



A Framework for Data Collection and Management to Support the Comprehensive Development of African Agriculture

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Authors' contributions

This work was carried out in collaboration among all authors. Author TAK designed the paper, performed data analysis, and wrote the first draft of the manuscript. Authors GND and COEAD completed the literature search and data collection activities and contributed to the design of the draft of the paper. Author AM is a GIS specialist who contributed to the reflection and the design of the proposed framework. Authors RCT and DSV participated in the design of the paper and the review of the drafts. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAEES/2024/v42i22369

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/112949>

Policy Article

**Received: 01/12/2023
Accepted: 05/02/2024
Published: 08/02/2024**

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ABSTRACT

Agriculture is a key source of food and health for humanity. However, the hazardous way this activity is still cared for in some developing countries like the Republic of Benin, with poor quality farming data collection mechanisms, can guarantee neither quality and sustainability of production, nor comprehensiveness and efficiency of agricultural interventions. Such shortcomings ineluctably contribute to the limited success of the Comprehensive African Agriculture Development Program (CAADP) promoted by the African Union and its regional chapters, in most African countries. Based on these preliminary remarks, this paper suggests a systematic and automated monitoring, evaluation, learning, and adaptation (MEL) framework that will further be tested, consolidated, validated, and promoted, first in the Republic of Benin, and later in other African countries. This framework is made of local, regional, and national geographic information systems (GIS) which will further serve as databases for planning and interventions in the agricultural sector. The proposed GIS superposes lands' details (sizes, soils' characteristics, rainfall data, etc.), stakeholders' details (demographics, crops, livestock, agricultural practices, etc.), and agricultural value chains' details. Local, regional, and national agricultural value chains' development platforms will bring stakeholders together, and serve as sources and co-users of the GIS data. Local, regional, and national MEL and GIS management skilled AEAS agents will facilitate systematic data collection and GIS database management. The data collection and treatment tools should allow the use of all kinds of data formats, including voice and image records, given the oral orientation of most agricultural stakeholders. This original idea emerged from observations during national and regional field experiences, and from the literature that revealed the efficiency of automated real-time and quality data for comprehensive and evidence-based decision-making in development interventions.

Keywords: Comprehensive African agriculture development; monitoring, evaluation, and learning; systematization; automation; agricultural extension, advisory services delivery system.

1. INTRODUCTION

Agriculture serves as the basis for the socioeconomic development of most developing, including African countries in the world [1]. Meanwhile, this activity is still poorly cared for in most African countries, including the Republic of Benin [2,3]. Evidence for this poor care comes from statistics and books by the world's Food and Agriculture Organization [4] and from much other literature, comprising those from the African Union (AU). This weakness of the African countries' agriculture development and the imperative to boost investment and results in this socioeconomic sector, brought the AU to design and launch the Comprehensive African Agriculture Development Program (CAADP) under the leadership of the New Partnership for African Development (NEPAD) in 2003 in Maputo and to update and re-launch this program in Malabo in 2014 [5]. Apart from this AU initiative, many other national, bilateral, and multilateral cooperation programs have been designed and implemented in most African countries, with, in general, poor effects on most of the concerned countries' economies. Among other reasons for this poor investment and development of African agriculture, poor political commitment, poor institution crafting and

governance, and poor technical and scientific backgrounds are cited [6-8]. Very rare publications specifically address the role of quality of monitoring, evaluation, and learning (MEL) in the poor performance of African agriculture. Meanwhile, the quality of data collected through MEL mechanisms and used for planning matters for all development projects. This paper fills in this gap, by highlighting shortcomings of the current agricultural extension and advisory services (AEAS) and agriculture-related data collection and management system in Benin, and by proposing a transformative framework for comprehensive and systematic quality agricultural data collection, management, and sharing among agricultural stakeholders in Africa.

2. METHODOLOGY

This article is a policy paper designed based on the authors' field, research, and teaching experiences across Africa, on the literature, and triangulation data collected from some agricultural data collection and management agents in the Republic of Benin. Indeed, the authors got the idea for this paper from their reflections on their intensive interactions with and on the lessons, they derived from – agricultural

extension and advisory services (AEAS), monitoring and evaluation of interventions, geographical information systems, and agricultural decision-making – both through field works, research and teaching across Africa and the world. To reinforce the information obtained from these field experiences, further updated data have been collected in Benin, on agriculture-related data collection and management stakeholders and mechanisms from the websites of key institutions. These institutions are the President's office; the Ministry of Agriculture, Livestock and Fisheries (MAEP); the Ministry of Development and Coordination of the Government's Actions (MDCAG); the Ministry of Industries and Trade (MIC); the Ministry of Economics and Finance (MEF); and the Directorate of Agricultural Statistics. Data collected from these websites relate to the roles played in agriculture management and agricultural data collection, management, and sharing. Semi-structured interviews with AEAS field agents, and ministries and directorates' agents helped triangulate data collected from institutions' websites and authors' field and research experiences. Furthermore, the literature on relevant ways to collect, manage, update, share, and make decisions with agriculture-related data has been consulted and exploited for the identification of the ongoing experiences' shortcomings, and for the design of the framework proposed.

