct complementary ground surveys to address some of the disadvantages of aerial surveys methods. Indeed, the latter:

- Cannot distinguish between sheep and goats, which can only be recorded as small ruminants. The precise ratio of sheep to goats requires a ground survey.
- Cannot distinguish between donkeys, mules and horses, all recorded as equines. Ascertaining their precise ratio requires a ground survey.
- Can only distinguish between cattle by colour types. A ground survey is necessary to assess breeds, and herd age and sex structure.

BOX 2.5. ETHIOPIA: AERIAL SURVEY AND COMPLEMENTARY GROUND SURVEY

Ethiopia: Aerial survey of nomadic livestock in Somali Region, 2004

Ground-truth surveys were conducted in representative weredas (districts) to complement aerial survey findings and provide objective estimates of the:

1. Ratios between the numbers of sheep and goats in different parts of the survey area, as from the air, both were counted together as "shoats";
2. Ratio of donkeys, mules and horses, because it was difficult to differentiate these equines from the air;
3. Sex and age composition of cattle, camel and different equine herds in different parts of the region; and
4. Average size of livestock holdings per household (holder).

Comparing the aerial survey with another ground livestock survey, the aerial survey of the Somali Region is considered to have produced the most reliable and accurate livestock population estimates. Given the remoteness and dimensions of the survey area (which was at least three times larger than that of the Afar census), aerial surveys are clearly the most effective means of assessing the distribution and abundance of livestock and human habitation.

3

Enumerating livestock: survey design and cost issues

In practice, it may be very difficult or even impossible to conduct a census of all nomadic and transhumant herders, due to their seasonal or random movements within and between countries. It is therefore necessary to use alternative methods of livestock enumeration, detailed in Chapter 2 above.

The survey design used to enumerate nomadic and transhumant livestock depends on the enumeration method adopted. This chapter presents the survey methods that can be used for each enumeration approach. The data usually collected and the relevant data collection tools will also be discussed. Finally, the issue of the cost of data collection for each enumeration approach will be explored.

3.1. SURVEY DESIGN, BY ENUMERATION METHOD

As discussed in Chapter 2, two main methods can be used to enumerate nomadic and transhumant livestock:

- Ground surveys, following one of two possible approaches (relying on enumeration points or on ethnic groups/clans)
- Aerial surveys

This chapter discusses some survey designs that are appropriate for these methods.

3.1.01. Ground surveys

3.1.01.1. Enumeration points

To collect data on transhumant and nomadic livestock from enumeration points, the most appropriate type of enumeration points must first be chosen (see Section 2.3.01 above). For the selected type, a complete list of all points (stratified by category, if relevant) must then be obtained. Next, it must be ascertained whether data must be collected on all enumeration points of the chosen type, or whether a sample of enumeration points should be drawn.

Statistical units

For the transhumant and nomadic livestock survey, various statistical units may be used, depending on the objectives of the survey in each country and on data quality issues. In Mali, for example, the statistical unit was the herd; in Jordan, it was the livestock holder. In Niger, the statistical unit considered was the breeder (or shepherd) identified as responsible for the herd, even if he did not own any herds.

Sampling frame

A complete listing of all enumeration points is necessary to establish a reliable national sampling frame for data collection. Generally, this listing is conducted during the general agricultural census or as an ad hoc operation. The enumeration points should be geo-referenced as much as possible using hand-held GPS devices.

Enumeration points must be identified and defined in a way that allows for the participation of all stakeholders: the government, local authorities, herders' organizations and civil society. It is also important to note that transhumant livestock and nomadic livestock may not always have the same enumeration points. In Niger, for example, the enumeration points identified were stock routes for nomadic livestock and water points for transhumant livestock.

Census or sample survey?

Two methods may be applied to collect data on livestock: (1) data is collected on all the enumeration points of the type chosen (complete enumeration); or (2) a sample of enumeration points is drawn and enumerators collect data from these. In choosing one option or the other, several factors should be taken into account: budget, timeline, accessibility of enumeration points and relevance for data quality. Ideally, information would be collected in parallel from all enumeration points, to minimize double counting.

Generally, complete enumeration is easier and preferable than a sample survey, especially for cross-border transhumant livestock, for which it is difficult to create and update a reliable sampling frame. In these cases, the most appropriate method is to count the livestock at border points along the stock routes. These routes can be determined on a map, and the enumerators must be positioned there permanently during the transhumant period. The transhumant period finishes when the crop plantation period begins.

Internal transhumance should be considered separately. In this case too, in most countries, the stock routes are known. The internal transhumant livestock and nomadic livestock can be counted using complete enumeration at all enumeration points, or by selecting a sample of enumeration points.

RECOMMENDATION

As discussed below, sampling enumeration points for transhumant and nomadic livestock enumeration is rather challenging and requires the support of professional statisticians. It is recommended to implement a complete enumeration at all the existing enumeration points of the chosen type. The greatest possible number of enumeration points must be covered in parallel by the census, and double counting must be avoided.

Sampling designs

A number of possible sampling designs and statistical methods to select a sample of enumeration points are presented below. The weights estimators are also provided for each method. These weights are essential to estimate the population of the statistical units (animals, herds, herders, etc.) and to extrapolate some figures relating to them (e.g. the number of animals per species).

Stratification

Depending on the types of enumeration points, it could be useful to stratify each type, to reduce statistical variation and improve the precision of estimates. In addition, a geographical stratification may be of assistance, considering the distribution of the number of enumeration points throughout the country.

Some strata may be completely surveyed; for others, a sample of enumeration points could be selected. The data collection strategy may also differ among strata, as shown in Box 2.2 above (see the case of Mali).

Stratified simple random sampling

When a complete list of enumeration points of the chosen type is available, and a complete enumeration cannot be achieved due to constraints posed by, for example, time or budget, a stratified random sampling method could be applied. In stratified simple random sampling, a representative number of enumeration points is randomly selected for data collection in each stratum, to obtain more precise estimates. As explained above, it is advised to stratify the enumeration points whenever possible. In most countries, a stratified simple random sampling may be the most appropriate method to sample enumeration points for livestock enumeration.

More details on simple random sampling technique can be found in standard textbooks (Cochran, 1977; Kish, 1965; Verma, 1992; Tiral, 2009).

Estimators and weights

Let us suppose that a stratified simple random sampling is applied and no animals are double-counted within and between strata.

Notations

N : total number of enumeration points in the country

n : size of the sample of enumeration points

H : number of strata

N_h : total number of enumeration points in stratum h

n_h : size of the sample of enumeration points in stratum h

m_{hj} : number of enumeration points frequented by animal j in stratum h

Let us consider a given animal j in stratum h.

The probability of selection (π_{hj}) of animal *j* is the probability that at least one enumeration point frequented by the animal *j* will be selected in the sample. It is also equal to 1 minus the probability that any enumeration point frequented by the animal *j* is not selected in the sample.

Thus:

$$\pi_{hj} = 1 - \frac{\binom{N_h - m_{hj}}{n_h}}{\binom{N_h}{n_h}}.$$

After developing and simplifying (π_{hj}), the following equation may be obtained:

$$\pi_{hj} = 1 - \left(1 - \frac{n_h}{N_h}\right) \frac{(N_h - n_h - 1)!\,(N_h - m_{hj})!}{(N_h - n_h - m_{hj})!\,(N_h - 1)!}.$$

The weight W_{hj} of the animal *j* is, therefore, the inverse of its probability of selection.

$$W_{hj} = \frac{1}{\pi_{hj}}$$

Let s_{hi} be the number of animals counted at the sampled enumeration point i.
The Horvitz-Thompson estimator of the total number of livestock is

$$\hat{Y} = \sum_{h=1}^{H} \sum_{i=1}^{n_h} \sum_{j=1}^{s_{hi}} W_{hj}.$$

The unbiased estimate of the Horvitz-Thompson variance is

$$\widehat{Var}_p(\hat{Y}) = \sum_{h=1}^{H} \sum_{j \in S_h} \sum_{j' \in S_h} \frac{(\pi_{jj'} - \pi_j \pi_{j'})}{\pi_{jj'} \pi_j \pi_{j'}},$$

where S_h is the sample of all animals counted in the stratum h and ($\pi_{jj'}$) is the joint probability of inclusion of units *j* and *j*'.
Given the complexity of calculating the joint probabilities of inclusion in this case, alternative methods – such as bootstrap, jackknife or linearization – will be useful to calculate the variance. In addition, approximations of the Horvitz-Thompson variance available in the literature may be used (Deville, 1999; Bruch et al., 2011).

Herd counting
If herds are counted (instead of animals), the relevant estimators of livestock number and variance are given below. The notation is the same as that used above.

Let us consider y_{hij} to be the number of animals of the herd *j* (collected, for example, from the herder's declaration) at the enumeration point i of the stratum *h*.

Let s_{hi} be the number of herds counted at the sampled enumeration point *i* of the stratum *h*.

The Horvitz-Thompson estimator of the total number of livestock is

$$\hat{Y} = \sum_{h=1}^{H} \sum_{i=1}^{n_h} \sum_{j=1}^{s_{hi}} W_{hj} y_{hij}.$$

The unbiased estimate of the variance is

$$\widehat{Var}_p(\hat{Y}) = \sum_{h=1}^{H} \sum_{j \in S_h} \sum_{j' \in S_h} \frac{(\pi_{jj'} - \pi_j \pi_{j'})}{\pi_{jj'} \pi_j \pi_{j'}} y_{hij} y_{hij'},$$

where S_h is the sample of all herds counted in the stratum h and ($\pi_{jj'}$) the joint probability of inclusion of herds *j* and *j'*. In this case too, alternative methods of variance estimation may be useful, given the complexity of calculating the joint probabilities of inclusion.

A NOTE OF CAUTION

In these cases, the main issue may arise in the collection of data on the number of enumeration points frequented by the animal in the year. These data must be the same for all animals of the same herd. If the enumerator asks the question correctly and in detail, the herder should be able to provide the information required.

An example of appropriate question may be as follows: "In general, during a year (or during the transhumance period), how many ***[category of water points]*** does your herd usually frequent for drinking?"

Category of water points	Number of frequentations
Lakes	|__|__|
Rivers	|__|__|
Ponds	|__|__|
Wells	|__|__|
Boreholes	|__|__|
Other	|__|__|

Multi-stage sampling

If a complete list of enumeration points is unavailable and cannot be straightforwardly established for the entire geographical zone covered by the enumeration, a multi-stage sampling can be done. This method also reduces costs. For example, a two-stage sampling can be performed by selecting a sample of census EAs as primary sampling units (PSUs) and then selecting all or a sample of enumeration points (secondary sampling units –SSUs) in each selected PSU. The lists of the enumeration points would be required only for the selected PSUs. The PSUs can be selected with probabilities proportionate to their sizes, or with equal probabilities. In each PSU selected, a sample of enumeration points could be selected with equal probability.

Estimators and weights

Let us suppose a stratified two-stage sampling of enumeration points is being implemented for livestock enumeration.

In these cases, it is rather complex to estimate the probability of selection (and then the weight) of each animal, due to the animals' mobility and their capacity to frequent, potentially, several enumeration points. An alternative method to estimate the weights is proposed below.

Indirect sampling method

To deal with the issue of multiplicity, collecting data on a sample of nomadic or transhumant herders through a sample of enumeration points can be considered from the perspective of indirect sampling.

The indirect sampling method provides a framework for estimating the parameters of two target populations that are related to each other on the basis of the observation units: in particular, the framework is based on a joint analysis of this relationship. One advantage is that the sampling frame selected can be indirectly related to the population of interest in terms of which the frame is incomplete, unavailable or not up-to-date. In addition, data can be obtained from the observation units that are related to one other.

One well-known method to estimate weights for unbiased estimates using indirect sampling is the Generalized Weight Share Method (GWSM) [1], devised by Lavallée (2007).

BOX 3.2. INDIRECT SAMPLING AND GWSM

When dealing with indirect sampling, the GWSM is important for estimating weights. According to Lavallée (2007), use of the GWSM is crucial in the context of indirect sampling, especially in the indirect sampling of clusters. Without this method, it can be almost impossible to produce estimates of simple totals or means.

The basic steps of indirect sampling and weights estimation using GWSM are outlined below. The statistical unit chosen is the herd, although it may certainly be animals or herders.

1 More detailed information on the application of this method in rural sector surveys can be found in the following source: Global Strategy to Improve Rural and Agricultural Statistics. 2015. Guidelines for the Integrated Survey Framework, available at http://www.gsars.org/category/publications/.

Link definition

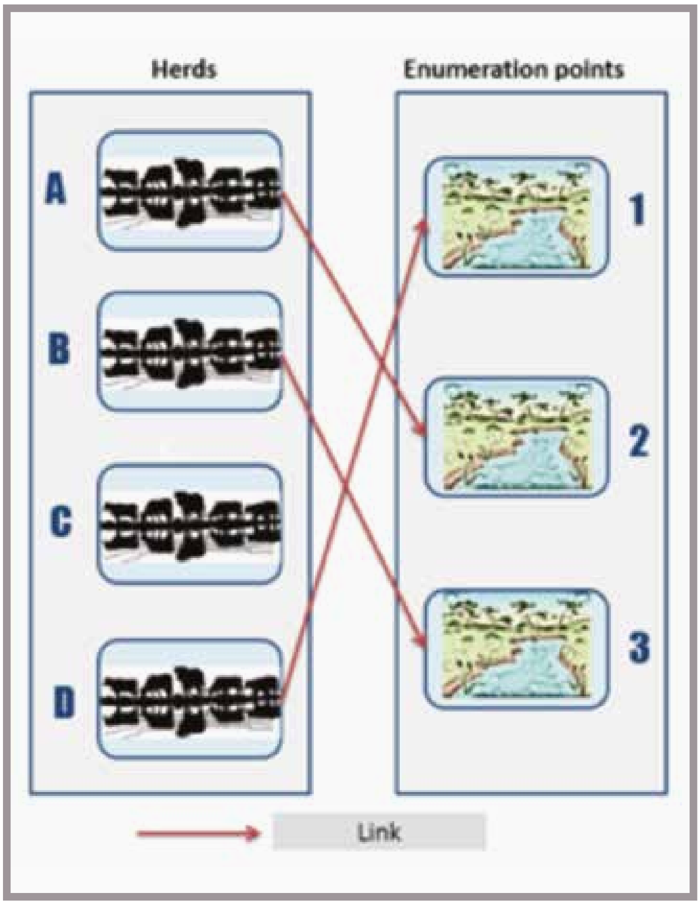
There may be several links between a herd and an enumeration point. For livestock enumeration, the following definition is proposed: a herd is considered to be linked to an enumeration point if it frequents that enumeration point at least once during a given period of time (usually one year or several months in a year).

Generally, four kinds of links may be identified:

(i) One-to-one

In one-to-one links, each herd is linked to only one enumeration point, and each enumeration point is linked to only one herd. Each herd frequents one – and only one – enumeration point during the year, and each enumeration point is frequented by only one herd. Obviously, this kind of link is very rare in practice.

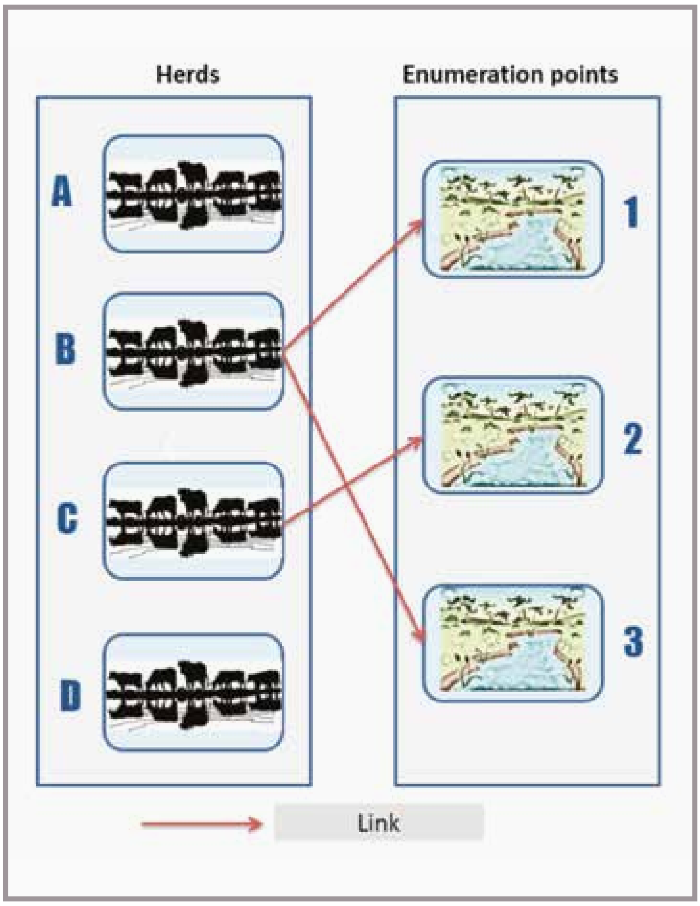
FIGURE 6. ILLUSTRATION OF ONE-TO-ONE LINK



(ii) One-to-many

In one-to-many links, a herd may be linked to several enumeration points (as herd B illustrated in Figure 7 below) but each enumeration point is frequented by only one herd. This kind of link is also rare in practice.

