



Statistical Methodologies for the Development of Colombian Agricultural Statistical System.

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1 Introduction

Agricultural sector is essential in the socio-economic development of Colombia, as it represents the economic sustenance of 24% of Colombian population. The statistics that are produced for such sector provide an objective basis for studying its problems and establishing effective policies for addressing them. The implementation of statistical investigations that observe the behavior of agricultural sector's variables are produced in benefit of life conditions of rural population, dealing with as economic as political, social and cultural aspects. Most of actors involved in this sector require the analysis of agricultural sector statistical information that both defines an objective evaluation basis and achieves the desired accuracy levels, the appropriated designs, the absence of errors, wide validity ranges and the possibility to calculate levels of uncertainty in terms of the quality of results.

It implies to have a set of statistical methods applicable for agricultural, livestock, and forestry sub-sectors that enable to plan their short, medium and long term development. This document was created with the purpose of studying the statistical methodologies suitable for the development of the Sistema Estadístico Agropecuario SEA (Agricultural Statistical System) in Colombia, bearing in mind the investigations that are currently carried out by The Departamento Administrativo Nacional de Estadística (National Administrative Department of Statistics) DANE.

This paper is divided as follows: the first part in which this primary introduction is presented, the second part i.e. the background - where the behavior of agricultural sector in the last years is briefly analyzed, the Agricultural Statistical System and its characteristics (in the framework of the National Statistical System – SEN) are defined, and a brief description of the different sector's investigations carried out by DANE are presented-. In the third section, the most important investigations concerning the agricultural sector are analyzed, the needs for strengthening the statistical operations carried out by this entity are pointed out, as well as are identified the potential investigations which DANE may apply, with the purpose of generating a relation between these demands and the statistical

methodologies that permit the design of statistics that meet such demands. Finally, a conclusion is set out.

2 Background

2.1 Information on the agricultural and livestock sectors in Colombia

The starting point to define the scope of agricultural statistics in Colombia corresponds to the System of National Accounts – SNA, which establishes the international regulations, concepts, definitions and classifications of economic activities¹. The DANE's Direction of Synthesis and National Accounts – DSNA, is the division in charge of calculating the annual, quarterly, departmental and satellite accounts on culture, environment, tourism amongst other. Regarding SNA, agricultural sector is measured taking into account the Agricultural and Livestock activities.

The first agricultural activity is made up of two major groups of products: Coffee and other agricultural products². In Colombia - In accordance with DANE (2013a) - the agricultural Gross Domestic Product GDP "... is calculated in a quarterly basis taking into account a sample of 22 products, which in 2005 represented the 98, 6% of the sector's total production. Estimations are produced either from constants and current prices, depending on the available indicators that may correspond to annual, monthly or quarterly production, by the demand components; or from indirect methods..." (p. 58).

In order to calculate the agricultural-GDP-, estimations are produced bearing in mind the annual production which is obtained from the information that is quarterly organized through planting schedules, for so defining the temporary distribution of crops. Estimations can be also produced from the half-yearly production of transition and permanent products, with six monthly indicators that are quarterly organized taking account of agricultural schedules. Likewise, for products such as cocoa and sugar cane, estimations are obtained from monthly data, whereas for the production of parchment coffee, flowers and banana, estimations are produced from the demand.

Regarding livestock activity, this is made up of three groups of products: Cattle and sub-products, poultry and sub-products, pigs and other livestock. For estimating the production, "The production of cattle, pigs, milk, poultry and eggs is calculated in a quarterly basis. In 2005, such products represented the 96, 1% of the total livestock production (...)" (DANE, 2013a:p.58).

Activities such as: forestry, wood extraction and similars are comprised of five groups of products: wood logs, firewood, forests planted with commercial and protection purposes, as well as services related with such activity. In the calculation of forestry's production -excluding wood-, an indicator is produced by means of the index of real production of wood from the Monthly Manufacturing Survey (MMM as its acronym in Spanish), and the index of paper pulp's production obtained based on the figures from The Asociación Nacional de Empresarios de Colombia (National Business Association of Colombia) ANDI. For the case of wood, the total rural population taken from the Great Integrated Household Survey (GEIH as its acronym in Spanish) is used as indicator. Finally, fishery products and

¹ The SNA 2008 "is a statistical framework that provides a complete, coherent and flexible set of macroeconomic accounts, for the formulation of policies, the analysis and investigation's objectives (...) it shows the changing needs of users, the new developments in the economic context and the progresses in the methodological research.", (ECLAC, 2009: p.1).

²This group includes cereals, legumes, edible roots and tubercles, fruits and nuts, seeds and oleaginous fruits, live plants; flowers and flower blossoms cut, flowers and fruits seeds, vegetable seeds, other crops of spices or drinkable plants, tobacco, cane crops, , vegetable raw material previously non classified, plants used for perfumery, pharmacy or as pesticides of fungicides, trees and crops permanently planted, inter alia. (DANE, 2013a).

aquaculture activities are made up of three groups: live fishes, fresh or chilled fishes, crustaceans, clams and other invertebrate animals (DANE, 2013a).

In this regard, the scope of basic agricultural statistics – which are relevant for the agricultural GDP calculation-, is given by the conceptual framework provided by the Food and Agriculture Organization of the United Nations [FAO] (2007). Such frame includes aspects concerning forestry, fishing, and land /water use (irrigation, irrigated lands, irrigation methods and resulting production). Recently, the FAO (2012) and its Agricultural Statistics' Division designed the Global Strategy to Improve Agricultural and Rural Statistics, where FAO recognizes that agricultural statistics – in a conceptual framework- are considered as the starting point for the SNA. Its scope should be defined concerning three dimensions: the economic, social and environmental dimension.

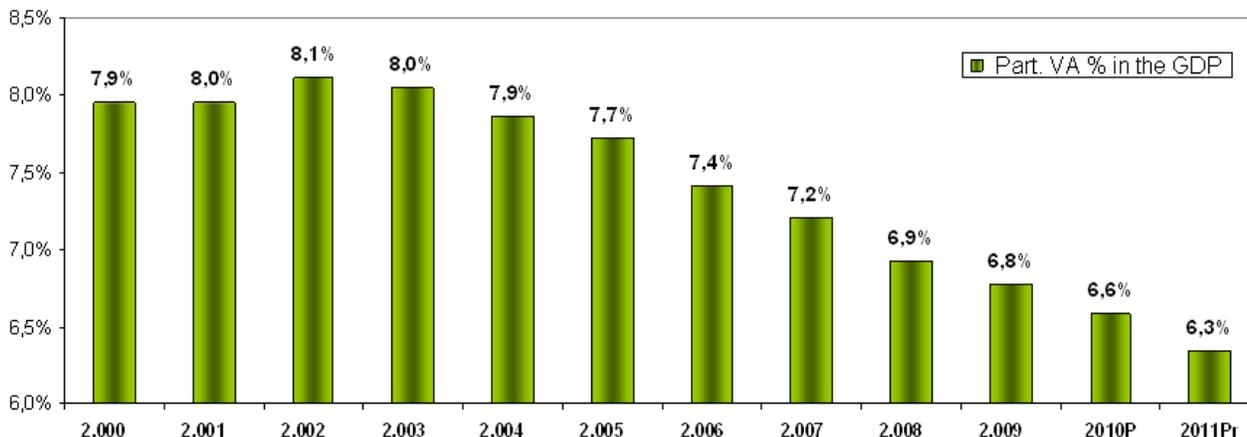
Likewise, this strategy has defined three pillars: (i) the definition of basic data for satisfying minimum requests, as well as the frequency and the methodology for achieving it; (ii) the integration of rural statistics to the Sistema Estadístico Nacional (National Statistical System) SEN “considered as an important element to produce statistics in coordination with Ministries and statistics institutes, to avoid double-counting or the non-coverage of statistical facts; and (iii) the creation of a sustainable statistical system which should be integrated to a public-financial plan that supports such system and also contributes with the governability and the development of an integrated work between statistics institutes and the corresponding ministries. Finally, FAO (2012) suggests that the existence of a legal framework, that regulates the Agricultural Statistical System in Colombia (SEA as its acronym in Spanish) and supports the infrastructure required for its sustainability, should be revised at the country level.

Given that the need for updating information is an important aspect in terms of agricultural statistics, Colombia has statistics and figures that supports facts such as: in the 2012p³, the agricultural sector's GDP was increased 2, 6% in comparison with the total Colombian GDP which was of 4, 0%, (DANE,2013b). In regards of participation, this sector has lost contribution in the total GDP considering that in 2000, this sector contributed with the 7, 9% and participated with the 6, 2%⁴ in 2012, having the sixth place within the national GDP, with a 7, 0% of average participation in the period between the years 2000-2012. Although the sector has lost participation during such period, it remains as one important sector due to its relevance in the provision of rural employment (with a contribution of 16, 3% of the total national population engaged –according with the GEIH, 2013)

³ Preliminary data

⁴ This decrease in the participation of the Agricultural GDP in the national total can be also explained by the growing of other economic sectors, such as mining.

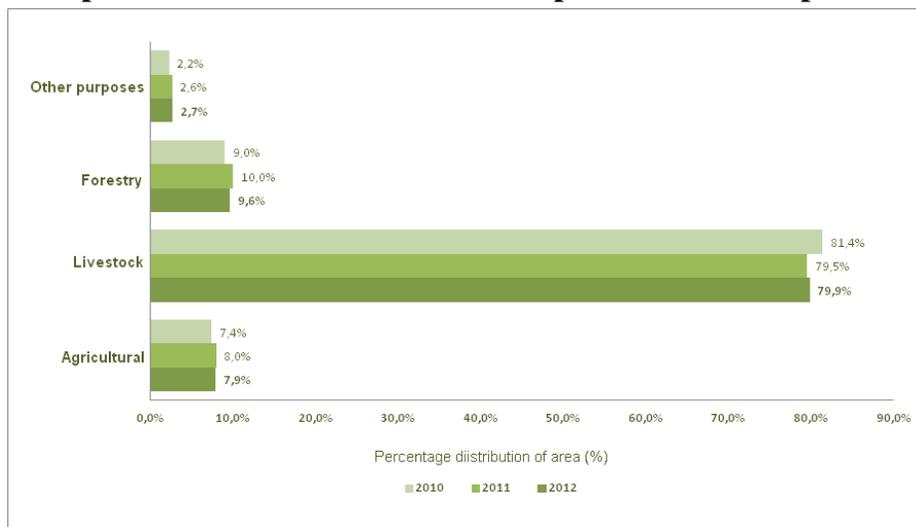
Graph 1. Participation of Agricultural Value Added in the GDP* 2.000 - 2.011 Pr.



Source: DANE- Direction of Synthesis and National Accounts (2013)

In Colombia, the agricultural production is linked to the soil use and management. In accordance with the National Agricultural and Livestock Survey – ENA (DANE, 2013c)⁵, whose sample covers 22 departments of the country⁶, soil is mainly used for livestock activities, forestry and agricultural purposes. In 2012, 62% of soil used for agricultural activities was mainly intended for permanent crops, 25% for transition crops, 12% for fallow lands, and the remaining 3% corresponded to soils at rest⁷.

Graph 2. Land use in 22 Colombian departments for the period 2010-2012



Source: DANE- National Agricultural and Livestock Survey (2012)

⁵In Colombia, agricultural investigations are mainly developed by DANE, which carries out the main surveys and investigations on this sector i.e. The National Agricultural Survey – ENA as its acronym in Spanish- The National Survey of Mechanized Rice –ENAM-, The Survey of Livestock Slaughtering –ESAG- and Agricultural Sector’s supplying and Price Information System –SIPSA- are just an example of the important and recognized agricultural sector’s investigations. These provide information on the medium and small producers. For the case of business producers, associated to products such as sugar cane, palm and banana for exportation, the production of statistical information is carried out by its related associations or trade unions.

⁶ From a total of 32 departments in the country, ENA approximately covers 37.941.476 inhabitants in 22 departments; excluding, Arauca, Amazonas, Caquetá, Chocó, Guainía, Guaviare, Putumayo, San Andrés, Vaupés and Vichada. Neither forests, rural-urban areas, zones with no agricultural use, palm oil domains, banana for exportation, nor sugar cane.

⁷ Fallow lands are those which are in temporary rest, before being once again used for planting purposes; whereas soils at rest are those that do not have any type of crop, and bearing in mind that such lands were previously cultivated, are not longer used for cultivation in a continuous basis during a period between 1 and 3 years, waiting for such land recovers its fertility, (DANE, 2013d).

Additionally, the most representative permanent crops in the country correspond to: coffee⁸, cocoa, panela cane, plantain and banana. In accordance with ENA, such products occupied an area planted of 1, 2 million hectares in 2012. Likewise, fruit crops had an area planted of 179.774 hectares.

On the other hand, transition crops include: tubercles, vegetables and cereals. Taking into account the first category, products such as potatoes and cassavas are highlighted. In the group of vegetables, onion crops, peas and tomatoes are the most important. In the third group i.e. cereals, the most important products correspond to white and yellow corn, barley, beans and wheat. In Colombia, the areas planted with white and yellow corn, potatoes and cassavas are the most relevant transition crops.

In terms of livestock, the land use is intended for three purposes: pasture and fodder, weeds and stubbles and special vegetations⁹. 65% from the 30 million of hectares used for livestock purposes correspond to pastures and fodders, 21% for weeds and stubbles and the remaining 13% for special vegetations.

The Livestock Slaughtering Survey (*Encuesta de Sacrificio de Ganado ESAG*) (DANE, 2013e), enables to have a record on the number of the most relevant heads of large and small species in the country. For instance, in 2012, the record of cattle slaughtered was 4, 1 million heads - figure that grew in 8% in relation with last figure reported in 2009.