FIGURE 7. ILLUSTRATION OF ONE-TO-MANY LINK

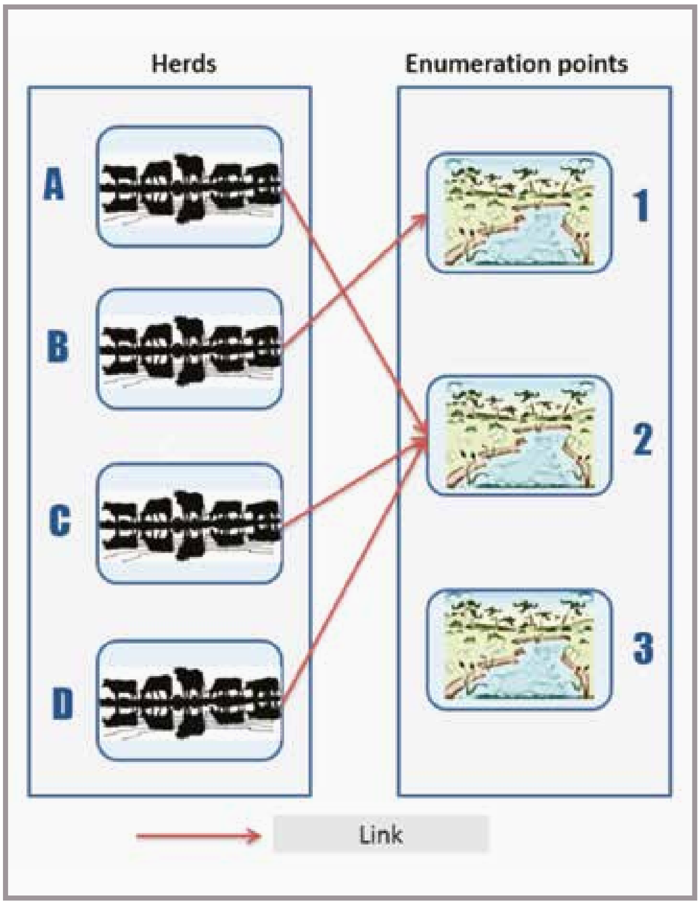


(iii) Many-to-one

In many-to-one links, a herd is linked to only one enumeration point; however, an enumeration point is frequented by several herds (see Enumeration Point 2 illustrated in Figure 8 below). This kind of link is more likely than one-to-one and one-to-many links, but is still rather rare to encounter in practice.

This type of link may exist in certain specific enumeration points: for example, if, in a given country, each nomadic herd tends to use only one stock route, then there is a "many-to-one" type of link between the herds and the stock routes in that country.

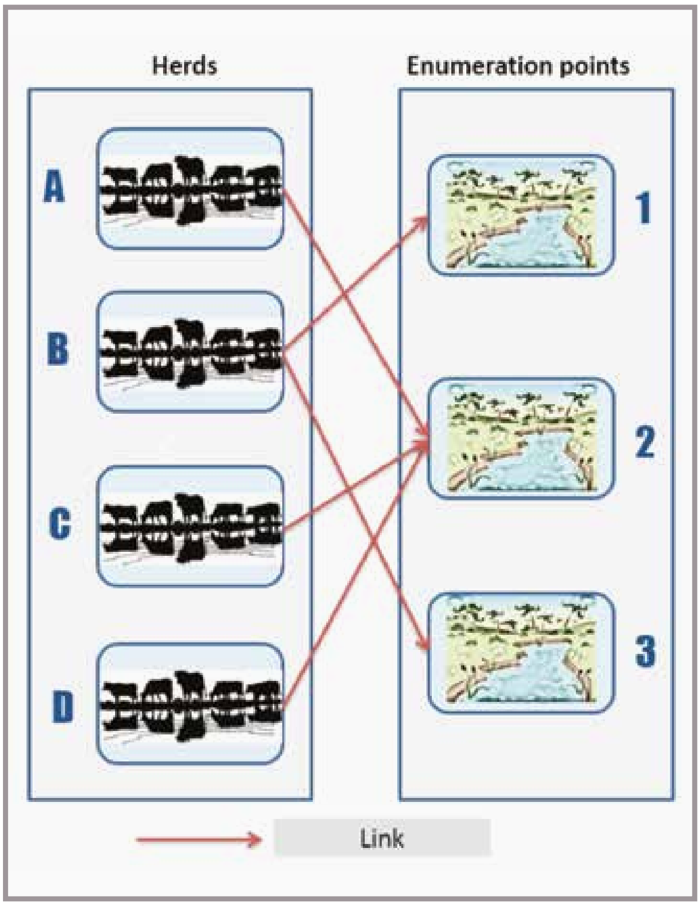
FIGURE 8. ILLUSTRATION OF MANY-TO-ONE LINK



(iv) Many-to-many

In the case of many-to-many links, several herds can be linked to a single enumeration point, and several enumeration points can be linked to a single herd. This kind of link is certainly the most frequently observed in practice.

FIGURE 9. ILLUSTRATION OF MANY-TO-MANY LINK



With regard to the definition of "link", it may be seen that a herd can generally be linked to several enumeration points, and several herds can be linked to a single enumeration point. For example, during one year, a transhumant or nomadic herd usually drinks at several watering points, and a specific watering point is frequented by many herds. Thus, there tends to be a "many-to-many" type of link between herds and enumeration points.

A NOTE OF CAUTION

When indirect sampling is used, the "**non-zero link condition**" must be observed to achieve unbiased estimates.

For the purposes of these Guidelines, this condition may be formulated as follows: all the statistical units (animals or herds) must be linked to at least one enumeration point.

In concrete terms, the different enumeration points must be identified as exhaustively as possible, as during the year under consideration, each herd is likely to frequent at least one enumeration point.

Data collection on links
After selecting the sample of enumeration points and calculating their weights (the inverse of the probability of selection), enumerators must collect data on all the herds that frequent those enumeration points over the period considered by the survey. To estimate the herds' respective weights, data must be collected on two important aspects:

I. For each herd linked to a given sampled enumeration point, the number of all enumeration points that are linked to the herd nationwide (i.e. the number of enumeration points, sampled and not sampled, that the herd usually frequents over a year); and

II. For each herd linked to a given sampled enumeration point, all sampled enumeration points that are linked to the herd (i.e. the sampled enumeration points that the herd is likely to frequent during the year). For this latter purpose, a specific questionnaire should be used.

If enumeration points are stratified, these enquiries must be made for each stratum.

Weight estimation using GWSM

The weights of the herds surveyed can be estimated with GWSM. The following steps apply:

- **Step 1: calculation of herd's initial weight**
  For each herd, an initial weight should be calculated. This initial weight is the sum of the weights of all sampled enumeration points linked to that herd.

- **Step 2: calculation of herd's total number of links**
  The herd's total number of links is the number of all enumeration points linked to it nationwide. This figure can be collected on the field, or estimated using secondary data.

- **Step 3: calculation of herd's final weight**
  The herd's final weight is calculated by dividing the initial weight (calculated in Step 1) by the total number of links (calculated in Step 2).

Practical example
Let us suppose a sample of enumeration points has been drawn using the sampling design shown here. These enumeration points (EPs) include points A, B and C. The weights of each have been calculated as illustrated below. Let us also suppose that the herder of herd H was interviewed at EP A. It is now necessary to calculate the weight of herd H.

Let us now begin with the two important questions that must be posed to the herder of herd H:

- **Q1: How many EPs are you likely to frequent with your herd this year?**
  For the purposes of this example, a hypothetical answer of seven will be given (comprising Eps A, B, C, D, E, F and G).

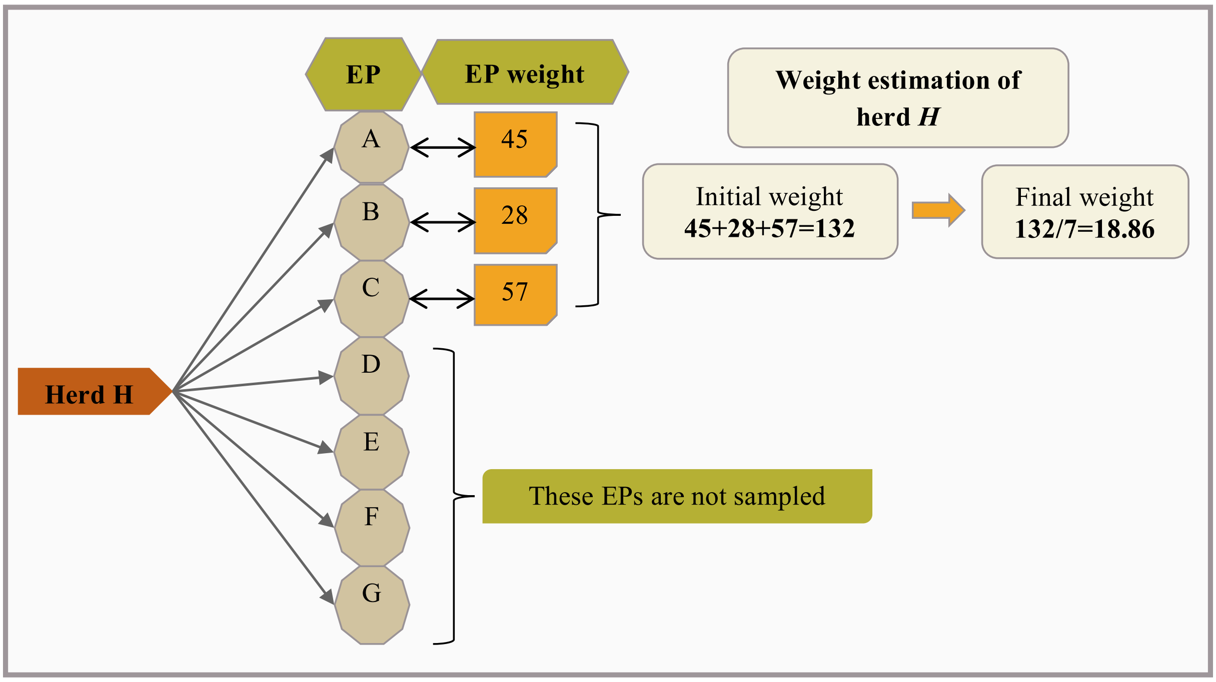
- **Q2: Of these EPs, how many are in our sample?**
  Here, it is important to learn, from the herder, all the sampled EPs that he is likely to frequent during the year. In this example, three sampled EPs will be frequented by herd H (A, B and C).

Calculating the weight of herd H

Let us now follow the three steps detailed above to calculate the weight of herd H.

Steps	Results
Step 1: calculation of herd's initial weight *For each herd, we must calculate an initial weight which is the sum of the weights of all the sampled enumeration points linked to it.*	Here, herd H is linked to 3 sampled EPs: A, B and C. Therefore, its initial weight is 45+28+57=132 (sum of weights of all sampled EPs linked to it; see Figure 10 below).
Step 2: calculation of herd's total number of links *That is the number of all nationwide enumeration points linked to the herd.*	In livestock enumeration, this data can be estimated on the field with herders. In this example, the answer is 7.
Step 3: calculation of herd's final weight *The herd's final weight is calculated by dividing the initial weight by the total number of links*	The herd H's final weight is 132/7=18.86 (see Figure 10 below)

FIGURE 10. ILLUSTRATION OF WEIGHT CALCULATION



Estimators' formulas

This section will set out the main estimators' formulas, considering that a stratified two-stage sampling will be used.

Here, the PSUs are EAs (however, it is also possible to choose counties, villages or other relatively small geographical areas). In each stratum, the PSU can be selected with either probabilities proportional to size or equal probabilities (both cases will be considered below). The SSUs are EPs that have been sampled, with equal probabilities, in each selected EAs.

The estimations must also be valid at subnational level (in this section, the level of "provinces" is chosen; however, it could be substituted with any other relatively important administrative areas).

For each province, let us use the following notation:

$M =$ number of EAs

$H =$ number of strata

$M_h =$ number EAs of stratum h

$N_{ih} =$ number of EPs of stratum h in EA i

$m_h =$ size of the sample of EAs of stratum h

$m = \sum_h m_h =$ size of the sample of EAs

$n_{ih} =$ size of the sample of EPs of stratum h in EA i

$n_h = \sum_i n_{ih} =$ size of the sample of EPs of stratum h

$i = 1, 2, \ldots, M_h$: indexes of EAs in stratum h

$j = 1, 2, \ldots, N_{hi}$: indexes of EPs of EA i in stratum h

$h = 1, 2, \ldots, H$: indexes of stratum

$K =$ total number of herds surveyed at sampled EPs

$k = 1, 2, \ldots, K$: indexes of herds surveyed

$y_{kh} =$ value of the variable of interest for herd k of stratum h (this could be the number of animals in herd k)

Weights of the EPs

According to the sampling design, for each province, the first stage requires m EAs to be selected with a probability proportional to size. In the second stage, n_ih EPs are selected with equal probabilities in each stratum h of the EA i selected.

Let us set

$$p_{ih} = \frac{N_{ih}}{\sum_{i=1}^{M_h} N_{ih}}.$$

Let π_{ih} be the inclusion probability of EA *i* of stratum *h*.

If PSUs are selected with probabilities proportional to size. then:

$$\pi_{ih} = m_h p_{ih}.$$

If PSU are selected with equal probabilities, then:

$$\pi_{ih} = \frac{m_h}{M_h}.$$

Thus, the inclusion probability of each EP *j* of stratum h in EA *i* is:

$$\pi_{jih} = \pi_{ih} \frac{n_{ih}}{N_{ih}}.$$

Herd weights

Let us identify the link between EP j and herd k with the indicator variable l_jk, where l_jk=1 if there is a link between EP j and herd k , and 0 otherwise. The three steps discussed above for calculating the weight of each herd using the GWSM (Lavallée, 2007) will be used here too.

Step 1: Calculation of herd's initial weight

For each herd k of stratum h, the initial weight is:

$$W'_{kh} = \sum_{i=1}^{M_h} \sum_{j=1}^{N_{hi}} l_{jk} \frac{t_j}{\pi_{jih}},$$

where t_j=1 if EP j is sampled and 0 otherwise.

Step 2: Calculation of the herd's total number of links

For each herd k of stratum h, the total number of links is:

$$L_{kh} = \sum_{i=1}^{M_h} \sum_{j=1}^{N_{hi}} l_{jk}.$$

Step3: Calculation of the herd's final weight

The final weight of each herd k of stratum h is:

$$w_{kh} = \frac{W'_{kh}}{L_{kh}}.$$

Variable of interest: the total

The Horvitz-Thompson estimator of the total in each province is:

$$\hat{Y} = \sum_{h=1}^{H}\sum_{k=1}^{K} w_{kh} y_{kh}.$$

Variance

Let

$$z_{kh} = \frac{y_{kh}}{L_{kh}}$$

and

$$Z_j = \sum_{h=1}^{H}\sum_{k=1}^{K} l_{jk} z_{kh}$$

According to Lavallée (2007) and this sampling design, an estimator of the variance of $\hat{Y}$ is:

$$\widehat{Var(\hat{Y})} = \sum_{h=1}^{H}\sum_{i=1}^{m_h}\sum_{j=1}^{n_{hi}}\sum_{j'=1}^{n_{hi}} \frac{(\pi_{jj'ih} - \pi_{jih}\pi_{j'ih})}{\pi_{jih}\pi_{j'ih}} Z_j Z_{j'}$$

where $\pi_{jj'}$ ih represents the joint probability of the selection of units *j* and *j'*.

The use of this formula may of course be difficult in practice. In these cases, alternative variance estimators, such as jackknife and bootstrap estimators, will be useful.

CAUTION

At this stage too, the main issue may arise in collecting data on the number of EPs frequented by the animals during the survey year. This issue is more complex for sampled EPs. If herders are familiar with a sampled EP (e.g. a river or a lake), it will be easy for them to know whether they are likely to frequent it during the year in question. However, this is probably not the case with all watering points. A great deal of time and exchanges with the herders will certainly be required to ensure that the data collected is reliable. To date, this approach has not been tested in any country, and its feasibility thus remains unknown.

This information is essential for weight estimation using the GWSM; thus, before implementing a multi-stage sampling which requires GWSM methods for weight estimations, it is crucial to ensure that it can certainly be collected.

3.1.01.2. Ethnic groups/clans

In this connection too, it is necessary to establish a sampling frame, which consists of a complete list of all the ethnic groups or clans of the country. This can be done during the General Agricultural Census or by means of updated secondary data (from administrative bodies, universities, NGOs, etc.). It would be useful if the list also contained basic information on each ethnic group or clan relevant to sampling purposes: population, movement of the livestock, species of the animals, etc.

In most countries, it may be easier to cover all ethnic groups/clans exhaustively to enumerate their livestock. When sampling is required, statistical methods such as stratification or multi-stage sampling, described above, may be used. The sample can also be selected with a probability proportional to size, using auxiliary data on the number of livestock held by each ethnic group or clan.

In Niger, during the 2004/2005Agricultural and Livestock Census, a complementary survey on nomadic camels was performed through a multi-stage sampling process: the PSUs were nomadic tribes and the SSUs were households.

Estimators and weights

Let us consider a two-stage stratified sampling process for the enumeration of livestock through ethnic groups or clan. The PSUs are clans (or ethnic groups) and the SSUs are herders (or their households).

In each stratum, the PSU can be selected with either probabilities proportional to size or equal probabilities (both cases will be explored here). Let us consider that the SSUs are sampled with equal probabilities in each of the selected PSU.