Other investigations such as the Sistema de Información de Precios y Abastecimiento del Sector Agropecuario (*Agricultural Sector's Supplying and Price Information System*) SIPSA, presents the wholesale prices of agricultural products which are traded nationwide, informs on the food supplying volume in the main cities, and provides information about the behavior of retail prices of inputs and factors associated with the agricultural production.

Within DANE, other investigations are carried out serving as complement of the agricultural sector's statistical surveys, enabling the sector's data integration and this way providing demographic information, foreign trade statistics (imports, exports), producer and consumer's price indices, as well as the socioeconomic information regarding the rural areas of Colombia.

2.2. Background on the provision of agricultural statistics in Colombia

Nationwide, statistics on the agricultural sector arise since 1915. In this year, a compilation of statistics on production and prices for producers was carried out with 12 agricultural goods and a livestock inventory (Gutierrez, 2009). Then, in 1943, the Agricultural Census' Preparation Office was created – an activity which was granted to the Office of The Comptroller General of the Republic on May 1951 and failed due to technical and public security issues. One year later, FAO contributed with the design of an agricultural investigation, which enabled to have information in the period between 1954 and 1956. Also, Gutierrez (2009) points out that the committee of agricultural statistics was created in 1959, whose functions concerned the centralization of statistical data produced by the different sector's entities, as well as analyzing the information and finally authorize its dissemination.

Acosta and Perez (2011) points out that DANE carried out the first National Agricultural Census in 1960, which was continued with surveys on topics of interests since 1964 to 1969. Subsequently, in

⁸ The statistical information on coffee crops is produced by the Federación Nacional de Cafeteros de Colombia (*National Federation of Coffee Growers of Colombia*), using the Sistema de Información Cafetero (*Coffee Information System*) SICA.

⁹ In accordance with DANE (2013), the concept: special vegetations consider lands with savannah, xerophile and paramo vegetations.

1970, DANE applied the second National Agricultural Census. Then in 1982, the application of the third National Agricultural Census – that was supposedly to be carried out in 1986- was approved; however, such project could not be engaged; as a result, the country adopted the methodology of agricultural area sampling, given by FAO.

Acosta and Perez (2011) points out that the methodology for the area sampling was tested in various regions of the country during the three following years, with successful results. At the end of 1988, such action allowed the creation of the First Agricultural Survey PENAGRO. In the same way, in 1993, the authors summarize that both the Ministry of Agriculture and Livestock and DANE proposed general regulations for carrying out the National Agricultural and Fishing Statistical System in Colombia, and the Colombian Agricultural Sector's information System – SISAC- was created, whose main purpose was to develop of a system of inter-census surveys as from the framework given by the Second Agricultural Census. In the subsequently 10 years, the DANE and the Ministry of Agriculture and Rural Development (MADR as its acronym in Spanish) carried out the Encuesta Nacional Agropecuaria (*National Agricultural and Livestock Survey*) ENA in an annual basis, and the unions of production independently, carried out their investigations for the development of surveys and the production of their statistics¹⁰.

In the same way, a relevant effort for attaching the General Census on Population and Housing with the Agricultural sector was done by DANE in 2005, when the population census was carried out, integrating agricultural economic units and whose results contributed with the creation of an approximated statistical framework of rural households. On the other hand, as from 2006, the MADR delegated to the Corporación Colombia Internacional [CCI] the development of ENA; however, such survey was once again applied by DANE in 2010.

In addition, in 2001, DANE started the development of the conceptual and methodological design of the Third National Agricultural Census – 3er CNA. The census' objective is to provide strategic, geo-referenced and updated statistical information regarding the agricultural, aquaculture, fishery, forestry and environmental sectors, for so creating the SEA. The third CEN will be carried out in 2014; as a result, during the years 2012 and 2013, DANE has focused on the construction of a data collection instrument and the definition of pre-census procedures. Likewise, such entity has been designing the data capture and processing system as well as other technological developments in order to make easy the monitoring, control and the communications along the census application; has configured the quality assurance system and prepared the cartographic materials, and finally has carried out both pilot tests as well as experimental censuses.

Finally, in 2012, the SIPSA – a research that has been developing in the CCI since 1994- was granted to DANE. With the integration of this system to the group of continuous and inter-census statistics, DANE has strengthened SIPSA's provision of agricultural statistics having the challenge of consolidating the SEA within the National Statistical System –SEN¹¹.

¹⁰ It is known that many efforts for having information on the agricultural sector in Colombia started from both the interests of unions; and the concern for attending their own needs. Nowadays, producers' unions have consolidated information systems, for instance: the Sistema de Información Cafetero (Coffee Information System) SICA, the Sistema de Información de la Caña de Azúcar (Sugar cane's Information System), managed by the Sugar cane's Research Center [CENICAÑA] and the Sistema de Información Estadístico del Sector Palmero (Palm Sector's Statistical Information Center).

¹¹ In accordance with DANE (2013f), "...the main source of statistical information is represented by the National Statistical System –NSS - an articulated set of components that ensure the production and dissemination of official statistics in Colombia-. This is made up by producers, sources of information, principles, standards, human and technical infrastructure, policies and technical processes. The NSS is coordinated by DANE, and integrates the statistics that are produced by ministries, administrative departments, decentralized entities, autonomous organizations, and private entities inter alia. Bearing in mind the regulations that govern the NSS, according to the Decree 262 of 2004, DANE will be in charge of -apart from the functions established in the 59 of Law 489 of 1998- coordinating and advising the execution of the National Statistical Plan as well as the sectoral and the territorial plans; likewise, to monitor, evaluate and disseminate them. The DANE is

2.3. The Agricultural Statistical System in Colombia - SEA

“The process to improve agricultural statistics should start with the integration of agriculture in the National Statistical System (...)” (FAO, 2012, p: 23). The integrated systems of statistics are important as they avoid the duplication of efforts, taking a better advantage of resources. In addition, such systems require the use of concepts, definitions and classifications, fact that in a long term allows having reliable and comparable data.

Therefore, the SEA (*Agricultural Statistical System*) - understood as a reliable and a long term system that provides quality information for the agricultural sector in Colombia - is based on the Plan Estadístico Sectorial (*Sectoral Statistical Plan*) of Agriculture, Livestock, Forestry and Fishing 2012-2015. PES is defined as “... a technical and permanent instrument for planning purposes which identifies and analyzes supply and demand of statistical information on the sector, in order to define strategies for filling the gaps of information, for putting together the inter-institutional statistical activities of the sector and for strengthening the production of the existent statistics...”, (DANE, 2013:p.11).

According with Acosta and Perez (2011), among the SEA objectives, it includes the improvement of communication between producers and users of agricultural statistics, the identification of needs for statistical information in order to adopt decisions in agri-food, socio economic and rural development, gender, production and environmental matters; the formulation and application of statistical programs that fulfill such needs, the coordination of sectoral data collection, validating and consistency, the improvement of statistics dissemination and the contextualization of statistical data which is produced.

All the above can be achieved through the development of an agricultural framework which can be used to design both survey investigations and samples. This is why an agricultural census is important in the production of databases that provide reference frameworks for decision-making. In the future, it is necessary to make the information from the third National Agricultural Census compatible with the results of surveys that contribute with information on the sector, and connect them with the rest of activities from SNA, with the purpose of making compatible the census frameworks with the frameworks taken from other censuses and enabling the derivation of sample surveys through different methods. Given the importance of having a systemic vision that works in coordination with the system of statistics of the country, the development of the third CAN represents a fundamental part for the integration of all this system.

2.4. Public and private offer of statistical investigations on the agricultural sector.

According with the PES (DANE, 2013f)¹², in Colombia are carried out 22 statistical operations are which implemented by 7 entities from the public sector attached to Agriculture. Moreover, the Instituto Colombiano Agropecuario (*Colombian Agriculture Institute*) ICA¹³ produces 9 administrative records

the organization that should coordinate the planning and the standardization of statistics, as well as ensuring the fulfillment of good practices in the processes of statistical production carried out in the entities that comprise the national public administration ...” (p.5).

¹² This plan was developed by the Direction of Regulation, Planning, Standardization, and Normalization – DIRPEN, in the framework of the Project of Statistical Planning and Harmonization, where its objective is to strengthen and consolidate the National Statistical System. “...Sectoral statistical plans analyze and consolidate the statistical production of a specific sector, involving a formulation process similar to PEN. These are based on specific objectives for the sector and provide answer to their punctual needs of information, which in some cases, are of national interest. Such plans also enable the design, formulation, monitoring and evaluation of sectoral public policies. (...) Sectoral statistical plans correspond to an important element for the Sectoral statistical plans correspond to an important element for the NSS’s strengthening , as far as its development and formulation require the interaction and constant participation of entities and institution involved...”, (DANE, 2013f: p.8).

¹³ ICA is the entity attached to MADR that works for the agricultural health and the safety in the primary production of businesses regarding the Colombian agriculture.

containing the information on the development of agricultural and livestock activities. In addition, as explained, unions of the main agricultural products carry out statistical operations. This way, information related with sugar cane, panela cane, cotton, coffee, cocoa and palm oil is obtained. In the livestock part, information on cattle, pigs and poultry is produced.

Table 1. The counting of statistical operations on the agricultural sector, by each production entity.

Entity	Agriculture	Livestock	Forestry	Fishing / Aquaculture	Agriculture / Livestock
Departamento Administrativo Nacional de Estadística – (<i>National Administrative Department of Statistics</i>) - DANE	-	1	-	-	4
Ministerio de Agricultura y Desarrollo Rural – (<i>Ministry of Agriculture and Rural Development</i>) MADR	-	1	1	1	1
Autoridad Nacional de Acuicultura y Pesca – (<i>National Authority on Aquaculture and Fishing</i>) Aunap	-	-	-	1	-
Instituto Colombiano Agropecuario – (<i>Colombian Agricultural Institute</i>) ICA	4	5	-	-	-
Bolsa Mercantil de Colombia (<i>Colombian Mercantile Exchange</i>)-BMC	-	-	-	-	1
Confederación Colombiana de Algodón – (<i>Colombian Confederation of Cotton</i>) Conalgodón y MADR (*)	1	-	-	-	-
Federación Nacional de Arroceros – Fedearroz y DANE (*) (<i>National Federation of Rice Growers</i>)	1	-	-	-	-
Total	6	7	1	2	6

Source: DANE (2013)

(*) Statistical operations carried out together with public entities and unions.

The PES (DANE, 2013f) indicates that the MADR highly contributes to the national statistics, especially with the Evaluaciones Agropecuarias Municipales (*Municipal Agricultural Evaluations*) – EVAS, whose strength is to provide data with levels of municipal desegregation. EVAS are carried out since 1972 and covers information on area and production of transition crops in a year, semi permanent and permanent basis. These also provide data on livestock, fishing and aquaculture sector. In terms of data collection, the sources of information for EVAS correspond to the local authorities and the technicians from the Secretarías de Agricultura Departamentales y las Unidades Municipales de Asistencia Técnica Agropecuaria (*Departmental Agriculture Secretariat and the Municipal Units of Agricultural Technical Assistance*) – UMATAS, which by consensus inform to MADR about the

evolution of the agricultural and livestock activities in their municipalities. Even though the MADR strengthens EVAS by means of the use of systems of geographic and participating mapping, the lack of statistical compliance and the use of subjective techniques make difficult data comparability, given the methodological differences in respect with the other surveys carried out by entities and unions.

In the same way, PES (DANE, 2013f) points out that the MADR in association with the *Autoridad Nacional de Acuicultura y Pesca (National Authority on Aquaculture and Fishing)* – Aunap, provides the fishing and the aquaculture information of the country. Nowadays, the measurements of general aquaculture activities and the fishing volumes landed are available. It is important to clarify that the thematic and geographical coverage, the improvement in the quality of the information and the creation of historic series are topics to be treated in future plans for the improvement of such statistics.

Likewise, MADR provides the forestry information from different sources. In this case, it is supported by the information from the Ministry of Environment and Sustainable Development – MADR and the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM). This entity provides data on forest plantations and their production, as well as for forest reserves; however, the geographic coverage, the continuity and the compliance are aspects to be strengthened. In relation with data on forest plantations with commercial purposes, the MADR deals with the record of the *Certificado de Incentivo Forestal (Forestry Incentive Certificate)* – CIF and the *Ventanilla Única Forestal - VUF (Forestry One-stop Service)*, enabling the interaction of forestry information in the country (DANE, 2013f).

On the other hand, livestock information is provided by different sources. In accordance with the PES (2013), unions concerning cattle and pigs carry out data production exercises in an independent basis, with no coordination with the census of species of animals developed by ICA, neither with the livestock modules for the ENA and the ESAG carried out by DANE. In this sense, differences can be seen in the figures presented by such sources.

Meanwhile, information obtained from statistical operations carried out by unions is produced in response of their objectives and occasionally may help to fill the lack of information in the sector; and even though such information is considered as of good quality, it only covers the union producers. Although data with departmental and municipal disaggregation is produced, databases are private; therefore the use of information is limited. In any case, the results of these investigations are used by official entities for carrying out consistency and coherence analysis, as well as of sectoral context (DANE, 2013f).

In conclusion, public and private organizations in charge of the statistical information on agricultural sector share the responsibility of producing agricultural statistics in Colombia. In this case, the sector's lead entity is the MADR and the statistical entity is the DANE. The MADR receives the support of related bodies in terms of issues such as: health care, land and fishing; likewise, such lead entity is supported by production unions.