Notation

M = total number of clans

M_h = number of clans of stratum h

N_h = number of herders of stratum h

N_{ih} = number of herders of stratum h in clan i

m_h = size of the sample of clans of stratum h

$m = \sum_{hmh} =$ size of the sample of clans

n_{ih} = size of the sample of herders of stratum h in clan i

$n_h = \sum_{inih} =$ size of the sample of herders of stratum h

y_{ihj} = value of the variable of interest for herder j of stratum h in clan i (e.g. number of animals of the herder j)

$i = 1, 2,\ldots, M_h$: indexes of clans in stratum h

$j = 1, 2, \ldots, N_{ih}$: indexes of herders of clan i in stratum h

$h = 1, 2, \ldots, H$: indexes of stratum

According to the sampling design, in the first stage, m clans are selected with a probability proportional to size. In the second stage, n_ih herders are selected with equal probabilities in each stratum h of the clan i selected.

Let us set:

$$p_{ih} = \frac{N_{ih}}{\sum_{i=1}^{M_h} N_{ih}}.$$

Let π_{ih} be the inclusion probability of clan *i*.

If the PSUs are selected with probabilities proportional to size, then:

$$\pi_{ih} = m_h p_{ih}.$$

If the PSUs are selected with equal probabilities, then:

$$\pi_{ih} = \frac{m_h}{M_h}.$$

Therefore, the inclusion probability of each herder *j* of stratum h in clan *i* is:

$$\pi_{jih} = \pi_{ih} \frac{n_{ih}}{N_{ih}}.$$

Total and mean of the variable of interest
The estimator of the total is:

$$\hat{Y} = \sum_h \sum_i \sum_j \frac{1}{\pi_{jih}} y_{ihj}.$$

The estimator of the mean can thus be deduced to be:

$$\hat{\bar{Y}} = \frac{1}{M} \hat{Y} = \frac{1}{M} \sum_h \sum_i \sum_j \frac{1}{\pi_{jih}} y_{ihj}.$$

Variances of total and mean
The mean can be rewritten as:

$$\hat{\bar{Y}} = \sum_{h=1}^{H} W_h \overline{y_h}.$$

where

$$W_h = \frac{N_h \sum_{i=1}^{m} M_{hi}}{\sum_{h=1}^{H} N_h \sum_{i=1}^{m} M_{hi}} \quad \text{and} \quad \overline{y_h} = \sum_{i=1}^{m} \frac{n_{ih}}{n_h} \left(\frac{1}{n_{ih}} \sum_{j=1}^{n_{ih}} y_{ihj} \right).$$

If the PSUs are selected with equal probabilities, then the estimator of the variance of the mean is

$$V\left(\hat{\bar{Y}}\right)=\sum_{h=1}^{h=k} W_h^{\,2}\left[\frac{\left(1-f_{1h}\right)}{m_h} S_{1h}^{\,2}+\frac{\left(1-f_{2h}\right)}{n_h m_h} S_{2h}^{\,2}\right]$$

where $f_{1h}=\frac{m_h}{M_h}, f_{2h}=\frac{n_h}{N_h}$

The estimator of the variance of the total can be deduced to be

$$V\left(Y\right)=V\left(M\hat{\bar{Y}}\right)=M^2 V\left(\hat{\bar{Y}}\right)=M^2\sum_{h=1}^{k} W_h^{\,2}\left[\frac{\left(1-f_{1h}\right)}{m_h} S_{1h}^{\,2}+\frac{\left(1-f_{2h}\right)}{n_h m_h} S_{2h}^{\,2}\right].$$

where $S_{1h}^{\,2}=\frac{1}{M_h-1}\sum_{i=1}^{M_h}(y_{hi}-\bar{y}_h)^2, S_{2h}^{\,2}=\frac{1}{N_h-1}\sum_{j=1}^{N_h}(y_{hj}-\bar{y}_h)^2$.

3.1.01.3. Specific livestock species

The global sampling technique and data collection approach discussed here may not be suitable for all livestock species. Indeed, certain economically important species may require special consideration. For example, in Mongolia, a separate stratum was created for camels, due to their relatively low number compared to other livestock species. This stratum was necessary to ensure that enough herders with camels would be selected in the sample, and thus estimates produced with a reasonable level of precision. In Niger, a specific questionnaire was designed for camels.

Estimators and weights

Let us suppose that a separate stratum is used for a given species. To collect data on this species, a simple random sampling process can be performed to select a sample of EPs or of ethnic groups or clans. The estimators and weights for these sampling designs are given above.

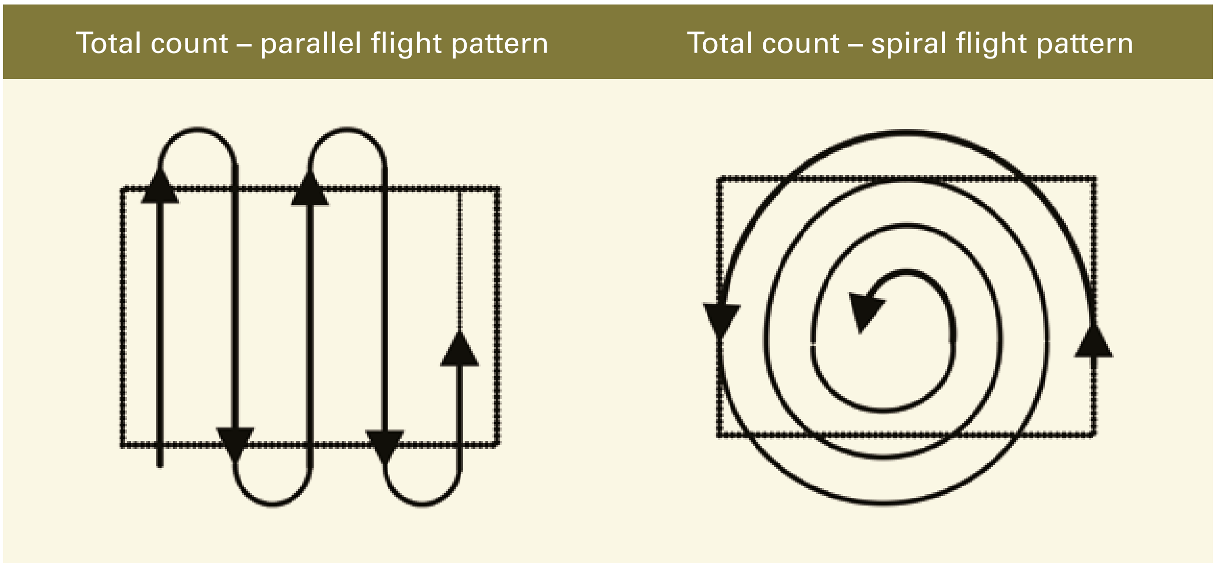
3.1.02. Aerial surveys

There are two main methods to assess livestock populations from the air: total aerial counts (or block counts) and sample counts.

3.1.02.1. Total Aerial Count Flight patterns

A total aerial count of animals in an area, also known as a block count, (Norton-Griffiths, 1978; Clarke, 1986) may be obtained by flying a series of closely spaced, parallel flight lines with overlapping observation strips, or by a circular "corkscrew" flight path of decreasing radius over the area of interest (see Figure 11). This flight pattern should be capable of covering the whole area without any gaps arising between the flown patterns.

FIGURE 11. POSSIBLE ALTERNATIVE PATTERNS FOR TOTAL AERIAL COUNTS



The total count of all animals seen should be the same as the total population, assuming that no animals are hidden or obscured by vegetation and that the sight and noise of the aircraft passing overhead did not cause animals to run away before being counted. For logistic and financial reasons, total counts are usually performed over relatively small areas of 100-500 km^2. This may appear to be a rather large area; nonetheless, an area of 20 km x 25 km would be a maximum optimal size.

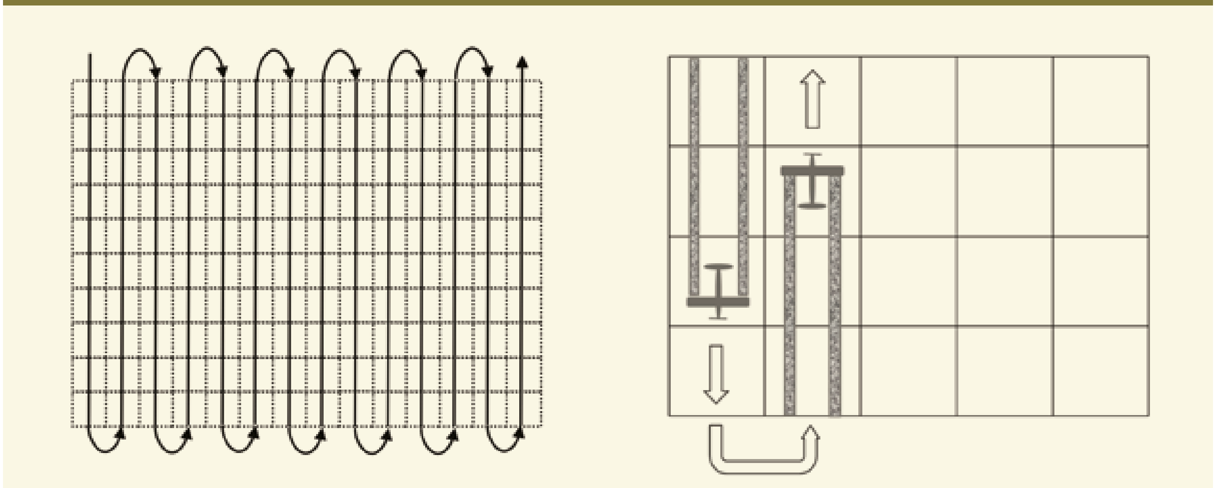
Aerial sample survey flight patterns

There are four main methods to sample livestock populations from the air: Systematic Reconnaissance Flights (SRFs), Stratified Random Aerial Transects (SRAT), Aerial Quadrat Sampling (AQS) and Aerial Block Sampling (ABS). All of these methods derive from approaches originally developed to assess wildlife populations (Norton-Griffiths, 1978; ILCA, 1981; Clarke, 1986).

Systematic Reconnaissance Flights (SRFs)

In SRF surveys, a series of parallel flight lines are flown at equal distance from each other across the designated area (Norton-Griffiths, 1978; ILCA, 1981; Clarke, 1986). Each flight line is divided in sectors equal in length to the flight line spacing, to create a grid over the entire area (see Figure 12, left). Within each strip flown, only a part of the area is counted (the grey strips to the right in Figure 12).

FIGURE 12. SRF GROUND SAMPLE COVERAGE



Therefore, with SRFs, only a part of the area is counted. Precisely this is the difference between the SRF method and the complete coverage method: instead of flying tracks that are immediately adjacent to each other in terms of coverage, gaps arise between the counted strips (see Figure 12 above). Effectively, this is the difference between aerial censuses and aerial sample surveys.

A known proportion of the area is counted. Observations for each flight line or grid cell are then added together and calculated as densities. From these, population estimates are derived by multiplying the counted areas' density by the total area. The Annex to these Guidelines sets out examples of SRF surveys of livestock conducted in the Somali region of Ethiopia and over the entire territory of Nigeria.

The SRF method is particularly advantageous in case of large, inaccessible areas, for which there are no reliable ground counting frames and no prior assumptions on livestock distribution.

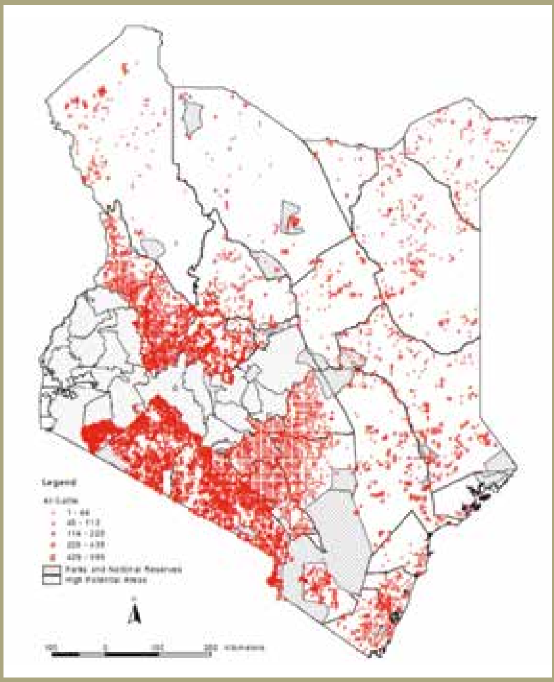
BOX 3.3. RESOURCE SURVEY AND REMOTE SENSING DEPARTMENT OF THE GOVERNMENT OF KENYA: AERIAL CENSUSES OF LIVESTOCK

The Department of Resources Surveys and Remote Sensing (DRSRS) of the Government of Kenya has an Aerial Survey Section, whose specific mandate is to conduct aerial censuses of livestock and wildlife populations in Kenya's rangelands. The Aerial Survey Section, formerly known as the Kenya Rangeland Ecological Monitoring Unit, has been operating since 1977.

SRF aerial surveys are usually conducted sequentially over individual administrative areas (counties) every three to five years, in line with national and county rural development plans. These surveys provide objective quantitative assessments of the spatial distribution and abundance of livestock and wildlife populations, to monitor changes and identify trends over time.

Source: Kenyan Ministry of Environment, Water and Natural Resources'
Website: http://www.environment.go.ke/archives/category. Accessed in June 2015.

CATTLE DISTRIBUTION IN KENYA: OBSERVATIONS FROM AERIAL SURVEYS



BOX 3.4. SRFS IN NIGERIA AND ETHIOPIA

Nigeria

National Survey of Livestock Resources, 1990

SRFs were flown over the entire country (extending over a total area of 912,000 km2) to provide a standard gridded frame of reference (2,280 cells, each measuring 20 x 20 km) and a nominal 5 per cent sample coverage. The aerial observers assessed the overall distribution and abundance of pastoral livestock populations and human habitation. The aerial survey grid also provided the framework for ground survey village sampling.

Aerial surveys were conducted seasonally: dry season operations took place in March and April 1990, and wet season surveys during September and October of the same year. During the dry season, the entire territory of Nigeria was surveyed from the air and the southern limit of pastoral livestock distribution was ascertained. To the south of this boundary, the distribution of livestock was essentially seasonal, because village animals do not move significant distances. The wet season aerial survey was therefore restricted to the northern four-fifths of the country, covering a total of 1,920 grid cells and a land area of 768,000 km2. For each grid cell, aerial observers also computed estimates of environmental parameters, such as the percentage cover of cultivation and various vegetation types, the incidence of erosion and the presence of water. Several types of habitation were recorded, both to establish seasonal changes in the locations of pastoralist dwellings, and to facilitate the integration of air and ground survey data.

Ethiopia

Aerial Survey of Nomadic Livestock in Somali Region, 2003

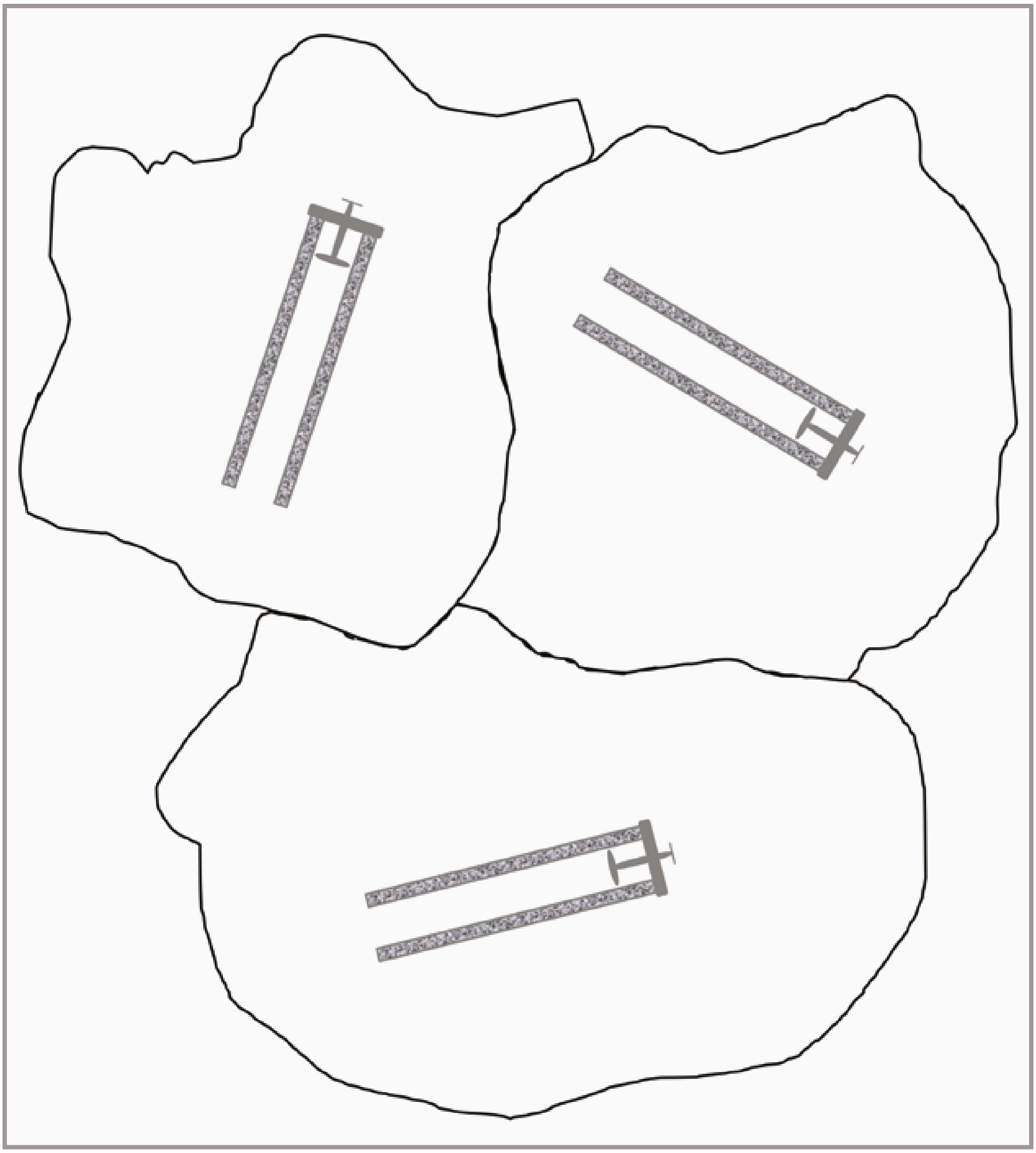
In 2003, Ethiopia's Central Statistics Authority (CSA), in collaboration with staff from Kenya's DRSRS Aerial Survey Section, conducted an aerial survey of livestock and wildlife over 241,500 km2 of the Somali region of south-eastern Ethiopia, in less than three weeks. The aerial survey was conducted according to the SRF method (Norton-Griffiths, 1978). In particular, a regular pattern of parallel flight lines was flown over the survey area. Each flight line was divided into sectors, each of which was equal in length to the flight line spacing. Thus, a regular sampling framework or grid for recording observations was formed. Visual estimates of the animals and structures seen within ground sampling strips on either side of the aircraft were recorded by sector, and photographs taken whenever possible for subsequent verification and error correction.