2.5. The strengthening of agricultural sector's continuous statistical operations carried out by DANE

In Colombia, DANE carries out the most important surveys investigations on this sector. Some aspects to be strengthened in each one of the operations led by such entity are mentioned as follows:

- a. National Agricultural Survey – ENA¹⁴. The main aspect to improve is the updating of the sampling framework, with which it is expected to improve the coverage of some products' results which are disseminated provides for calculating the agricultural GDP.
- b. Survey of Livestock Slaughtering –ESAG¹⁵. Among the factors that contribute to the ESAG's strengthening we have the permanent updating of the sampling framework and the sample expansion, in order to provide disaggregated information at departmental level. Moreover, this survey aims to include questions enabling the establishment of the age range of slaughtered cattle in the country.
- c. National Survey of Mechanized Rice – ENAM¹⁶. This survey needs a modernization of mobile capture devices in which the information is collected; this way facilitating the data quality verification and the monitoring, tracking and control applications of the survey.
- d. Agricultural sector's Supplying and Price Information System – SIPSA¹⁷: Due to its recent transfer to DANE, the strengthening of methodological and consistency aspects of information have been possible. The aspects to be improved correspond to the sample extension concerning the module of prices for dairy raw milk, the coverage expansion regarding the food supplying module, the perfection of the data capture device concerning the module: Inputs and Factors Associated to Production, the consolidation of the System's Information dissemination by means of computer tools, and the reconstruction of prices' historical series.

With the above mentioned list of investigations, it is possible to understand the agricultural sector's importance and the need for consolidating the Agricultural Statistical System through the framework produced by the Third National Agricultural Census CNA. This fact would enable to strengthen and improve the existing operations, to optimize resources, to complement efforts and also to design and implement new investigations in order to fulfill the needs of information which are not covered yet.

In view of the above, the PES (DANE, 2013f) studied in detail the unsatisfied needs of the sector's information, concluding that DANE should apply the Third CAN in a short term and also propose, design and implement a survey on the costs of production, so enabling the identification of values per agricultural product in their unproductive and productive stages, the operational costs (inputs, materials, services, fuel, infrastructure maintenance, transport, animal and plant health, organic and

¹⁴ ENA produces estimations on the use of soil, sowing areas of transition and permanent crops, cultivated areas, production and performance of transition and permanent crops, areas sowed with pastures, fodder and forestry, amount of total plants and productive age of scattered trees, carries out an inventory of bovine animals and swine regarding productive purposes, sex and age at national and departmental levels, and the amount of heads of other livestock species by sex, volume and the destination of bovine milk production the day before the interview. Finally such survey inquires and carries out the estimations of other study variables such as (irrigation, fertilization and commercialization).

¹⁵ Its objective is to provide information disaggregated by sex, standing and carcass weights of slaughtered cattle as domestic as foreign destination. Likewise, it measures the production of livestock activity in terms of meat extraction by sex, origin and destination of slaughtered cattle as well as it contributes to establish the main destinations of the meat consumed in the country.

¹⁶ The purpose of this survey is to estimate the sowing areas as well as the production and performance of mechanized rice crops (irrigated and upland rice) each six months in Colombia. ENAM is carried out together with DANE and the union FEDEARROZ, where the first entity provides support in the survey's statistical and conceptual design, as well as the information processing; whereas the union is in charge of the field operations.

¹⁷ SIPSA provides information on the wholesale prices' behavior, the food supplying and information of retail prices of inputs and factors associated to agricultural production; through the data collection in the country's main wholesale centers, the cities' entrances and in stores specialized on the selling of inputs. Such system reports on the wholesale prices of food and their variations concerning the preceding period (daily, weekly and monthly) for the 61 country's wholesale centers, panela prices in 9 regional markets, information of the dairy milk's Price in 189 milk producer's municipalities, rice prices at mills for 27 municipalities and meat in 7 slaughterhouses. Likewise, the food volume that enters to 13 wholesale centers the loads go through 23 vehicle traffic controls.

inorganic fertilizer, interests, taxes and workforce) and finally fixed costs such as land, infrastructure and equipment.

Finally, PES (DANE, 2013f) identified that DANE should produce, in a medium and long term, information on the employment state in the rural sector, the workforce's productivity, as well as on the state of environmental resources within the agricultural activity; for understanding phenomena such as: climate variation and its effects in the agricultural production and food security; similarly, the use of water resources, soil degradation, deforestation and the use of fertilizers and agro-chemical products.

3. Analysis of the statistical methodologies for the development of SEA (*Agricultural Statistical System*) in Colombia

The World Programme for the Agricultural Census (FAO 2007) suggests the planning of an integrated system of agricultural statistics in which the main module corresponds to the Agricultural Census, whereas the supplementary module is the program of agricultural surveys that are formulated from such census. This last module should be developed through the use of sampling methods or with a combination of them.

In accordance with Nusser y House (2011), the production of statistics for the agricultural sector represents challenges in term of complexity, diverse nature of target population and the type of information that this sector requests. Such challenges are related with : (i) the use of adequate methodologies for the different sampling units (ii) the selection or updating of an efficient and complete sampling frame, (iii) the handling of changes in the observation units whose trend can be consolidated as big agricultural units that can be divided into smaller units, taking into account the corresponding changes in the limits of land use both cases, (iv) the handling of low response rate in the surveys, (v) the production of efficient and consistent estimators, compatible with the administrative records and other supplementary sources of information (vi) the optimal identification of all population units through geo-referential methods (viii) production of information on farmers who are located in small geographical areas and work at the production of specialized goods, (viii) the provision and analysis of information which is required due to the growing demand of specialized investigators and users, so allowing the full access to data bases and their use by means of technological tools, and (ix) the assurance of confidentiality of information and sources¹⁸.

In view of the above, sampling methods in agricultural investigations can be directly or indirectly attached to the land use. In a direct manner because such investigations contributes to know the state of variables such as: amount of production within the area; whereas in an indirect manner because these makes easy the understanding of auxiliary variables such as: the implementation of conservation practices, or the behavior of environmental factors, inter alia.

3.1. Sampling of area frames

According to Nusser y House (2011), the sampling of area frames¹⁹ have been widely used in agricultural surveys. Such technique enables to directly sample land units through multiple-staged and

¹⁸ In addition, the production of agricultural statistics in Colombia have to confront current challenges such as: the implementation of Income Generation Policies in Rural Population, the Increase of Agricultural Competitivity, The Extension and Diversification of Domestic and Foreign Markets, the Equity in the Regional Development, The Management of Agricultural Risks, The Integral Policy OF Lands, as well as the factors associated to the internal armed conflict inter alia.

¹⁹ Holland (2011) points out that area frames correspond to a set of land segments which are divided by means of physical limits, enabling the identification of exploitations, crops and animals within each segment. Such frames are created by using digital maps, aerial photographs or satellite images, in which the surface is divided in strata regarding the land use and the aptitude for agricultural production, and a sample

stratified designs. The major advantage of using area frames is that they provide a complete coverage of the area under study, being more efficient in the sampling design, and therefore in data collection. The measurements obtained as from their use, as consequence, are directly correlated with the area of observed units. However, area frames usually have extensive sampling errors, in special when rare phenomena are being measured.

In Colombia, the ENA is the only survey which was designed by taking into account area frames. This survey is carried out each six months through probability sampling and data are disseminated in an annual basis. Bearing in mind the advantages that could be taken by having an area frame, ENA could be strengthened by updating the frame -task which has been partially carried out with the support of both the geographical computerized systems from the Geographical Institute Agustín Codazzi (IGAC as its acronym in Spanish), and field trips carried out by the ENA staff. However, the need for applying the third National Agricultural Census CNA is clearly evidenced; due to this represent the central component of the integrated system of agricultural surveys and an important input for updating the frame with which ENA is carried out. In this regard, from the results obtained from CNA, the National Agricultural and Livestock Survey ENA would have to optimize its sampling design, to extend both its coverage for the estimation of products and its scope concerning aquaculture, livestock and forestry sub- sectors, to overcome its geographical coverage limitations and to construct continuous series of information.

A second use of area frame's sampling in the Agricultural Statistical System, could be identified as the design of a survey that permits the monitoring of land conditions and of the inventory of natural resources. Such exercise, apart of coverage and land use, would enable to collect data regarding the soil erosion, the diversity of habitats, the conservation practices and other natural resources' attributes. The Natural Resources Inventory of United States – proposed by Goebel and Baker (1982)- referenced in Dayton, Herrick, Pierson, Pellant, Pyke (2003), is a clear example of the design of area frames' sampling (stratified at two levels); in which the primary frame was obtained as from the use of remote sensing and is periodically updated with sub-samples that are visited on field. In terms of levels, the first one is selected from the political-administrative division of the country, whereas the second level is selected in function of either the variables of interest of each state (department) or the diversity of geographical domains. In this type of sampling, the segments are square-shaped – 1, 6 km each side-; however these could be smaller or bigger depending on the land characteristics. Furthermore, the sampling ranges between strata and the randomness are restricted for so assuring a better geographical coverage and obtaining in detail, information on the survey's variables of interests.

Another potential application of the area frame's sampling methodology in the Agricultural Statistical System corresponds to the development of the Inventory of commercial forestry holdings. According to Bechtold, McRoberts, Patterson, Reams, y Scott (2005),- who were investigators from U.S Department of Agriculture Forest Service-, forestry inventories should be periodically carried out for evaluating the factors related with the change of soil use, trees growing and mortality, and the absorption among inventories. In terms of sampling, such investigation is carried out by stages for stratifying the land

for each stratum is selected. Area frames are used by selecting a sample of segments which are usually kept for a period of 5 years, and then are rotated in a 20% of the sample each year. This tool permits to have information on all exploitations with a surface within segments; moreover, the results of this can be expanded by using the probabilities of selection based on the land surface. Furthermore, areas include and cover all segments. Each area should be provided with available cartographic material and permanent limits between the updating moment and the field work should be also defined. The cartographic aspect of each area is the primary factor concerning this type of sampling. The application of this technique is useful due to it enables to have a total coverage, less non sampling errors and contributes to the estimation of products which are regularly generated. This is a versatile tool with a wide useful life; however this frame has disadvantages such as: (i) their construction and utilization may be expensive, (ii) it is difficult to estimate the behavior of special products, (iii) they are sensitive to data which is out of range, which means that such frames need of clearly-defined physical limits.

surface under study, using auxiliary data such as satellite images or aerial photographs and intensifying the accuracy of measurements regarding the crops' health state, the existent biological diversity and the environmental wealth.

It should be also added that the use of technological tools supports the sampling methodology by area frames. The availability of aerial photographs, remote sensing and satellite images complement the information of sampling units and permit the sample selection in a specific basis. In Colombia, progress has been made in terms of the conversion of actual area frame's sampling segments to digital analogue formats. Specific points have been geo-referenced within primary sampling units, and the updating of stratification of such units by means of satellite images have been carried out.

3.2. Sampling of list frames

The sampling of list frames is also considered as relevant for the SEA²⁰ consolidation. Although the area frame's sampling methodology has been used for measuring the performance of small and medium producers (who comprises the relevant population in the country's rural area), the list frame's sampling can be focused on evaluating the agricultural holdings with business purposes. The use of list frames allows the application of well-recognized sampling methodologies, including the simple random sampling, systematic sampling, stratified sampling, probability proportional to size, multivariate probability proportional to size and permanent random number²¹.

In the country, producers' unions and associations count with lists of business producers which can be used as list frames, provided that these have detailed information in order to increase the accuracy of estimations as from the stratification of such lists. Likewise, administrative records managed and systematized by public entities or unions, as well as the lists of users of projects on agricultural and social development may be useful for creating list frames.

In accordance with Nusser y House (2011) major producers should have a bigger representation in the samples created from list frames in comparison with small farmers, given that major producers have a most important participation in the production. Nevertheless, conglomerations in the sample shall be avoided for ensuring the production of estimations of all products under study. In these cases, stratified sampling should be defined, primarily by the product of interest and then by the size of agricultural holdings. In the case that agricultural units have different crops, each unit should be included in more than one stratum, giving more priority to those products which are less common. This is an effective system, when a minimum amount of products are evaluated; however, when lots of crops are obtained, stratification becomes more complex. Here, the Poisson's sampling method developed by Kott and Bailey in 1997 is recommended, which is based on the creation of multiple list frames that are partially overlapped.

²⁰ Holland (2011) defines list frames as a base containing data that identify, locate and contact the producers and agricultural enterprises. Such frame is created by contacting the organizations and unions of farmers, by consulting lists of agricultural programs, through compulsory records at departmental and municipal level, by means of lists of other government or private entities, by updating the information of surveys or through the application of the Agricultural Census. This frame is used through the lists classification for identifying producers and/or agricultural enterprises that may provide relevant information. Subsequently, a stratification or grouping of similar units regarding the size or the amount of variables to be measured is carried out; then, the sample selected i.e. the units within each group are selected and the survey is carried out. Among the advantages involved in this type of frame, we have: data reporting by using the selection probabilities, the use of low-cost collection methods, the analysis of specific or rare products and the reduction of variability generated due to the sampling exercise. However, regarding the frame's disadvantages, the following are highlighted: list frames do not cover the total population, become rapidly outdated; it increases the non sampling errors because of the data collection methods and therefore needs of permanent maintenance.

²¹ In order to know more on these sampling techniques by means of list frames, it is required to develop a more deep and punctual investigation for each case.

Given the data collection methods, it is known that these may vary in function of the observation unit, the type of complexity of the information to be collected, the available time for data collection and the budget considerations. In the case of business agricultural producers, surveys applied via internet – on the website- are considered as an excellent alternative for capturing information, provided that awareness-raising and training processes are previously carried out, this way making easy the understanding of the survey's questionnaire.

On the other hand, in relation with the operations which are currently carried out by DANE, the SIPSA's module of dairy raw milk prices requires an updating and a complementation of the current list frame, which is stratified by the size of the dairy herd, the milk production volumes and milk production regions. In addition, such frame should be unified with the list of milk producers which is managed by the livestock union – FEDEGAN, for restoring the sampling design and unify the estimation of volume of milk produced nationwide. This same frame can be fed with auxiliary information from the processing industries or cooperatives that buy milk in the country.