To cover the very extensive survey area within a reasonably short period of time, three high-wing Cessna aircraft were deployed. The flight lines were flown 10 km apart, at a nominal height of 300 feet to 400 feet above ground level.

Stratified Random Aerial Transects (SRAT)

In Stratified Random Aerial Transect surveys, the area of interest is divided into various zones or strata with similar ground cover characteristics – such as vegetation cover or land form – and random flight lines are flown across each zone, as shown in Figure 13 (Norton-Griffiths, 1978; Anon, 1986). This provides a sample of the land within each zone or stratum. The observations for each zone or stratum are then added together and calculated as densities, from which population estimates for each zone or stratum may be derived. These can then be used to calculate the total population, although statistical advice should be sought on estimating the confidence interval or range. This method is suitable for large, inaccessible areas, for which no reliable ground counting frames are available.

FIGURE 13. SAMPLE COUNT: STRATIFIED RANDOM AERIAL TRANSECTS



Aerial Quadrat Sampling (AQS)

As described by Norton-Griffiths (1978), in this method, the sampling units are quadrats (rectangles) located within the census zone in some suitable random fashion. The selected quadrats are marked on a map of the census zone. The aircraft visits each one of them to locate and count all the animals therein.

Aerial Block Sampling (ABS)

Also described by Norton-Griffiths (1978), block sampling is very similar to quadrat sampling, except that the sample units are blocks demarcated by physical features (rivers and stream, roads and tracks, hills, ridge tops, edges of woods, etc.). A sample of blocks may be selected by locating random points in space, or by making a list of blocks with their size to enable a random sampling process, with equal probability or probability proportional to size.

Comparing the aerial sampling methods

On the basis of Norton-Griffiths' findings (1978), Table 10 below synthesizes the results of the comparison of the various aerial sampling methods. Generally, it may be seen that the transect method is preferable to quadrat or block sampling in terms of cost, navigation, boundary effects, sample errors and fatigue of crews.

TABLE 10. COMPARISON OF THE AERIAL SAMPLING METHODS

Domain	Comparison
Cost	Transects are less expensive than blocks or quadrats because: The aircraft never retraces its tracks, nor does it backtrack The transects are parallels and adjacent to one another: the proportion of "dead time" (time spent by the aircraft to travel from one sample to another) is therefore low.
Navigation	With transects, navigation is considerably easier.
Boundary effects	To a certain extent, all methods examined suffer from boundary effects, in that it is always difficult to decide whether an animal is within or outside of the sample unit. This problem particularly affects quadrat sampling.
Counting	In this context, the most important difference is that in the transect method, the aircraft passes along each transect line only once, such that the observers have only one chance to locate or count animals. Instead, in block and quadrat sampling, the aircraft makes as many passes as are required.
Sample error	Transects tend to reduce sampling error, while blocks and quadrats tend to accentuate it.
Fatigue	The transect method is less tiring for pilots and observers; this is important to achieve reliable counts.

According to the International Livestock Centre for Africa (ILCA, 1979), the cost of surveys based on quadrats are 40 per cent higher than those based on transects.

Estimators

Generally, enumerating livestock by means of aerial sampling consists in estimating the density of animals in the sampled area and then calculating the total number of animals, by multiplying this density with the total area of the survey. Let us consider a stratified aerial sample count.

Notation

M= total number of units (transects, quadrats, blocks…)

A= total area of census zone

H= number of strata

A_h = area of stratum h

M_h = number of units of stratum h

m_h= number of sample units of stratum h

a_{ih}= area of sampled unit i of stratum h

y_{ih} = number of animals counted in sampled unit i of stratum h

Population estimation

The density of animals $\widehat{D_h}$ in stratum h is estimated as follows:

$$\widehat{D_h} = \frac{\sum_{i=1}^{m_h} y_{ih}}{\sum_{i=1}^{m_h} a_{ih}}.$$

The total population $\widehat{Y_h}$ of stratum h is:

$$\widehat{Y_h} = \widehat{D_h} \times A_h.$$

The total population $\widehat{Y}$ of the census zone is:

$$\widehat{Y} = \sum_{h=1}^{H} \widehat{Y_h}.$$

Variance

Let S_{yh}^2 be the variance between the numbers of animals in the sampled units of stratum h:

$$S_{yh}^2 = \frac{1}{m_h - 1}\left(\sum_{i=1}^{m_h} y_{ih}^2 - \frac{1}{m_h}\left(\sum_{i=1}^{m_h} y_{ih}\right)^2\right).$$

Let S_{ah}^2 be the variance between the areas of the sampled units of the stratum h:

$$S_{ah}^2 = \frac{1}{m_h - 1}\left(\sum_{i=1}^{m_h} a_{ih}^2 - \frac{1}{m_h}\left(\sum_{i=1}^{m_h} a_{ih}\right)^2\right).$$

Let S_{yah} be the covariance between the numbers of animals and the areas of the sampled units of stratum h:

$$S_{yah} = \frac{1}{m_h - 1}\left(\sum_{i=1}^{m_h} (a_{ih} \times y_{ih}) - \frac{1}{m_h}\sum_{i=1}^{m_h} a_{ih} \times \sum_{i=1}^{m_h} y_{ih}\right).$$

According to Jolly (1969), with due adaptations for the sampling design illustrated here, the variance of the total population $\widehat{Y}$ is:

$$V(\hat{Y}) = \sum_{h=1}^{H} \frac{M_h(M_h - m_h)}{m_h} (S_{yh}{}^2 - 2\widehat{D_h} \times S_{yah} + \widehat{D_h}^2 \times S_{yah}{}^2).$$

3.2. DETERMINING THE DATA TO COLLECT AND THE METHODS FOR ITS COLLECTION

3.2.01. Determining which data to collect

The information collected when enumerating livestock depends to a great extent on national and local circumstances. The purpose of any enumeration should be stated clearly at the outset. Generally, the more data collected, the more-time consuming and expensive the study will be. However, with regard to remote areas, where much of the survey time is spent travelling to and from the isolated sites, collecting as much data as possible could be the more practical and cost-effective choice.

Enumerating livestock is useful and serves important purposes. However, counting animals alone is of limited utility, as the figures indicate only the number of animals in the given territory. At the very least, this should be accompanied by a breakdown by species, given the implications that would derive for feed requirements, animal health services, potential production and benefits for livestock keepers.

Additional data would also be useful to enable a better comprehension of the production system(s) and relevant implications. For example, the composition of ruminant herds in terms of age and sex will provide indications on the animals' reproductive health and feed requirements. The percentage of a livestock population consisting in breeding females is another important item to record, as it enables the estimation of growth trends in the livestock population. Likewise, the proportion of young animals compared to breeding females will indicate the herd's fertility rates, often strongly linked to nutrition.

As noted in these Guidelines, there are several ways to count animals. However, not all are capable of providing a sound overview of the population in terms of age and sex. Air counting can give an approximate idea of the age structure (as the animals of the same species may be distinguished in terms of size). With these methods, however, sex differentiation may be difficult; ground counting would be necessary to obtain a reliable breakdown by age and sex. To achieve such a breakdown, some ground counting methods are more suitable than others. For example, not all young animals may always be vaccinated, brought to dip tanks or even to watering points. Male animals may also be kept away, because they may be difficult to handle or due to the concern to preserve their fertility. Thus, counting at watering points, dip tanks and vaccination points may certainly be useful, but risk producing partial and biased results.

The best method to obtain details on herd age and sex structure, and possibly differentiate between sheep and goats, is probably to engage in ground walks covering a set area and to visit individual herds or flocks. Indeed, from a distance, it is not always easy to distinguish hair sheep from goats, with the position of the animals' tails being perhaps the best indicator.

Further details on production systems, such as how animals are fed and watered, home consumption levels and the ages at which animals are sold and the purpose of such sales can only be obtained by meeting and talking with producers.

It is possible – if not probable – that gathering detailed information on livestock population size, livestock population structure and relevant production systems require a combination of methods, depending on the specific information sought. In agricultural censuses, a two-tiered approach is often adopted, in which a general questionnaire with relatively few questions is administered to all farming households, and a more detailed questionnaire is administered to a smaller, randomly selected, sample thereof.

Ideally, ground-based livestock enumeration by means of general questionnaires should include the following data:
- Date
- Administrative or Enumeration Area (province, district, village/community area, etc.)
- Location (name and geographical coordinates)
- Type of enumeration site (water point, camp site, vaccination point, market, etc.)
- Mode of usage or occupancy (year-round or seasonal)
- Name of information provider
- Status of information provider (herder, owner, other)
- Ethnicity of information provider
- Location of information provider's home area
- Livestock species
- Livestock breed, with a basic differentiation between local/indigenous and improved/exotic animals
- Livestock sex (male or female)
- Livestock age class (young, immature, breeding adult, non-breeding adult)
- Name of enumerator
- Name of supervisor.

By way of example, the field data collection forms used in the National Census of Transhumant and Nomadic Livestock in Mali are included in the Annex to these Guidelines.

Subsampling design
When dealing with transhumant and nomadic livestock, it is also difficult to collect data on some of the useful information mentioned above (age, sex, species, etc.) by counting animals. Indeed, counting animals of large herds while at the same time collecting data on this additional information will be far too time-consuming. In these cases, it is preferable to select a random sample of herds or animals and collect data on their age, sex, species, etc. This will enable estimation of some structural statistical parameters (such as proportions in terms of sex or age class) that can be used to calculate the overall number of livestock by sex, age class or species. Because the subsample must be selected on the field, systematic sampling will be suitable here.

Further details on simple random sampling techniques may be found in the standard textbooks indicated in the paragraphs above.

The subsampling design may be the same as that adopted for the enumeration survey. For example, let us suppose that livestock are counted by means of a stratified simple random sample of EPs. Due to budget constraints, it may be decided, for example, to select a number of herds at each EP and collect data on the age, sex and species of the animals. This may also be done on the basis of a sample of EPs. In this case, a number of EPs in each stratum may be selected.

Estimators

Let us suppose the proportion of animals by sex must be estimated.

Notation:

n: number of subsampled EPs

y_{im}: number of male animals counted on EP i

y_{if}: number of female animals counted on EP i

y_m: total number of male animals counted on subsample

y_f: total number of female animals counted on subsample

y_{mf}: total number of animals counted on subsample

p_m: proportion of male animals

p_f: proportion of female animals

Estimation of the proportion

$$p_m = \frac{\sum_{i=1}^{n} y_{im}}{\sum_{i=1}^{n}(y_{im} + y_{if})} = \frac{y_m}{y_m + y_f} = \frac{y_m}{y_{mf}}$$

$$p_f = 1 - p_m$$

Variance

$$V(p_m) = \frac{1}{{y_{mf}}^2} V(y_m) + (\frac{y_m}{{y_{mf}}^2})^2 V(y_{mf}) - 2\frac{1}{y_{mf}}\frac{y_m}{{y_{mf}}^2} COV(y_m, y_{mf})$$

$$= \frac{1}{{y_{mf}}^2}[V(y_m) + {p_m}^2 V(y_{mf}) - 2p_m COV(y_m, y_{mf})]$$

3.2.02. Data collection tools

In recent years, the potential methods for livestock enumeration, field data collection, and the analysis and presentation of results have greatly improved, given the advent of hand-held navigation devices, more powerful computers and general advances in Information and Communications Technology (ICT). However, due to the rapid pace of change, computer skills are in high demand and short supply, and there is a general need for further capacity-building at all levels of the agricultural and livestock sector, from field officers to senior administrators.

3.2.02.1. Pen And Paper Interviewing (PAPI)

The compilation of paper records (by means of Pen And Paper Interviewing – PAPI) is a traditional method in which enumerators record the data collected during the interview using a paper questionnaire. This used to be the main method applied in surveys, and continues to be relied upon in several countries. PAPI is relatively simple and reliable and does not require a high level of technical knowledge for implementation, compared to the new electronic questionnaires. However, it also presents several disadvantages compared to electronic questionnaires, among which the ample storage space needed for the records, the complex logistics that must be put in place for distribution, and the time-consuming modalities of data entry and of the data-corresponding IT infrastructure. However, in arid and remote areas where the telephone and Internet network coverage is unreliable, PAPI could be a convenient means of data collection.

3.2.02.2. Computer-Assisted Personal Interviewing (CAPI)

Today, several systems now for recording field data directly onto electronic devices are in circulation. These range from specialist data collection hardware to Android apps that can run on smartphones or tablets. There are even digital pens, that are capable of recording data on forms as well as transmitting the data via standard cell phones (i.e. not smartphones).

The use of Computer-Assisted Personal Interviewing (CAPI) tools to collect data on livestock is increasing. CAPI is an interviewing technique in which the respondent or interviewer uses a computer or tablet to record the answers to the survey questions. For some household interview surveys, these tools have almost entirely replaced the PAPI method. However, CAPI methods should be evaluated in light of individual countries' administrative conditions and technological capabilities (particularly, the Internet coverage available).

Complex dedicated data recording systems are probably inappropriate for one-off surveys. However, if such systems are being used in the given country or region for other purposes, they may be worth considering. Likewise, if it is anticipated that further similar sample surveys will be conducted, they may be worth the investment.

3.2.02.3. Complementary tools

In some countries, the use of Computer-Assisted Telephone Interviewing (CATI) may also be considered. However, this method is not appropriate for long and complex questionnaires. Rather, it is mainly suitable for post-survey checks and in sedentary systems of agricultural production.

For one-off surveys, smartphone and tablet applications (or "apps) are simpler and more appropriate systems, in terms of both costs and necessary infrastructure. The data collection form may be designed specifically for the survey and the data may be entered into the device in the field. The data are then transmitted to a central database held on a server, and can be downloaded locally.

An example in this respect is Epi Collect (see http://www.epicollect.net).

One advantage of all electronic systems is the ability to accurately record the geographical location at which the data is collected and to automatically include it in the data itself. The data can then be easily mapped using software such as Google Earth. This is invaluable for accurately locating and recording the geographical coordinates of enumeration sites (e.g. water points, camp sites, vaccination points and markets), survey transects, unmarked tracks and paths used by enumerators. Such data can easily be transferred at a later stage to computers for initial display and examination; it can also be linked to other enumeration data to create spatial databases, on the basis of which further analysis, tabulation and mapping can be performed.

Recording the location can be done manually, using dedicated GPS machines, or even simply activating a mapping app or an add-on GPS app in a smartphone or tablet. Once the enumerator has returned to the office, these data can be downloaded, stored and displayed using software such as Google Earth.