Recently, the Survey of Livestock Slaughtering (ESAG) updated the frames of the centers intended to livestock slaughtering in the country, in finding the coverage expansion that enables to provide information at departmental level, facilitating the analysis of this sub-sector. It is important to remember that ESAG collects information by means of a web-questionnaire; as a result, the coverage expansion was efficient in terms of costs and results.

Likewise, list frames that update products relevant for unions such as flowers, potatoes, palm oil, corn, cocoa, plantain, panela cane, rubber inter alia are analyzed by DANE for defining sampling designs that facilitate or improve the statistical data production of such institutions. In this sense, the fact of replicating the exercise carried out together with FEDEARROZ - in which DANE provides support to the ENAM's statistical and conceptual design, and to the information processing; whereas FEDEARROZ carries out the field operation-, would represent an important step forward in the SEA, by ensuring the application of statistical methodologies that encourage comparability and also assure data quality. In the same way, this approach can be adjusted and serve as complement to the future research that DANE will carry out i.e. the survey on Costs of Agricultural Production²².

3.3. Sampling of mixed frames

The use of combined sampling frames – list and area frames- in a statistical investigation or survey corresponds to the methodology of mixed sampling frames, which is considered as a manner for taking advantage of the strengths of both frames. In accordance with Holland (2011), by means of this methodology, sample is selected by a listing exercise and by areas; then, data are collected from the units selected in both frames, this way determining if agricultural holdings in the sample by areas are also included in the list. As a result, data in the sample by list and the information on agricultural holdings of the sample by area that are not included in the list can be expanded, by using selection probabilities.

In accordance with FAO (2007), the sampling of mixed or dual frames is highly used in agricultural survey, especially for household sector. "... Its main advantage is the easy and cheap creation of lists of agricultural holdings only in the selected areas, instead of making it in the entire country. Data

²² Bearing in mind the design of statistics on costs of production, alternatives such as the implementation of longitudinal surveys should be evaluated. This technique would help to define how changes in cultural practices of certain groups of producers contribute to improve their results in specific periods of time. With such type of studies, a monitoring of costs of production during each of the stages of a given crop could be performed.

collection is also cheap because sample units are conglomerated in the selected areas, instead of being spread in all the country's territory..." (p.68). Moreover, another advantage consist in the jointly way in which frames cover the target population. Given that it is a sampling method, variability can be controlled; in addition, such methodology enables the study of special or rare products.

However, this methodology has weaknesses. For instance, it can be difficult to identify overlapping in the frames, producing bias in the estimation if such overlapping is incorrect. Therefore, lists and areas frames should keep updated in an independent manner.

Nusser y House (2011) points out that the frames combination is effective bearing in mind two aspects: A complete and well developed list of agricultural enterprises supported by auxiliary information can provide an effective sample; even though it sometimes may provide incomplete data. For its part, an area frame may be ineffective for specific data collection, but it contributes to have a more complete coverage. In this way, by using dual frames estimations from the domains' overlapping are weighted by the inverse of the standard error of each frame. In other words, standard errors provided by an area frame are considerably bigger than in a list frame. Consequently, with the domains' overlapping, the error is estimated almost in exclusive way since the list frame.

In Colombia, progress should be made in the use of sampling of dual frames for producing information on employment in the rural sector (and other variables), using a household sampling framework. This can be achieved through the design of a particular survey that inquires on the workforce occupation in the rural area, or by the extension of the employment modules in the Great Integrated Household Survey (GEIH) which are applied in rural households. Some inquiries have been brought up on the contribution of woman, youth and elderly workforce, child work or the non agricultural workforce. Food security in the rural context is another survey option which can be designed as from the use of this methodology. In any of both cases, it is expected that the third CAN provides the framework of households and agricultural holdings in the country.

In addition, the methodology of mixed frames can be useful concerning the improvement of measurements of bovine inventory which are carried out in the country. One approximation to the sampling design can be consulted in the World Programme of Agricultural Census 2010 (FAO, 2007: p.69).

3.4.Statistical estimations for the agricultural sector

Statistical estimations comprise the processing of information, imputation, weighting and the estimation of parameters and variances. As in a common survey, estimation methods depends on the objectives previously defined. The most common estimations for the agricultural sector has to do with production forecasts which are complex due to these require the integration of information from surveys and administrative records – data usually obtained by using different methodologies in different periods of time.

Bearing in mind the high dependency of agriculture to factors impossible to anticipate and control such as climate or diseases; uncertainty can be handled by using production forecasts. This information is useful for producers, traders and other agents involved in this sector. For instance, producers should use forecasts for planning their harvest strategies, storage and distribution. Likewise, traders as well as agro-industries require forecast information for making logistics decisions. In this sense, records of meteorological seasons are relevant for carrying out reliable and timely forecast exercises.

In Colombia, further work on the use of statistical methods that go beyond production predictions²³ is needed i.e. microdata and administrative records' assembling techniques which by engaging a simple analysis, these generate statistical routines and analyze the products' behavior in terms of exports, imports, needs for storage, raw material availability for agro-industry and market purposes, balance sheets' calculations, among other type of analysis.

Finally, for the case of ENA, regarding the use of SIPSA's food supplying database, estimations of the marketing margins along the agri-food chain have been undertaken in Colombia. In the same way, SIPSA has the challenge of recovering the historical series of wholesale prices by using estimations that combine the current price information, with the historical consumer and producer price indices – PPI/CPI, the ENA's information of production and the analysis carried out by the DANE's Direction of Synthesis and National Accounts.

Table 2. Summary of statistical methodologies useful for the Agricultural Statistical System (SEA)

Methodology	Definition	Main advantage	Main disadvantage	Current use in Colombia	Use in the Agricultural Statistical System (SEA) in Colombia
Area frames sampling	Set of land segments which are divided by means of physical limits, enabling the identification of exploitations, crops and animals within each segment.	It enables to have a total coverage, less non sampling errors and contributes to the estimation of products which are regularly generated.	High costs, (ii) it is difficult to estimate the behavior of special products, they are sensitive to data which is out of range, which means that such frames need of clearly-defined physical limits.	National Agriculture/Livestock Survey – ENA.	<ol style="list-style-type: none"> 1. Strengthening of the National Agriculture-Livestock Survey – ENA- 2. Design of the Land Conditions Survey and the natural resources' inventory. 3. Design of the Commercial Forestry Operations' inventory
List frames sampling	It's a base containing data that identify, locate and contact the producers and agricultural enterprises.	It enables: data expansion by using the selection probabilities, the use of low-cost collection methods, the analysis of specific or rare products and the reduction of variability generated due to the sampling exercise.	Such frames become rapidly outdated; it increases the non sampling errors and therefore needs of permanent maintenance.	<ol style="list-style-type: none"> 1. SIPSA's module of prices for dairy raw milk. 2. Livestock Slaughtering Survey–ESAG. 3. Surveys and investigations from unions and associations of producers 	<ol style="list-style-type: none"> 1. Updating and complementing the list frame used in the SIPSA's module of prices for dairy raw milk. 2. Updating of the frame of centers involved in livestock slaughtering –ESAG. 3. Strengthening of surveys on products such as: flowers, potatoes, oil palms, corn, cocoa, plantain, panela cane, rubber.
Mixed frames sampling	The use of combined sampling frames – list and area frames- in a statistical investigation or survey.	<ol style="list-style-type: none"> 1. Provides an efficient sample, allowing a more complete coverage. 2. Data in the sample by list and the information of the sample by area that is not included in the list can be expanded, by using selection probabilities. 3. Its 'creation and application is easy and cheap. 	<ol style="list-style-type: none"> 1. It can be difficult to identify overlapping in the frames, producing bias in the estimation. 2. Ineffective to be applied in the collection of very specific data. 	National Survey of Mechanized Rice – ENAM.	<ol style="list-style-type: none"> 1. Design and implementation of surveys on both employment in rural areas and food security. 2. Improvement of the conditions of bovine inventory.

²³ Nowadays, only the production of some transitory crops is predicted in order to calculate the quarterly GDP

		<p>4. Cubren mejor la población objetivo, al ser un muestreo que puede controlar la variabilidad.</p> <p>5. Such frames cover in a better way the target population, given that it is a sampling method where variability can be controlled.</p> <p>5. It enables the study of special or rare products.</p>			
Statistical estimations	Consists on the processing of information, imputation, weighting and the estimation of parameters as well as variances.	It's application is cheap.	These require the integration of information from surveys and administrative records – data usually obtained by using different methodologies in different periods of time.	<p>1. Estimation of the production of some transitory crops in order to calculate the quarterly GDP.</p> <p>2. In the ENA's research, estimations of the marketing margins have been undertaken regarding the use of SIPSA's food supplying database.</p>	<p>1. The analysis of the products' behavior in terms of exports, imports, needs for storage, raw material availability for agro-industry and market purposes, balance sheets' calculations, amongst other.</p>

4. Conclusions

The need for high quality information for the agricultural sector is fundamental to engage the sector's development in all its contexts. Best analysis should come from the combined use of information derived from the implementation of surveys with adequate statistical methodologies. The planning of an integrated system of agricultural statistics -in which its main module correspond to the Agricultural Census, and the supplementary module is the program of agricultural surveys- is the strategy followed by Colombia for strengthening its Agricultural Statistical System (SEA), understood as a long term stable system that produces quality information for the agricultural sector in Colombia.

The DANE is the major sector's statistics supplier which is currently preparing the Third National Agricultural Census -3rd CNA-, and is also planning both the strengthening of its continuous statistical operations and the design and implementation in a short, medium and long term of new investigations. As from the use of all sampling methodologies previously analyzed (area, list and mixed frames, and statistical estimations), DANE has identified the methodological alternatives which can be applied for the SEN's configuration.

References

- Acosta, S. y Pérez, J. (2011). El Sistema Estadístico Agropecuario Colombiano Bajo una Nueva Conceptualización. En *Revista IB de la Información Básica Estadística* (pp.184-206). Bogotá: CANDANE.
- Bechtold, W., McRoberts, R., Patterson, C., Reams, G. Scott, C. (2005). The Enhanced Forest Inventory and Analysis Program of the USDA Forest Service: Historical Perspective and Announcement of Statistical Documentation. Recuperado el 18 de junio de 2013 de <http://naldc.nal.usda.gov/download/40665/PDF>
- Comisión Económica para América Latina y el Caribe [CEPAL] (2009). Sistema de Cuentas Nacionales 2008. Recuperado el 16 de julio de 2013 de <http://www.eclac.cl/cgi-bin/getProd.asp?xml=/deype/publicaciones/externas/1/50101/P50101.xml&xs=/deype/tpl/p54f.xsl&base=/deype/tpl/top-bottom.xsl>
- Dayton, B., Herrick, J., Pierson, F., Pellant, M., Pyke, D., Shaver, P., Spaeth, K. y Thompson, D. (2003). *New Proposed National Resources Inventory Protocols on Nonfederal Rangelands*. Recuperado el 7 de junio de 2013 de http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1045659.pdf
- Departamento Administrativo Nacional de Estadística [DANE] (2013a). Metodología de las Cuentas Trimestrales -CT Base 2005. Recuperado el 16 de julio de 2013 de http://www.dane.gov.co/files/investigaciones/fichas/Cuentas_trimestrales_b2000_05_13.pdf
- Departamento Administrativo Nacional de Estadística [DANE] (2013b). Boletín de Prensa, Cuentas Nacionales Trimestrales - Producto Interno Bruto, Segundo trimestre - Septiembre de 2013. Recuperado el 16 de septiembre de 2013 de http://www.dane.gov.co/files/investigaciones/boletines/pib/bolet_PIB_IITrim13.pdf
- Departamento Administrativo Nacional de Estadística [DANE] (2013c). Comunicado de Prensa, Encuesta Nacional Agropecuaria. Recuperado el 16 de julio de 2013 de http://www.dane.gov.co/files/investigaciones/agropecuario/ena/cp_ena_2012.pdf
- Departamento Administrativo Nacional de Estadística [DANE] (2013d). Metodología General Encuesta Nacional Agropecuaria – ENA. Recuperado el 2 de agosto de 2013 de http://www.dane.gov.co/files/investigaciones/fichas/Metodologia_ENA_13.pdf
- Departamento Administrativo Nacional de Estadística [DANE] (2013e). Boletín de Prensa, Sacrificio de Ganado I trimestre de 2013. Recuperado el 2 de agosto de 2013 de http://www.dane.gov.co/files/investigaciones/boletines/sacrificio/bol_sacrif_IITrim13.pdf
- Departamento Administrativo Nacional de Estadística [DANE] (2013f). Plan Estadístico Sectorial de Agricultura, Ganadería, Silvicultura y Pesca 2012 – 2015. Bogotá: DIRPEN.
- Food and Agriculture Organization of the United Nations [FAO] (2007). *A System of Integrated Agricultural Census and Surveys*. Rome: Communications Division FAO.

Gutiérrez, J. (2009). La Estadística Estratégica Del Sector Agropecuario En Colombia: Un Nuevo Modelo De Oferta. Recuperado el 2 de agosto de 2013 de http://www.dane.gov.co/revista_ib/html_r6/articulo3_r6.html

Holland, T. (2011). Construcción y Utilización de los Marcos de Muestreo por Áreas para Censos y Encuestas Agropecuarias. Recuperado el 10 de junio de 2013 de http://www.fao.org/fileadmin/templates/ess/ess_test_folder/Workshops_Events/Workshop_Montevideo/Programa.pdf

International Bank for Reconstruction and Development (World Bank). Food and Agriculture Organization of the United Nations (FAO), and United Nations (UN) (2012). Global Strategy to Improve Agricultural and Rural Statistics. Washington D.C: World Bank.

Nusser, S. y House, C. Sampling, Data Collection, and Estimation in Agricultural Surveys (2011). En D. Pfeffermann y C. RAO (Ed). *Essential Methods for Design Based Sample Surveys* (pp.161-176). Great Britain: North Holland Publications.