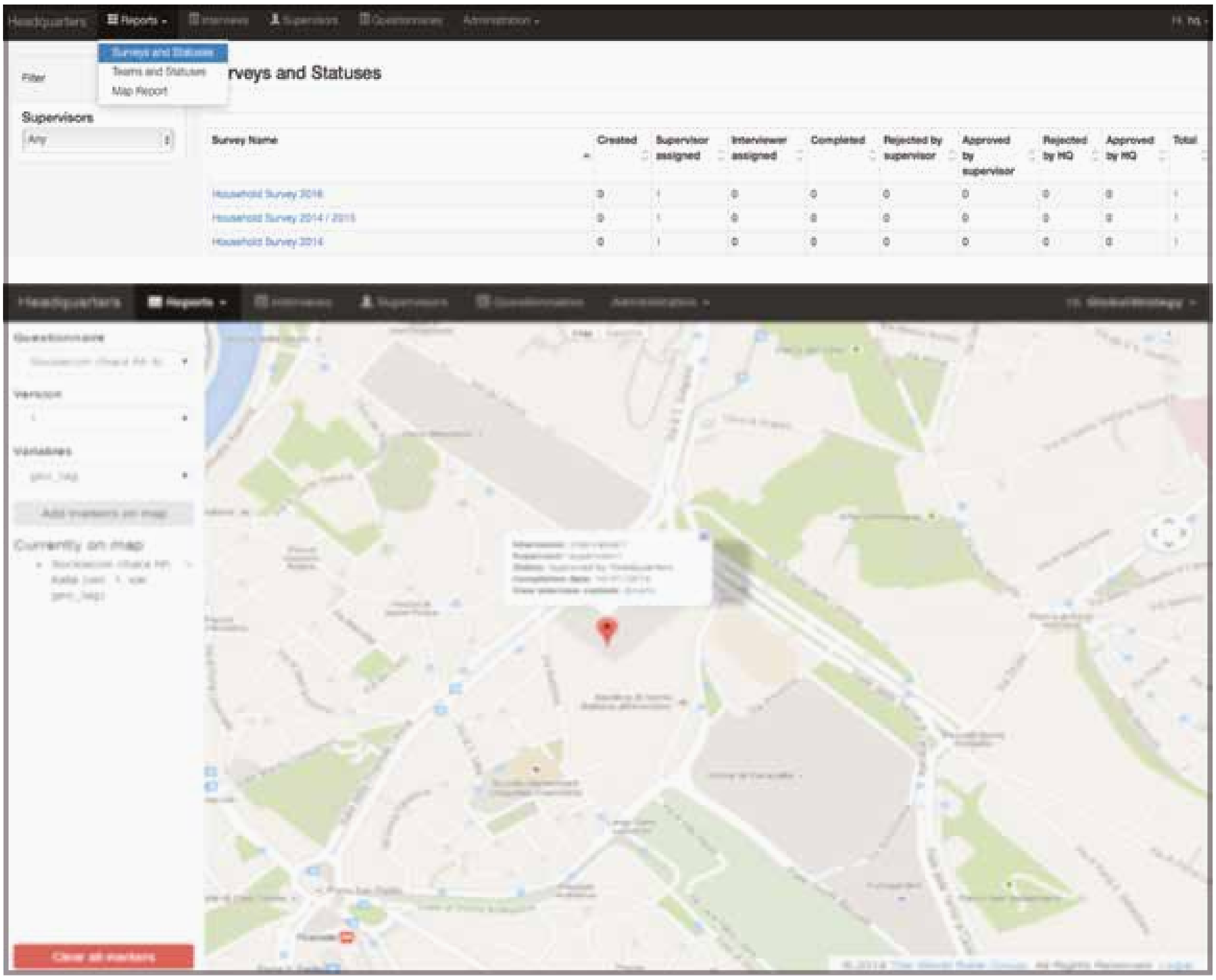
An example of a more complex application is Survey Solutions (SuSo), a CAPI product currently increasingly used surveys throughout Asia, Africa, and Latin America. SuSo was developed by the World Bank with the support of the Global Strategy, and was first released in September 2013. Among SuSo's key features are a complex questionnaire programming tool, data management tools and a steep learning curve. Overall, it is a robust software suite that addresses every element of data collection. It includes a questionnaire designer, an Android interviewer app and an online interface to serve the purposes of importing and exporting data and of survey management. The application may be obtained (upon request) from the World Bank, free of charge.

SuSo's questionnaire designer is a point-and-click interface that can build single-select, multi-select and multi-select ordered, numerical, date, text, GPS, list, barcode and photographic question types. Skip patterns and validation conditions may also be created.

The SuSo survey management tools are built into a web interface that is connected to a centralized server, which stores the data and keeps track of the questionnaires. The World Bank can host and maintain the server for the user; alternatively, the software may also be installed onto a local server. As interviews are conducted on tablets, enumerators may transmit completed questions to the server.

SuSo's survey management and reporting features make it easy to monitor ongoing surveys. Figure 14 below illustrates two of these features. The first shows the number of interviews conducted and the stage reached by each (i.e. whether it has been created, completed, approved, etc.); the second is a map report that can be used for questions seeking to capture geo-references.

FIGURE 14. SUSO – EXAMPLE OF REPORTING FEATURES



3.2.02.4. A note of caution on electronic devices

The effective use of portable electronic devices depends on the ability to recharge their batteries and, where data needs to be transmitted, adequate access to a mobile phone network or an Internet connection. When working with nomadic and transhumant livestock systems, the remoteness of the areas to be visited may entail certain difficulties in this respect, especially with regard to mobile phone networks or Internet access. In addition, modern smartphones tend to be "power-hungry" and need frequent charging. If smartphones are chosen, spare batteries for them should be provided. In this respect, smartphones are advantageous, in that their batteries can usually be replaced; this is not the case with most tablet computers.

Before it is decided to use electronic systems, it is important to ensure that the data can be securely stored on and retrieved from the data loggers, tablets or smartphones. In this respect, data loggers may be preferable, as their data storage system is usually designed to be more stable. However, tablets and smartphones may be fitted with microSD cards, which are also capable of providing a stable storage system (an aspect that should be considered whenever tablets and smartphones are to be used). However, it should be noted that GPS only requires the relevant device to have power, as the GPS signal comes from the apposite GPS satellites.

The use of all electronic technology will make it necessary for the enumerators to be trained in using and maintaining the equipment in the field, as well as ensuring that it is clean and safely stored when not in use, and equipped with a fully charged battery prior to use in the field.

3.2.02.5. Electronic identification devices for livestock

In several developed countries, electronic identification is compulsory for some species of livestock. For instance, Regulation (EC) No. 21/2004 establishes that in the European Union, since 2010, identification of small ruminants with two identifiers is compulsory in all Member States having animal populations exceeding the figure of 600,000. Essentially, three devices may be used for electronic identification (European Commission, 2009):

- Ear tag: Electronic ear tag transponders are transponders covered in plastic that are fixed to the ear of the animal using a one-time locking mechanism, or that must be attached to an ear tag in such a manner that it cannot be removed from the tag without damaging it.
- Bolus: Electronic ruminal bolus transponders are transponders placed into a container with a high specific gravity, which is orally administered to ruminants and remains permanently in their fore stomach.
- Injectable: Injectable transponders are small transponders that are encapsulated with a biocompatible and non-porous material, such as glass, and which are injected into an animal's body.

Electronic identification provides several advantages:

- it ensures that animals are individually traceable whenever they move from one holding to another;
- the codes relating to an individual animal may be read directly into a database; and
- some devices provide information useful to on-farm management (notably, production records of data such as milk yield, fertility, weight and feed consumption).

The use of electronic identification devices thus appears to be among the best solutions to obtain a reliable number of the livestock (nomadic, transhumant or sedentary) in a short period of time. The data collection may be performed through administrative sanitary sources.

The main issue relating to this method may, however, be its cost. Indeed, although additional benefits certainly exist, as mentioned above, the cost per animal of using electronic identification appears much higher than that of classical aerial or ground surveys. Saa et al. (2005) have estimated that the cost per animal for the national sheep and goat populations of Spain ranges from €4.47 to €4.64. However, prices depend to a great extent upon the number of devices purchased. Collective buying can considerably reduce unit prices (European Commission, 2015).

Therefore, it is essential for each country to conduct a rigorous cost-benefit analysis for both the short-term and the long-term, to fully comprehend whether there is an effective need to use electronic identification for livestock enumeration purposes, in light of the financial resources required.

3.2.03. Costs of field data collection

The overall costs of enumerating nomadic and transhumant livestock vary a great deal, as they depend on several factors including survey design (census, simple random, stratified, etc.), the information required (livestock count, population structure, production, etc.) and the methods that may be feasibly applied under local conditions (household visits, using concentration points, aerial surveys, etc.). Likewise, how the costs are calculated and the relative value for money also varies between possible designs and methodologies.

It is difficult to compare costs between countries, because the background costs (salaries, fuel, allowances) vary greatly among countries. In addition, the studies reported below and detailed in the Annex to these Guidelines were performed in different years. If costs are to be effectively compared, they would have to be adjusted for inflation and converted to Purchasing Power Parity (PPP) values, which reflect the variations in costs between different countries (for example, one litre of petrol may enable the same distance to be travelled, but its cost may be very different in different countries). These transformations are beyond the scope of these Guidelines.

Certainly, it can never be appropriate to calculate the cost per animal for the estimated population as a whole, unless a census is being conducted. Indeed, the cost per animal should always be calculated on the basis of the animals enumerated. The number of animals to be counted depends on the design required by the survey design and question(s) . For a sample survey, the sampling theory shows that the size of the sample (n) is not particularly influenced by the overall population size (N). Therefore, calculating the costs per animal using overall population size would produce misleading results: the overall costs increase as the number of animals to be enumerated, and not the overall population, increases. In the examples illustrated in the Annex to these Guidelines, aerial counting appears to be cheap when it is calculated per animal in the estimated population; however, it is expensive when calculated on the basis of the animals counted. The former figure fails to take into account the fact that the aerial count was a sample survey covering 3.5 per cent of the total land area; thus, the cost per animal counted is approximately 30 times greater than the apparent cost per animal in the overall population.

Table 11 summarizes the examples illustrated in the Annex to these Guidelines, providing details of each survey as well as the cost, per animal counted and per animal of the population.

TABLE 11. COMPARISON OF COSTS OF ENUMERATING NOMADIC/TRANSHUMANT LIVESTOCK

Country	Year	Method	Total cost (US$)	Total nomadic/ transhumant animals counted	Estimadet total nomadic/ transhumant population	Cost per animal counted (US$)	Cost per animal in estimated population (US$)
Afghanistan	2002	Census: village visit	No cost given	Unclear as many may be sedentary			
Ethiopia-Afar	2004	Stratified sample: house hold visit	312,416	Not clear	9,014,365	Cannot be calculated	0.03
Ethiopia-Somali	2004	Aerial: 3.5% Systematic sample	223,453	477,694	13,648,408	0.47	0.02
Jordan	1991	Census: Costructed locations	2,476,616	3,346,000	3,346,000	0.74	0.74
Mali	2001	Census: water points	241,535	4,193,848	4,193,848	0.06	0.06
Mongolia	2012	Ground: 33% stratified sample	277,976	13,640,000	40,920,000	0.02	0.01
Niger	2004-5	Stratified sample: water points and transhumance routes	No cost given	Not given	10,644,899		
Nigeria	1992	Aerial: 5% systematic sample	No cost given				

Table 11 emphasizes that calculating the cost per animal counted is a possible, albeit scarcely useful, method to compare the value for money of the various surveys undertaken in the case studies examined in the Annex. These surveys are very different in terms of design and purpose, which also has a major influence on overall costs – and thus ultimately on the cost per animal counted.

A single national-level estimate of livestock numbers is quick and simple to obtain, requiring fewer people, less training, less equipment and less time; it will also be relatively cheap. If, in the same country, reliable estimates at lower administrative levels than the entire country are sought, it may be necessary to construct a stratified sample; as the overall sample size increases, so does the cost. If details on herd structure, production etc. are also required, then the cost per animal will also rise, again increasing the overall cost. When comparing costs for different data collection methods, it is essential to ensure that other variables (such as survey design and purpose) remain the same.

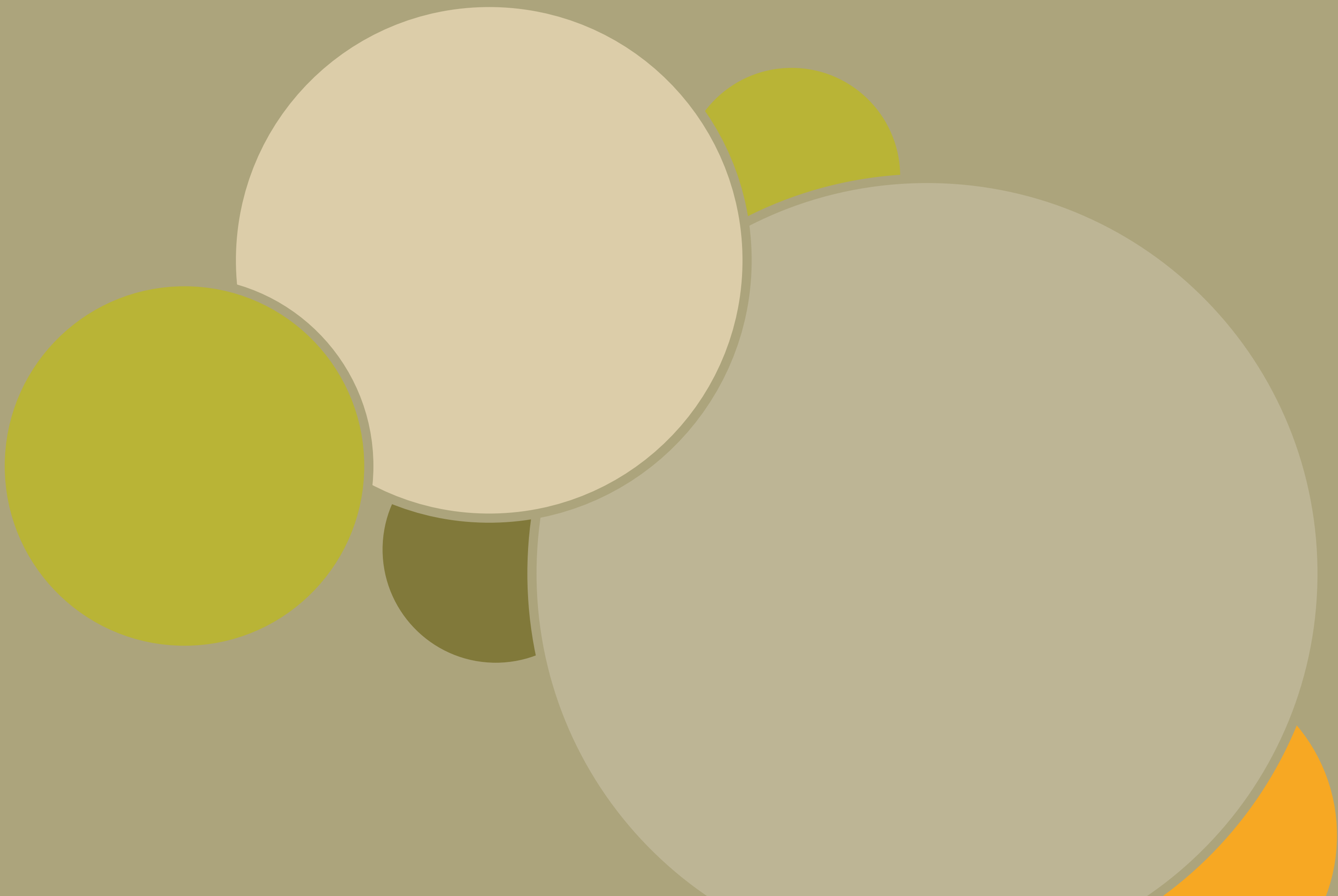
How the data is obtained will also affect the overall cost and the cost per animal counted. The highest cost per animal counted was in Jordan, at US$ 0.74; this may be due to the fact that specific facilities were constructed for counting the animals. The next highest cost was the aerial survey in Ethiopia, at US$ 0.47; this is undoubtedly due to the fact that using an aircraft requires highly specialized equipment and highly trained staff. However, in certain situations, this may be the only practicable solution.

The remaining enumerations for which costs are available display a cost per animal counted that is much lower than registered in Jordan or for the aerial survey, in the order of 10 per cent per animal. The cost per animal counted ranges from US$ 0.06 to US$ 0.02.

However, even these figures, reasonably low as they may be, can only be considered as an approximate historical guide. It will always be necessary to recall the purpose of the enumeration, how much the enumeration will cost and the resources available. If the resources are insufficient to answer the first set of questions, these will have to be adjusted to what is available, or extra funds must be sought. Ultimately, there is almost always a trade-off between the objectives and the resources available. If the resources are limited, the operations possible may be insufficient to provide results that are reliable enough to act as a foundation upon which to base any decisions. In these cases, it would not be worthwhile to use those resources, if the only answers that can be produced are likely to be seriously misleading. This is another good reason to involve sampling specialists in the design phase, as they may help to ascertain the likely accuracy and precision of the best enumeration design possible in light of the resource constraints.

TABLE 12. COMPARISON OF METHODOLOGIES APPLIED IN EXAMPLES OF NOMADIC/ TRANSHUMANCE ENUMERATION

Country	Year	Method	Design
Afghanistan	2002	Ground All villages visited	Census (total enumeration) Whole country included Single-level result
Ethiopia - Afar	2004	Ground	Stratified sample survey Result at wereda (zone) level 40 households per kebele (village). All kebele visited
Ethiopia - Somali	2004	Aerial	Systematic sample survey (3.5% of area surveyed) Single-level result
Jordan	1991	Ground survey; herds brought to specially constructed counting centres	Census (total enumeration) Whole country covered Single national-level result
Mali	2001	Ground Dry season concentration areas around water points	Census (total enumeration) All areas included Single national-level result
Mongolia	2012	Ground survey, visits to individual herds	Stratified sample survey. Result at aimag (province) level 33% of herds sampled (why this many?)
Niger	2004-5	Ground Water points and transit corridors	Stratified sample survey Results at national, regional and department levels Several months in duration
Nigeria	1989-91	Aerial	Systematic sample survey (5% of area surveyed) Single national-level result
	1992	Ground	Targeted surveys



4

Summary Recommendations

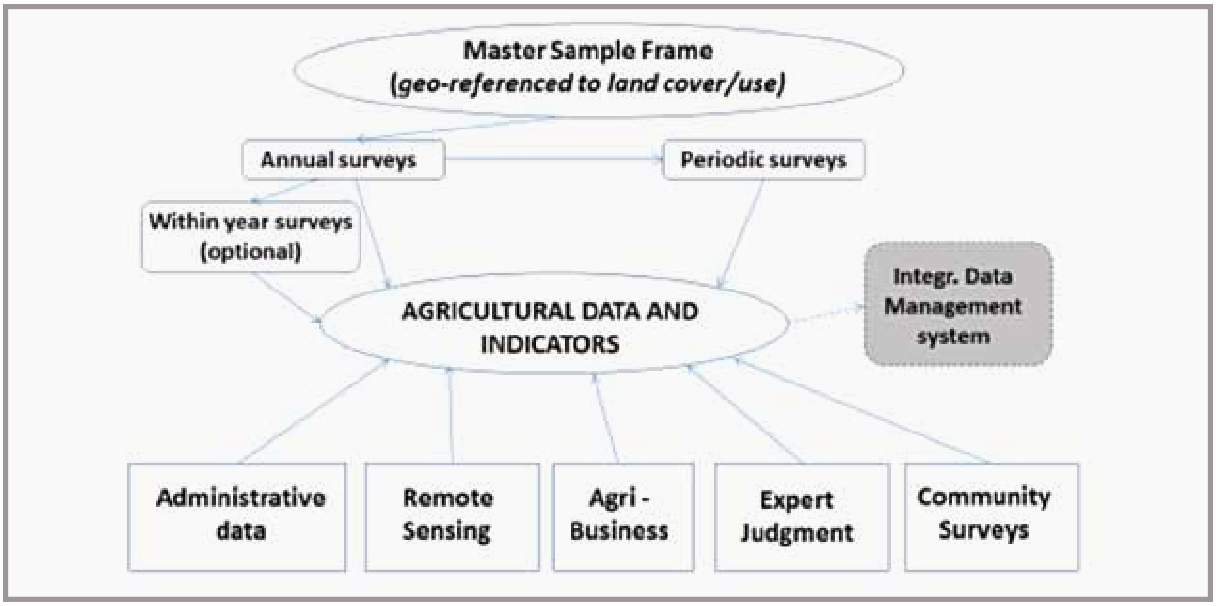
This chapter provides general guidance on various aspects of planning and organizing enumerations of nomadic and transhumant livestock, and includes: a decision tree to assist selection of which method to use; a summary table of the advantages, disadvantages and prerequisites of each method; and a list of key information to be collected.

4.1. GENERAL RECOMMENDATIONS

4.1.01. Close linkage and coordination with national agricultural census

It is essential that all activities relating to the enumeration of nomadic and transhumant livestock be closely linked and coordinated with national agricultural surveys and censuses, and that they conform to national and international standards. The Global Strategy recommends that countries implement an integrated survey framework (Figure 15). It is suggested that surveys on nomadic and semi-nomadic livestock – when necessary – be included in the framework as periodic surveys, which are implemented at regular yearly intervals.

FIGURE 15. THE GLOBAL STRATEGY'S INTEGRATED SURVEY FRAMEWORK



Source: World Bank, FAO & UNSC, 2011.

4.1.02. Training and Guidelines for standardized data collection

It is also essential to provide field enumerators and supervisors with adequate guidance and training on the purpose of livestock enumeration, recognizing livestock breeds, conducting surveys and interviews, and the information to be collected. Experience has shown that to ensure the survey's best outcome, the staff involved in enumerating livestock should include statisticians and livestock specialists.

4.1.03. Avoiding double counting

Nomadic and transhumant livestock is potentially highly mobile, both within and across national borders. Therefore, it is essential that reliable measures be introduced to avoid, or at least minimize, the risk of double counting. Such measures may include:

- The zonation of large survey regions into discrete EAs, where different methods of assessment may be used as appropriate;
- Conducting field surveys as quickly as possible (preferably, less than one month);
- Coordinating the timing of field surveys, both internally and, when possible, with neighbouring countries, such that fieldwork may take place at the same time;
- Permanently marking enumerated animals, through e.g. ear notching, as is the practice in vaccination campaigns; and
- Issuing herders with date-stamped certificates for all animals enumerated, for presentation as proof of enumeration to other enumerators.

4.1.04. Advance public awareness campaign

As with any activity that relies upon the participation and cooperation of various agencies and rural communities, it is essential to mount a well-organized and carefully targeted public awareness campaign, to ensure that all stakeholders are aware of the purpose of livestock enumeration and that all information provided will remain confidential. This information is essential to ensure proper collaboration on part of the herders, as these are often reluctant to provide accurate data on their animals. In countries where traditional or formal organizations or associations exist, these channels should be used to inform herders, and should also be closely associated to all phases of the survey.

4.1.05. Dissemination of results to stakeholders

Having mounted an advance public awareness campaign to explain the purpose of the enumeration, and – hopefully – gained the respondents' confidence and cooperation, adequate financial provision must be made to ensure that the findings are disseminated to all stakeholders in a readily understandable format.

4.2. DECIDE WHICH METHOD(S) TO USE

First, it is essential to establish what information is required, why it is necessary, and the resources required to obtain it. The formal proposals made must be realistic and reflect national capabilities, and include an indicative budget and time frame.

4.2.01. Decision tree for selection of method to enumerate livestock

Figure 16 below presents a decision tree designed to assist determination of the most appropriate enumeration method to be used, taking different circumstances into consideration.

How to use this decision tree

The herders may not all provide the same answers to the questions asked at each step of the tree. Therefore, at each step, it is important to distinguish between the different categories of herders corresponding to the various possible answers, and follow the decision tree with regard to each category. This will make it possible to ascertain the most suitable method for each category.

Before implementing a livestock enumeration, the first important question to ask regards the mobility of herders: *are they permanently settled in their home base or are they constantly mobile?*

If the herders are settled, the next question to ask is: *do the animals stay in the same location all year round?*

This question seeks to understand whether herders remain constantly in their locations with their herds, or whether they sometimes leave their households (generally during specific seasons) and travel long distances (possibly for several days) to find fresh pasture for their animals, before returning to their homes.

- If animals remain in the same location all year round, then the livestock enumeration can be included in standard agricultural surveys: indeed, the enumerators can interview herders and directly count their animals at any time.
- If the animals do not remain in the same location all year round, this is a case of transhumant (semi-nomadic) livestock. In these cases, it is important to obtain detailed information on the timing of the transhumant herders' movements and their accessibility by enumerators during a standard agricultural survey. Those who are available and accessible when the general agricultural census is held may be included in that census (its timing could be adjusted to the time when most transhumant herders are settled in their homes). The transhumant livestock that cannot be included in the standard agricultural census will be treated as nomadic livestock.

If herders are mobile and do not have a permanent location (nomadic livestock), the question to ask is: *do animals concentrate in well-recognized areas in certain times of the year?*

If the answer is yes, then it is possible to consider implementation of a ground survey. First, it is important to identify the concentration areas (EPs) and to analyse whether it is possible to compile a comprehensive list (complete enumeration) thereof. In the case of ground surveys the objective of which is to count animals in nomadic or semi-nomadic settings, water points and stock routes are the best EPs, as all animals must be fed and need water in any case; government programmes or livestock-related infrastructures, on the other hand, are not necessarily available for all animals and/or livestock keepers. Other EPs should be used only if information on water points or stock routes are unavailable, or due to logistical or cost concerns.

- If it is possible to compile a comprehensive list of the EPs chosen, a ground survey may be planned: it is recommended to first conduct a complete census, followed by an enumeration of the livestock through a sample of or all EPs.
- If a large proportion of EPs are unknown (not localized) or inaccessible, an aerial survey would be preferable. Also, in large and/or remote survey areas and desert environments, an aerial survey may be the most appropriate method.

Depending on the size of the area covered by the survey and the budget, a total aerial count or a sample aerial count can be implemented.

4.2.02. Decision tree for ground survey sampling designs

Figure 17 contains a proposed decision to assist in the selection of suitable sampling designs for ground surveys.

As a starting point, it is necessary to ascertain whether a complete list of all EPs of the chosen type in the country exists. If yes, then, depending on the budget available and the accessibility of the EPs, a complete census may be performed.

If a complete census is not available, the next question is: "*Are estimates required for subgroups (defined by administrative boundaries or criteria relating to points or livestock) within the larger population of interest?*" This question is related to the possibility and the necessity to engage in stratification. The next question seeks to ascertain whether a complete list exists of specific areas that can be sampled for the survey (see section 3.1.01. These areas may be official administrative zones, such as EAs or other zones. Depending on the existence of this list and the possibility of stratification, in accordance with the decision tree, a multi-level or a simple random sampling design may be chosen, which may or may not be stratified.

If there is no complete list of EPs, then it is necessary to ask whether there is a complete list of specific areas that can be sampled for the survey (see section on multi-stage sampling in 3.1.01). If this list does not exist, it may be preferable to consider an aerial survey. If the list does exist, and if all the EPs of each area can be enumerated, a multi-level sampling design can be created and stratified depending on whether strata are feasible and relevant.

4.2.03. Prerequisites, advantages and disadvantages

For ease of comparison, the prerequisites, advantages and disadvantages of each method of enumeration are summarized in Table 13.

FIGURE 16. DECISION TREE FOR SELECTING METHOD TO ENUMERATE LIVESTOCK

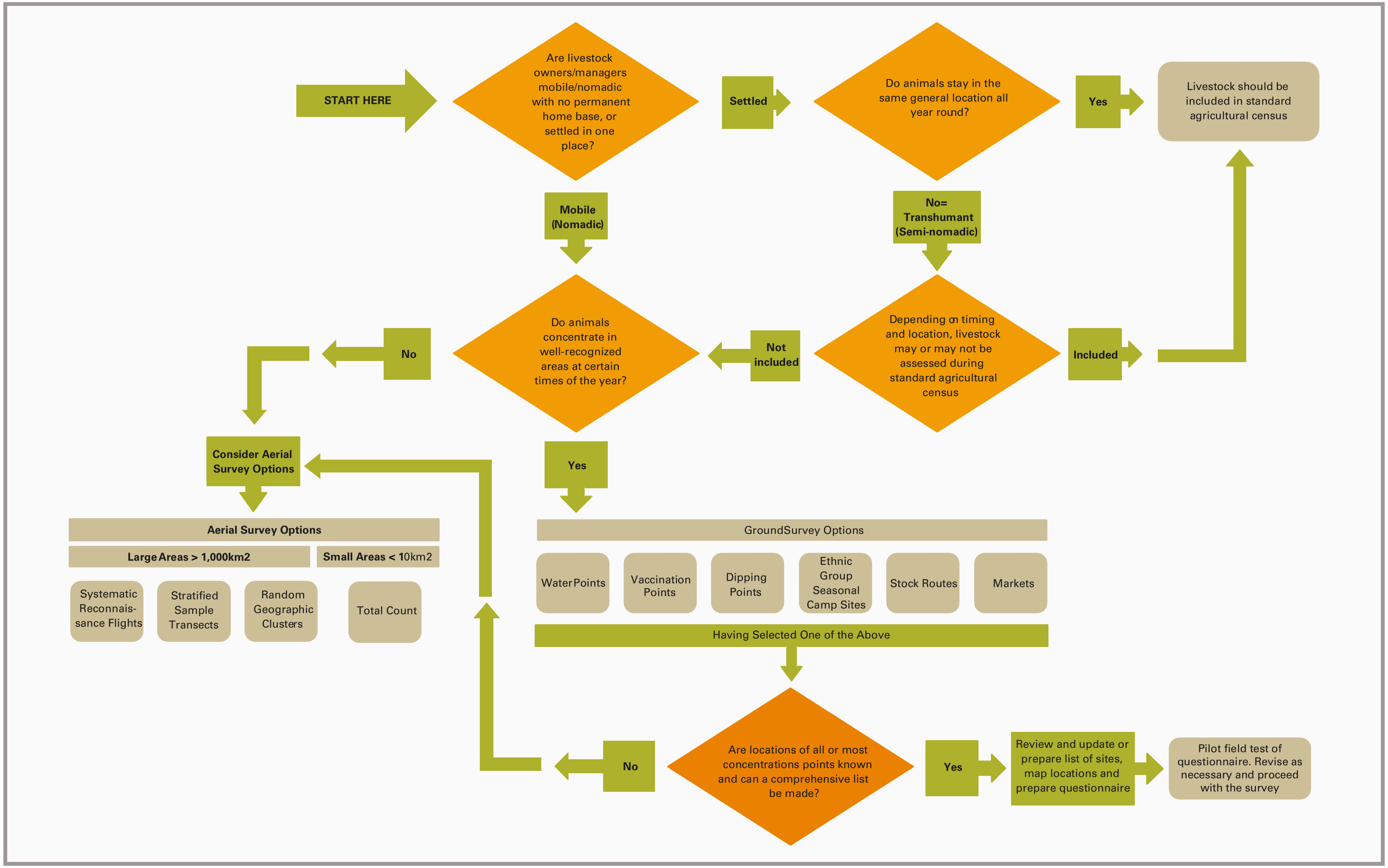


FIGURE 17. DECISION TREE FOR GROUND SURVEY SAMPLING DESIGN

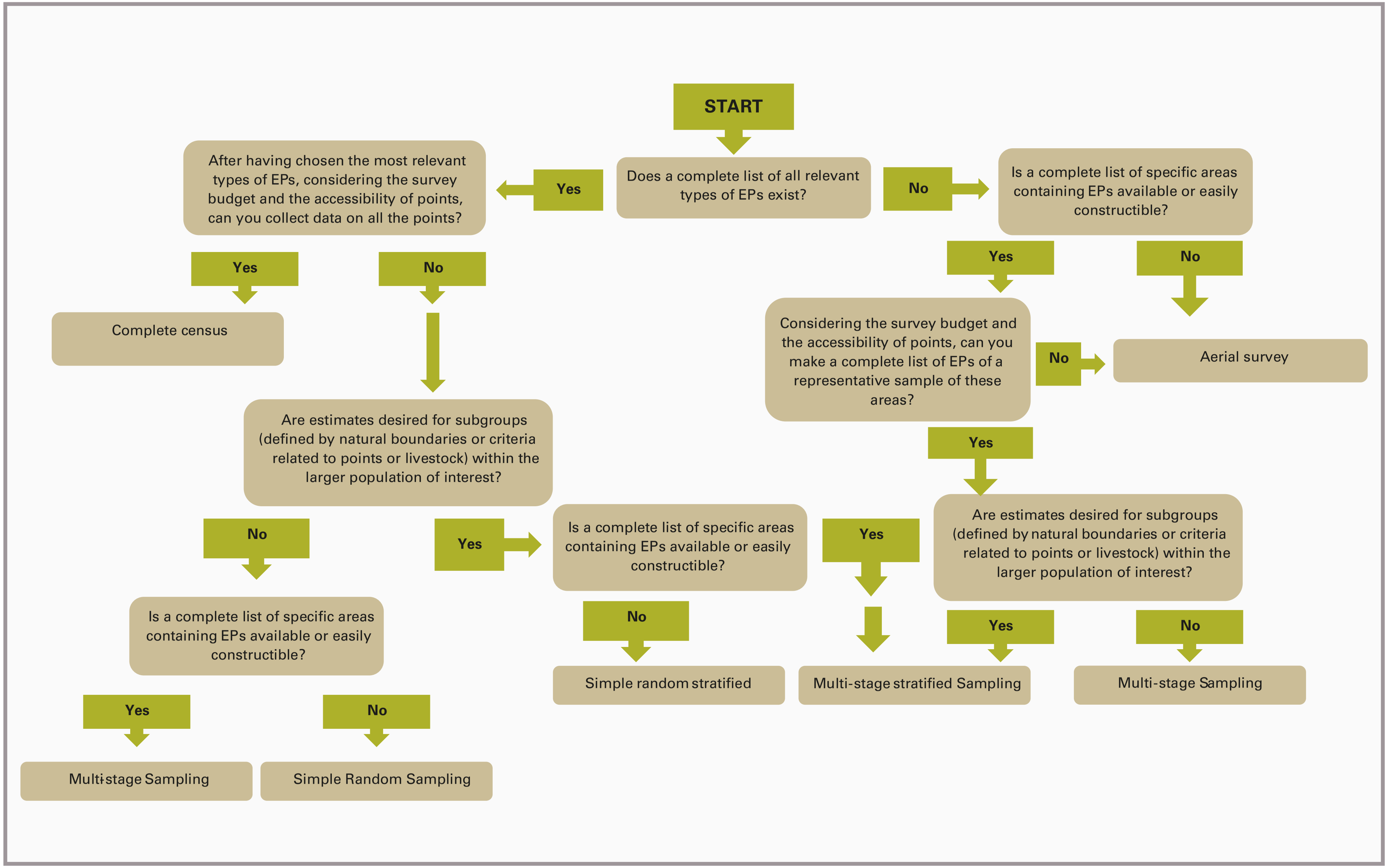


TABLE 13. PREREQUISITES, ADVANTAGES AND DISADVANTAGES OF SURVEY METHODS

Prerequisites	Advantages	Disadvantages
Ground Survey - Water Points	Example: Mali Survey	
Complete list and map of all water points in EA.	• Animals come to water points where enumerators can be positioned • Animals can be easily seen and counted • Logistically simple and easy to organize	• Watering frequency varies with species and location, and must be determined for each species to estimate population sizes • Animals brought are not necessarily nomadic/ transhumant – some may be sedentary • Depending on how watering is organized, can be difficult to avoid double counting • Young stock may not visit water point, and may thus be excluded • Additional information/surveys are required to determine watering frequencies and proportion of nomadic/transhumant animals, to estimate population size
Ground Survey - Vaccination Points		
Complete list and map of all vaccination points in EA	• Animals come to vaccination points where enumerators can be located • Animals can be easily seen and counted • Relatively simple and easy to organize	• Different vaccinations for different species • Not all animals are brought for vaccination • Animals brought are not necessarily nomadic/ transhumant – some may be sedentary • Additional information/surveys may be required to assess the proportions of vaccinated and nomadic/ transhumant animals, to estimate population size
Ground Survey - Dipping/Spraying Points – (dip tanks or spray races)		
Complete list and map of all dipping/spraying points in EA	• Animals come to dipping/ spraying points, where enumerators can be positioned • Animals can be easily seen and counted • Relatively simple and easy to organize	• Not all animals are brought for dipping/spraying • Animals brought are not necessarily nomadic/ transhumant – some may be sedentary • Young animals may not be included • Additional information/surveys may be required to determine proportion dipped/sprayed animals and proportion of nomadic/transhumant animals, to estimate population size
Ground Survey - Ethnic Groups/Clans Example: Ethiopian Afar Region Survey		
Prior agreement and full cooperation of all group members List and map of all camp locations in EA	• Group/clan leaders: • Participate in planning; • Assist in identifying and locating all members; • Explain purpose of enumeration; • Facilitate information collection.	• Assumes that clan leadership knows camp site locations of all members • Areas may be very large, so that exact locations may not be known • Some pastoral areas are shared by more than one group/clan; in these case, more than one set of leaders may have to be involved
Ground Survey - Stock Routes		
Complete list and map of all stock routes in EA Cooperation of herder to channel animals through/past checkpoints.	• Can be good indicator of numbers moving from one area to another • Animals pass along stock route, where enumerators can be located	• There may be many routes • Routes are not always well-defined • Often, there may be multiple tracks • May change from year to year • Not all animals use the same route • Difficult to count large herds of moving animals

Prerequisites	Advantages	Disadvantages
Ground Survey - Livestock Markets		
Complete list and map of all markets in EA Long-term records over at least one year (preferably longer) for seasonal and inter-annual comparison.	• Good places to meet owners, sellers and buyers for information on market conditions • Long-term records of volumes and prices can provide useful insights on seasonal patterns and inter-annual trends	• Market sales and prices are sensitive and/or confidential information, which is not always willingly shared • Numbers sold may or may not reflect population size – this depends on the circumstances • Not necessarily all animals are nomadic/transhumant stock • Sellers (middlemen) may have recently bought stock from previous owners who are not present, such that animal history may not be known • Additional surveys of herd structure are required to determine the off-take percentage, to estimate population size
Aerial Survey - Systematic Reconnaissance Flight		
Preferably, clearly defined boundaries, visible from the air e.g. coastlines, mountain ranges, rivers and roads.	• Good for large, inaccessible areas, for which reliable ground counting frames are not available • No prior assumption with regard to livestock distribution • Can also record wildlife species	• Cannot distinguish between sheep and goats - recorded as small ruminants – and ground survey is required to determine ratio • Cannot distinguish between donkeys, mules and horses - recorded as equines – and ground survey necessary to determine ratio • Can only distinguish cattle colour types – ground survey is required to assess breeds and herd age and sex structure
Aerial Survey – Stratified Random Transects		
Preferably, clearly defined boundaries visible from the air e.g. coastlines, mountain ranges, rivers and roads.	• Good for large, inaccessible areas, for which reliable ground counting frames are unavailable	• Assumes that identified strata are relatively homogeneous with regard to livestock distribution • Cannot distinguish between sheep and goats – recorded as small ruminants – and ground survey is necessary to determine ratio • Cannot distinguish between donkeys, mules and horses – recorded as equines – which requires ground survey • Can only distinguish cattle colour types – ground survey is required to assess breeds and herd sex and age structure
Aerial Survey – Complete Coverage		
Preferably has clearly defined boundaries visible from the air e.g. coastlines, mountain ranges, rivers and roads.	• Good for relatively small areas, from 100 to 400 km2	• Cannot distinguish between sheep and goats - recorded as small ruminants - ground survey required to determine ratio • Cannot distinguish between donkeys, mules and horses - recorded as equines - ground survey required to determine ratio • Can only distinguish cattle colour types – ground survey required to assess breeds and herd sex and age structure
Cluster Sampling		
Elements of population(s) being enumerated can be grouped into clusters	• Does NOT require a complete list of all elements • More practical in dispersed populations – sampled elements are closer together • Cheaper	• Precision of estimates reduced • Larger sample sizes are necessary, • Calculation of confidence intervals is more complicated

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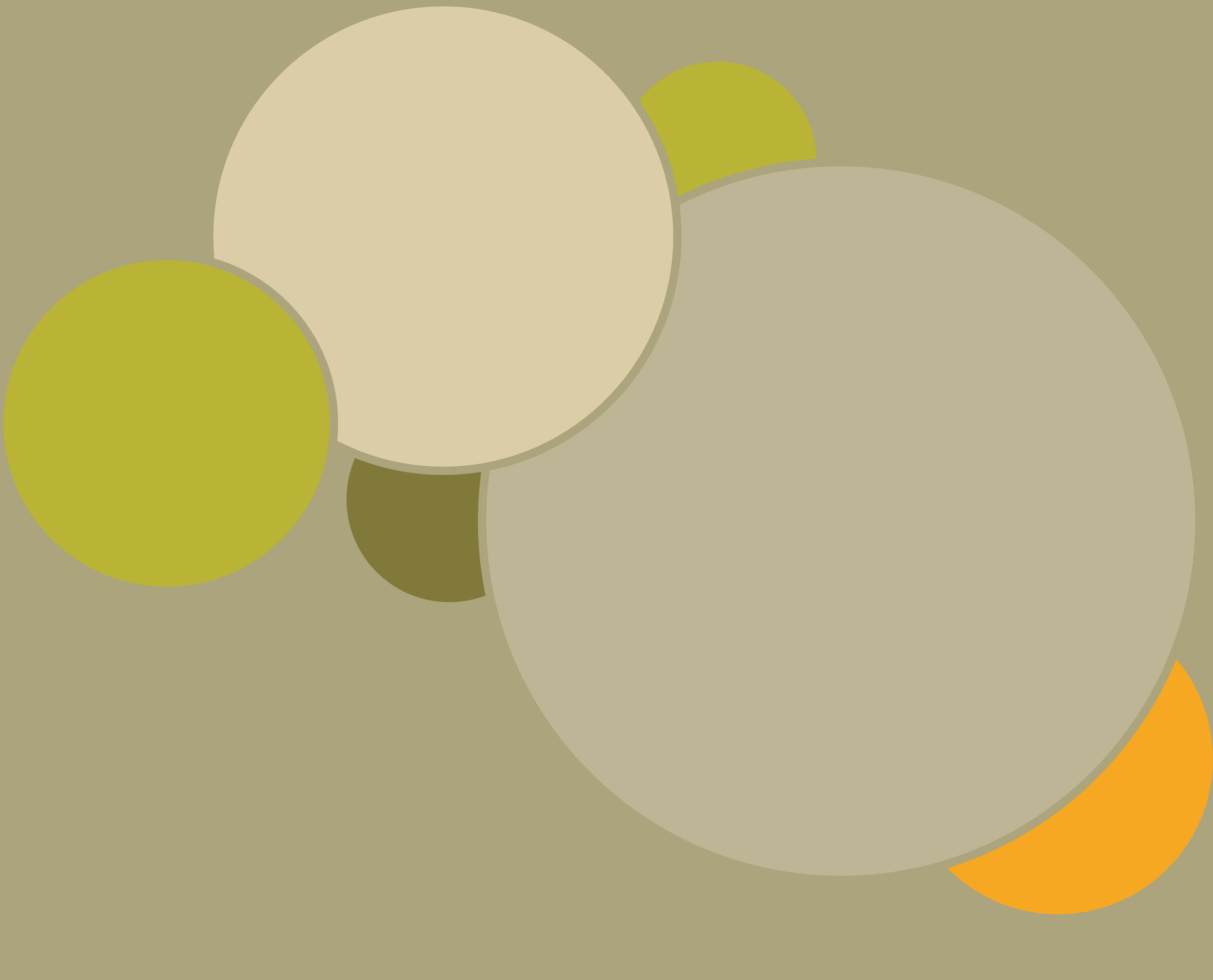

Annex

COUNTRY CASE STUDIES

GROUND SURVEYS

BACKGROUND	
Country	**Afghanistan**
Available meadows and pastures, 2013 (ha)	30 million ha (79% of agricultural area)
Type of pastoral populations	Nomadic and seminomadic, with permanent residences
DESIGN	
Survey years	2002-2003
Survey coverage	National
Survey type	Complete enumeration to estimate livestock population; sample survey for detailed information on livestock production
Target pastoral population(s)	Fully nomadic and semi-nomadic
Livestock species	Cattle, sheep, goats, donkeys, camels, horses, poultry, ducks, turkeys; by age, sex and performance
EPs	Mosque assemblies in villages
Other information collected	Women's role in animal production Access to markets Karakul sheep pelt production
Statistical units	Herders
Source of frame	information from field staff
Survey design	A two-tiered data collection strategy was adopted. Level 1 was designed to provide a complete enumeration of all livestock species, including limited information on livestock demography and recent changes in livestock assets. Level 2 data collection from farmer/herders included detailed information on animal husbandry, feed management and markets administered by supervisors to individual households in randomly selected districts and villages. Two additional surveys were also conducted to assess the role of women in livestock production, and to determine the status of Karakul sheep production.
Data collection method	Interviews
Data collection tool	Paper

IMPLEMENTATION	
Timing, from preparation to results dissemination	NA
Timing, data collection	2 months
Number of EPs	53,214
Number of statistical units	3,044,670
Number of enumeration teams	849
Composition of enumeration teams	28 supervisors and 821 enumerators
Total cost	NA
Cost of data collection	NA
RESULTS	
Estimated cattle population	3.72 million
Estimated sheep population	8.77 million
Estimated goat population	7.28 million
Estimated donkey population	1.59 million
Estimated camel population	0.18 million
Estimated horse population	0.14 million
Estimated poultry population	12.16 million
Estimated duck population	0.42 million
Estimated turkey population	0.6 million
Use of data	NA
LESSONS LEARNT	
Survey design	• Due to the focus on mosque assemblies in villages for the enumeration of family livestock holdings, nomadic and semi-nomadic groups without permanent settlements (such as the mainly sheep- and goat-herding Kuchi people) were not included; • Certain aspects of Level 2 survey data collection may also have been biased, due to the non-random selection of villages within districts and provinces and the non-random selection of farmers. This could be ascribed to the fact that there was no sampling frame that the survey could use; • In addition, some provinces had to be omitted for security and logistics reasons; • When more reliable sampling frames become available, such as village and household/family listings, they should be used to randomize livestock data collection and generate more robust statistics. • Future livestock surveys could also consider stratifying their data collection into more homogenous zones, such as the livestock production zones identified in Figure 1, so that the variation between sample units is minimized and estimates are more precise.
Survey implementation	• It was not possible to equip surveying teams with GPS within the time frame of the study. Thus, the location of communities visited during the total Level 1 enumeration was based on local names and site descriptions; • A key lesson learned from the experience is that census quality is a direct function of the time available for preparation and execution. Logistic problems must be analysed carefully and their impact on data quality assessed as conservatively as possible. It is critical 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.

BACKGROUND	
Country	**Bolivia**
Available meadows and pastures, 2013 (ha)	33 million ha (87% of agricultural area)
Type of pastoral populations	Fully nomadic and seminomadic
DESIGN	
Survey years	Three experiences of transhumant livestock enumeration are provided in the case study. • *2010 (Registration of Livestock by the Servicio Nacional de Sanidad Agropecuaria (SENASAG))* • *2002, 2004 and 2005 (Enumeration of Livestock by the Campesino Organization)* • *1999 and 2000 (Enumeration of Livestock in Tariquia National Reserve)*
Survey coverage	*Valle Central de Tarija*
Survey type	*Census by complete enumeration*
Target pastoral population(s)	*Fully nomadic and semi-nomadic*
Livestock species	*cattle, goats, sheep, horses, pigs, poultry*
EPs	Enumeration points are used in two experiences: • control posts covering the principal routes and roads used by cattle commerce (Registration of Livestock by SENASAG) • strategic spots of the trails used by herders (Enumeration of Livestock in Tariquia National Reserve)
Other information collected	NA
Statistical units	Animals
Source of frame	Available list
Survey design	Complete enumeration
Data collection method	Direct counting
Data collection tool	Paper
IMPLEMENTATION	
Timing, from preparation to results dissemination	NA
Timing, data collection	• Registration of livestock by SENASAG: data is collected continuously by the SENASAG's officers at control posts • Enumeration of livestock by Campesino Organization: NA • Enumeration of livestock in Tariquia National Reserve: 120 days
Number of EPs	NA
Number of statistical units	• Registration of livestock by SENASAG: NA • Enumeration of livestock by Campesino Organization: NA • Enumeration of livestock in Tariquia National Reserve: 24,000
Number of enumeration teams	NA
Composition of enumeration teams	NA
Total cost	NA
Cost of data collection	NA

RESULTS	
Estimated cattle population	• Registration of livestock by SENASAG: NA • Enumeration of livestock by Campesino Organization: NA • Enumeration of livestock in Tariquia National Reserve: 24,000
Use of data	Connection of the data collected with other animal health studies, such as those relating to blood urine (*orina de sangre*) disease, or *hematuria enzootica*, which the reserve administration believed was caused by the ingestion of a native wild fern left after decades of selective grazing of the mountain forests' natural grasslands (Enumeration of Livestock in Tariquia National Reserve).
LESSONS LEARNT	
Survey design	NA
Survey implementation	For the Tariquia Park administration, it is very important to register livestock movement on a periodical basis for biodiversity management purposes. However, the administration relies upon the reserve's area and boundaries, which is not a coherent spatial delimitation to comprehend transhumant livestock movement in the territory, such that there is a partial and uncertain registration of transhumant livestock.

BACKGROUND	
Country	**Ethiopia**
Available meadows and pastures, 2013 (ha)	21,900,000 ha (60% of agricultural area)
Type of pastoral populations	Semi-nomadic
DESIGN	
Survey years	2004
Survey coverage	Afar region
Survey type	Sample survey
Target pastoral population(s)	Semi-nomadic
Livestock species	Cattle, sheep, goats, camels, poultry; by type, age and sex
EPs	NA
Other information collected	NA
Statistical units	Households
Source of frame	Available list of *kebele* (ward) from the Population and Housing Census cartographic work, and listing of all agricultural and livestock-owning households in each *kebele* in the field.
Survey design	A stratified, single-stage, sample design was used for the selection of ultimate sampling units. Each *wereda* (district) was treated as a stratum for which major findings of the sample census were to be reported.
Data collection method	Interviews
Data collection tool	Paper
IMPLEMENTATION	
Timing, from preparation to results dissemination	9 months
Timing, data collection	14 days
Number of EPs	None
Number of statistical units	NA
Number of enumeration teams	344
Composition of enumeration teams	278 enumerators and 66 supervisors
Total cost	US$ 312,416
Cost of data collection	NA
RESULTS	
Estimated cattle population	2,376,656
Estimated sheep population	2,541,914
Estimated goat population	4,398,596
Estimated camel population	884,290
Use of data	NA
LESSONS LEARNT	
Survey design	NA
Survey implementation	NA

BACKGROUND	
Country	**Jordan**
Available meadows and pastures, 2013 (ha)	742,000 Ha (70% of agricultural area)
Type of pastoral populations	Fully nomadic and semi-nomadic
DESIGN	
Survey years	1991
Survey coverage	All desert (*Badiya*) regions: Safawi, Ruwaished and Sabha in the northern Badiya, Giza and Muwaqqar in the central *Badiya* and the southern *Badiya*
Survey type	Census by complete enumeration
Target pastoral population(s)	Fully nomadic and semi-nomadic
Livestock species	Sheep, goats, cattle, horses, camels, mules, donkeys; by age, sex, breeds
EPs	Counting centres
Other information collected	Purpose of keeping (trade, keeping, fattening)
Statistical units	Animals
Source of frame	The counting frame for the livestock census was based on preliminary field work carried out by the 26 Areas Committees entrusted with identifying and listing counting centres in all Governorates of the Kingdom.
Survey design	Complete enumeration
Data collection method	Direct counting
Data collection tool	Paper
IMPLEMENTATION	
Timing, from preparation to results dissemination	NA
Timing, data collection	1 day
Number of EPs	1,298 counting centres
Number of statistical units	3,903,692
Number of enumeration teams	10,000
Composition of enumeration teams	Controllers, recorders, counters, markers, Inspection Committee members
Total cost	2,476,616
Cost of data collection	NA
RESULTS	
Estimated sheep population	2,671,317
Estimated goat population	1,079,363
Estimated cattle population	64,150
Estimated horse population	9,441
Estimated camel population	32,155
Estimated mule population	3,510
Estimated donkey population	43,756
Use of data	NA

LESSONS LEARNT	
Survey design	NA
Survey implementation	• The census administration could not establish permanent counting centres according to the technical specifications, due to the limited time available. Instead, enumeration sites were established in the yards of local livestock holders. • During the long interval between determining the number of counting centres to be used in each area and the actual census, some livestock holders had moved to another location, resulting in reduced workloads in some areas and increased workloads in others on census day. • The DoS sought the assistance of the Armed Forces and rented cars from the private sector to make up for an unexpected shortage of government vehicles that should have been allocated to field teams. The shortage resulted from non-compliance with the Prime Ministerial decree on part of some ministries and departments. The shortage delayed the start of the counting process in some areas and increased the work pressure for the remaining hours of the census. • A small number of owners of individual animals reared indoors failed to register their animals with municipal and village councils as instructed; these were not included in the census. • Despite a major media campaign, a few citizens remained unaware of the importance of including their animals in the census and did not receive a counting card. Therefore, they were unable to obtain fodder at the subsidized price. • The original intention was for the DoS to process and analyse the census data, but the Higher Ministerial Committee subsequently decided to assign this role to the Royal Scientific Society. This decision delayed the release of census results by three months. • The DoS repeatedly sought to conduct the census in the spring (April being the peak breeding month); however, formal announcement of the census date was repeatedly delayed, so that the census took place in the fourth quarter of the year, when livestock numbers are relatively low. • Various data recording errors were detected, most notably the failure to record the age and sex of the animals and the purpose of ownership. Other errors included recording exotic dairy cows in data fields meant for local cows in the census questionnaire. • Gold spray colour did not show up well on black hair; therefore, other colours were used instead. • Failure of some livestock holders to accompany their herds to counting centres (sending their children or relatives instead) meant that some census questions could not be answered.

BACKGROUND	
Country	**Mali**
Available meadows and pastures, 2013 (ha)	35 million ha (85% of agricultural area)
Type of pastoral populations	Fully nomadic and semi-nomadic
DESIGN	
Survey years	2001
Survey coverage	National
Survey type	Census by complete enumeration
Target pastoral population(s)	Fully nomadic and semi-nomadic
Livestock species	Cattle, goats, camels, sheep, horses and donkeys; by species and breed and by region, circle and commune
EPs	Water points
Other information collected	NA
Statistical units	Animal
Source of frame	Local knowledge
Survey design	Livestock concentration areas were classified into two types: • Type I Concentration Areas, with deep water or isolated pools, boreholes, wells or small isolated ponds. Usually, there are relatively few points in each concentration area. • Type II Concentration Areas, with surface water (perennial ponds, large lake, rivers and tributaries – there are no specific convergent points where all animals are taken to drink). These areas are typical of concentration areas in the Inland Delta and along the Niger River. In Type I Concentration Areas, enumerators were stationed at each water point and recorded all animals coming to drink over a two-day period. The maximum period between watering for cattle is two days, but is much longer for camels. The watering frequency of camels was determined by interview and the number of camels observed watering over the two-day enumeration period was adjusted accordingly. For Type II Concentration Areas, as many enumerators as possible were mobilized to enumerate all livestock within each area as comprehensively and as quickly as possible, before moving on to the next area as soon as possible to minimise double counting.
Data collection method	Direct counting
Data collection tool	Hand counter and GPS locator
IMPLEMENTATION	
Timing, from preparation to results dissemination	December 1999 to March 2002
Timing, data collection	April to June 2001
Number of EPs	NA
Number of statistical units	4,193,848
Number of enumeration teams	401
Composition of enumeration teams	NA
Total cost	US$ 241,535
Cost of data collection	NA

RESULTS	
Estimated cattle population	1,486,955
Estimated sheep population	1,264,871
Estimated goat population	1,058,897
Estimated donkey population	101,038
Estimated horse population	2,354
Estimated camel population	279,733
Use of data	NA
LESSONS LEARNT	
Survey design	• It is essential to conduct a comprehensive study to identify and characterize all concentration areas as soon as possible before the census, so that the enumeration and logistics can be properly planned and organized.
Survey implementation	• Human, material and financial resources allocation should be based on the relative size and degree of isolation of the concentration area; • Public awareness campaigns should ensure that information and/or education materials provided are in a form that target communities can understand; • Essential to be aware of recent changes in the environmental conditions that may influence typical patterns of seasonal movement (new water sources, irrigated agriculture, exceptional climatic conditions, disease, insecurity, etc.) and to design contingency plans to respond to such eventualities; • Enumerators should be given specific training in recognizing of livestock breeds; • Special attention should be given to the most appropriate way to assess camel numbers, because of their less frequent watering cycle; • Specific provision should be made for thorough analysis of the census database and dissemination of findings; • Specific provision should be made to ensure that census results are disseminated effectively to all producer groups and archived on a secure website, for wider general access.

BACKGROUND	
Country	**Mongolia**
Available meadows and pastures, 2013 (ha)	113 million ha (99% of agricultural area)
Type of pastoral populations	Fully nomadic, semi-nomadic and sedentary
DESIGN	
Survey years	2012
Survey coverage	National
Survey type	Sample survey
Target pastoral population(s)	Fully nomadic, semi-nomadic and sedentary
Livestock species	Cattle, sheep, goats, camels, horses by age, sex
EPs	None
Other information collected	Some social indicators
Statistical units	Households
Source of frame	Available list

Survey design	Separate stratified sample design was set for each *Aimag* (province). An Excel routine calculated the optimum strata boundaries using the iterative Lavallée and Hidiroglou (1988) method, creating one certainty strata and five sampled strata. All herders in the certainty strata were be included in the sample. Since this procedure is run separately on each livestock species, a combination of the results was used to set the final stratum boundaries for each *Aimag*. A separate stratum was assigned to camels because of their relatively low number compared to the other livestock species. This stratum was required to ensure that enough herders with camels would be selected in the sample to produce estimates with a reasonable level of precision. An overall sample was allocated to each stratum at the *Aimag* level. The sample size was determined using a Neyman allocation for the strata, based on variances calculated from data supplied by the National Statistics Office (NSO). This process sets a sampling fraction of the number of herders to be selected from each stratum. That sampling fraction was then applied to the corresponding stratum at the *Soum* level. The following mathematical formulae were used to estimate totals, variances, covariances, standard errors, coefficients of variation and ratios. ***For any variable X and Y:*** N_{ijk} = population count in the i^{th} *Aimag*, j^{th} *Soum*, and k^{th} stratum n_{ijk} = number of observations (usable) x_{ijkl} or y_{ijkl} = value of the variable reported on the questionnaire ***At stratum level:*** $DE_{st}X = \sum(N_{ijk}/n_{ijk})x_{ijkl} = \sum ex_{ijkl}$ (Direct Expansion of X or Y) $VAR_{st}X = [((N_{ijk}-n_{ijk})/N_{ijk})*(n_{ijk}/(n_{ijk}-1))*(\sum(ex_{ijkl}^2)-((\sum ex_{ijkl})^2/n_{ijk}))]$ (Variance of X or Y) $SE_{st}X = \sqrt{VAR_{st}}$ (Standard Error of X or Y) $CV_{st}X = (SE_{st}X/DE_{st}X)*100$ (Coefficient of Variation of X or Y) $R_{st} = DE_{st}X/DE_{st}Y$ (Estimate of the ratio) $VAR_{st}R = R_{st}^2[(VAR_{st}X/DE_{st}X^2) - 2(COV_{st}XY/(DE_{st}X*DE_{st}Y)) + (VAR_{st}Y/DE_{st}Y^2)]$ where $COV_{st}XY = [((N_{ijk}-n_{ijk})/N_{ijk})*(n_{ijk}/(n_{ijk}-1))*(\sum(ex_{ijkl}*ey_{ijkl})-((\sum ex_{ijkl})(\sum(ey_{ijkl})/n_{ijk}))]$ (Variance of the Ratio) $SE_{st}R = \sqrt{VAR_{st}R}$ (Standard Error of the Ratio) $CV_{st}R = (SE_{st}R/R_{st})*100$ (Coefficient of Variation of the Ratio) ***At Soum level*** $DE_{so}X = \sum DE_{st}X$ or $\sum\sum e_{ijkl}$ (Direct Expansion of X or Y) $VAR_{so}X = \sum VAR_{st}X$ (Variance of X or Y) $SE_{so}X = \sqrt{VAR_{so}X}$ (Standard Error of X or Y. Note: $SE_{so}X \neq \sum SE_{st}X$) $CV_{so}X = (SE_{so}X/DE_{so}X)*100$ (Coefficient of Variation of X or Y) $R_{so} = \sum DE_{st}X/\sum DE_{st}Y$ (Estimate of the Ratio) $VAR_{so}R = R_{so}^2[\sum VAR_{st}X/(\sum DE_{st}X)^2 - 2(\sum COV_{st}XY/(\sum DE_{st}X*\sum DE_{st}Y)) +$ $\sum VAR_{st}Y/(\sum DE_{st}Y)^2]$ (Variance of the Ratio) $SE_{so}R = \sqrt{VAR_{so}R}$ (Standard Error of the Ratio) $CV_{so}R = (SE_{so}R/R_{so})*100$ (Coefficient of Variation of the Ratio)
Data collection method	Interviews and traditional "eye count" method
Data collection tool	Paper

IMPLEMENTATION	
Timing, from preparation to results dissemination	From preparation to results in months
Timing, data collection	15 days
Number of EPs	-
Number of statistical units	70,000
Number of enumeration teams	2,300
Composition of enumeration teams	Enumerators and supervisors
Total cost	US$ 22,907.20
Cost of data collection	US$ 22,171.60
RESULTS	
Estimated cattle population	2,584,600
Estimated goat population	17,558,700
Estimated sheep population	18,141,400
Estimated horse population	2,330,400
Estimated camel population	305,800
Use of data	NA
LESSONS LEARNT	
Survey design	For census results to be credible, it is essential that the lists of households with livestock in each Soum are as complete and reliable as possible. Prior to the annual census, special attention should be given to updating these lists and recording all households with livestock that have moved in, or out of, each Soum since the previous registration. That information should then be shared with other Soums, so that enumeration lists can be reconciled and revised accordingly.
Survey implementation	Greater attention must be paid at Soum level to ensure that households with livestock know when and where censuses and surveys are to take place, so that on the due date, animals can be kept near a specified location for inspection.

BACKGROUND	
Country	**Niger**
Available meadows and pastures, 2013 (ha)	29 million ha (64% of agricultural area)
Type of pastoral populations	Fully nomadic and semi-nomadic
DESIGN	
Years of survey	2004-2005
Coverage of survey	National
Type of survey	Census by sample survey
Target pastoral population(s)	Fully nomadic and semi-nomadic
Livestock species	Cattle, sheep, goats, camels, horses and donkeys; by age, sex, breeds
EPs	Water points and transhumance corridors
Other information collected	Vaccination and destinations of transhumant livestock
Statistical units	Livestock herd/flock
Source of frame	Preliminary survey implemented to establish a comprehensive list of water points and transhumance corridors
Survey design	All water points were surveyed and complete inventories of animals were taken in Tahoua, Maradi and Tillabéry, well known to be traditional nomadic herding areas. Only a stratified sample of water points in Agadez, Zinder and Diffa could be visited, however, because of their wide dispersal and difficult access.
Data collection method	Direct counting
Data collection tool	Paper, GPS
IMPLEMENTATION	
Timing, from preparation to results dissemination	NA
Timing, data collection	7 months from September 2004 to March 2005
Number of EPs	A total of 1,223 water points were included in the census.
Number of statistical units	10,644,899
Number of enumeration teams	370
Composition of enumeration teams	13 national supervisors, 8 regional supervisors (one per region), 36 supervisors and 313 enumerators
Total cost	NA
Cost of data collection	NA
RESULTS	
Estimated cattle population	2,589,306
Estimated sheep population	3,454,207
Estimated goat population	2,755,512
Estimated camel population	1,339,716
Estimated horse population	45,181
Estimated donkey population	460,978
Use of data	NA
LESSONS LEARNT	
Survey design	NA
Survey implementation	NA

COUNTRY CASE STUDIES

AERIAL SURVEYS

BACKGROUND	
Country	**Ethiopia**
Available meadows and pastures, 2013 (ha)	21,900,000 ha (55% of agricultural area)
Type of pastoral populations	Nomadic
DESIGN	
Years of survey	2003
Coverage of survey	Somali Region
Type of survey	Sample survey
Target pastoral population(s)	Fully nomadic
Livestock species	Cattle, sheep, goats, camels and equines
Other information collected	Dams and *birkas* (all man-made water retention and storage devices); traditional roof structures; modern roof structures; all wildlife species; presence or absence of surface water and temporary wells (hand-dug wells in river beds) in each flight line sector
Type of aerial survey	Low-level flights
Complementary ground-survey	Yes, to provide objective estimates of the ratios between the numbers of sheep and goats in different parts of the survey area; the ratio of donkeys, mules and horses among the equines; the sex and age composition of cattle, camels and different species of equines; average size of livestock holdings per household (holder)
Survey design	Sampling design: regular pattern of parallel flight lines over the survey area; each flight line is divided into sectors equal in length to the flight line spacing, to form a regular sampling framework or grid for recording observations. Sample size – approximately 3% Area surveyed: approximately 240,000 km^2 Estimators: population estimates were derived from each zonal database using the Jolly II Method for sample units of unequal size (Jolly, 1969). Using the notation provided by Caughley (1977), this estimates the population Y as $Y=AD$, where A is the survey area and D is density. The density D is estimated as $D=\Sigma y / \Sigma a$, where y is the number of animals counted in a, the area sampled. The variance of Y is estimated as: $Var(Y)=N(N-n)\ \Sigma y^2+D^2\Sigma a^2-2D\Sigma ay\ /n(n-1)$, where N is the total possible number of transects in the survey area and n the number of transects sampled.
Type of flight patterns	Systematic Reconnaissance Flights (SRFs)
Data collection method	Visual estimates of animals and structures seen within ground sampling strips on either side of the aircraft are recorded by sector; photographs are taken whenever possible, for subsequent verification and error correction.
IMPLEMENTATION	
Timing, from preparation to results dissemination	4 months for estimation of livestock population
Timing, data collection	1 month for flights (November 2003)
Number of aircraft used	3 aircrafts
Total cost	US$ 223,453
Cost of data collection	US$ 163,123

RESULTS	
Estimated cattle population	670,275
Estimated goat population	5,525,463
Estimated sheep population	6,410,801
Estimated camel population	1,041,869
Use of data	NA
LESSONS LEARNT	
Survey design	Given the remoteness and size of the survey area, aerial survey is clearly the most effective means of assessing the distribution and abundance of livestock; aerial surveys cannot reliably distinguish between sheep and goats, or horses, donkey and mules; nor can it assess herd structures. Complementary ground surveys are required to obtain such information.
Survey implementation	The aerial survey of the Somali Region was much more cost-effective than the ground survey.

BACKGROUND	
Country	**Nigeria**
Available meadows and pastures, 2013 (ha)	30 million ha (43% of agricultural area)
Type of pastoral populations	Fully nomadic and semi-nomadic
DESIGN	
Years of survey	1989 - 1992
Coverage of survey	National
Type of survey	Census by complete enumeration
Target pastoral population(s)	Fully nomadic and semi-nomadic
Livestock species	Goats, sheep, donkeys, horses, camels, pigs, cats, dogs, rabbits, giant rats, guinea pigs, poultry; by age, sex, breeds
Other information collected	Habitation, vegetation and land use distribution
Type of aerial survey	Low-level
Complementary ground-survey	Ground operations took place throughout 1990. The survey teams obtained the widest possible coverage during the drier months, and concentrated on the more accessible areas during the rains. Village surveys were conducted in the states sequentially, working with officials from the State Governments as much as possible. Three types of ground survey were carried out: Village surveys assessed livestock numbers in relation to rooftop numbers in rural villages, and recorded socioeconomic data; Animal productivity surveys assessed productivity parameters for the major breeds of large livestock species, using the mature breeding female history technique; Urban surveys assessed animal numbers in the larger towns by measuring livestock densities in sample wards.
Survey design	Complete enumeration
Type of flight patterns	SRFs
Data collection method	Direct counting
IMPLEMENTATION	
Timing, from preparation to results dissemination	NA
Timing, data collection	Aerial surveys were conducted seasonally: dry season operations took place in March and April 1990, and wet season surveys were carried out during September and October 1990. Ground operations took place throughout 1990.
Number of aircrafts used	NA
Total cost	NA
Cost of data collection	NA

RESULTS	
Estimated cattle population	13,885,813
Estimated goat population	34,453,724
Estimated sheep population	22,092,602
Estimated donkey population	936,832
Estimated horse population	206,212
Estimated camel population	87,839
Estimated pig population	3,406,381
Estimated cat population	3,265,554
Estimated dog population	4,543,003
Estimated rabbit population	1,719,846
Estimated giant rat population	64,433
Estimated guinea pig population	474,108
Estimated poultry population	104,257,960
Use of data	NA
LESSONS LEARNT	
Survey design	NA
Survey implementation	NA

Notes

Notes

Layout:

- Laura Monopoli

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