3. RESULTS AND DISCUSSION

This section discusses the current farm data collection and management mechanisms and their shortcomings and proposes a framework to improve the ongoing experience.

3.1 Current Farming Data Collection and Management Mechanisms

Up to date, local, regional, and national agriculture-related data are collected through various more or less independent channels (see Table 1), and as desired by channels' leaders. Existing channels are governmental, financial, and technical partners, non-governmental organizations (NGOs), the private sector, farmers' organizations, and research institutes and universities.

As shown in Table 1, agricultural data collection and management vary according to channel leaders' concerns, although these data relate to interdependent stakeholders, and could be useful

for all the stakeholders. Therefore, a harmonized agriculture data collection and management framework has hardly existed till today. Thus, agricultural interventions have been lacking comprehensive, accurate, and harmonized data needed for effective and sustainable agricultural development. This has been happening as such, not necessarily because agriculture development leaders lack awareness about the importance of comprehensive, accurate, and harmonized data in quality planning and interventions, but possibly because of a lack of commitment to success, leadership, and technical skills [9,3]. This paper aims to contribute to filling this technical reflection and decision gap.

3.2 Shortcomings of the Current Agriculture-Related Data Collection and Management Mechanism

The two main shortcomings identified for the ongoing agricultural data collection and management mechanisms are discussed in this section. They relate to the structuration and linkages among the above-mentioned stakeholders; and to the accuracy and comprehensiveness of the data collected.

3.2.1 Poor structuration and linkages among stakeholders on data collection, storage, and sharing

Agriculture-related data collection and reporting within the Ministry of Agriculture is, to some extent, well-structured from the local (municipality) to the national level, depending on the agricultural commodities. However, the existing structuration is overall still loose with an overload of AEAS and other agents in charge of data collection, storage, and sharing, due to large areas and farmers to handle. For example, the structuration stops at the municipality level, and districts and villages are covered by the municipal agriculture offices (communal cells of the territorial/regional agriculture development agencies), and specific commodity development AEAS agents hardly exist in the public sector extension and farm data collection system. Also, the structuration within national cash crops' value chains is tighter, compared to those within non-cash crops' value chains, because, due to the economic values of cash crops, they are given all kinds of attention by the government and its partners. Meanwhile, non-cash crops are more or less orphans with poor attention from the government and its partners, in terms of extension, data collection, storage, and sharing.

Table 1. Agriculture-related data collection and management stakeholders and their roles in Benin

N°	Stakeholders	Interventions or roles in agriculture	Data collection, management, and sharing strategies
1.	President's office	Overall policy orientations; regulation; financing; supervision; monitoring and evaluation	<ul style="list-style-type: none"> - Diagnoses, surveys, supervision, and M&E reporting for the president and his teams, based on needs; - Given reports availed online for the public or upon request
2.	Ministry of Development and Coordination of Government Actions, and its deconcentrated and decentralized (local, regional, and national) institutes, directorates, and offices	Overall orientation and supervision of policy design; monitoring and evaluation	<ul style="list-style-type: none"> - Periodical censuses, surveys, supervisions, and M&E reporting, upon needs, and government and partners' demand; - Given reports availed online for the public or upon request
3.	Ministry of Agriculture, Livestock, and Fisheries, and its deconcentrated and decentralized (local, regional, and national) institutes, directorates, and offices	Agricultural development (extension, research, governance) policy, programs, and projects - design, implementation, monitoring, and evaluation	<ul style="list-style-type: none"> - Periodical censuses, surveys, supervisions, and M&E reporting, upon needs, and government and partners' demands; - Monthly data collection and reporting by AEAS agents - Given reports availed online for the public or upon request
4.	Ministry of Industries and Trade, and its deconcentrated and decentralized (local, regional, and national) institutes, directorates, and offices	Agricultural industry and trade policy design, implementation, monitoring, and evaluation	<ul style="list-style-type: none"> - Surveys, supervisions, and M&E reporting, upon needs, and government and partners' demand - Given reports availed online for the public or upon request
5.	Ministry of Economics and Finances, and its deconcentrated and decentralized (local, regional, and national) institutes, directorates, and offices	Overall economy and finances policy design, financing, implementation, monitoring, and evaluation	
6.	Researchers and lecturers from research institutes and the education system	Contributions to agriculture-related education and scientific research and innovation policy design, implementation, monitoring, and evaluation	<ul style="list-style-type: none"> - Surveys and reporting among researchers and their partners, and with other non-partners upon request - Given reports and publications availed online and upon request
7.	Financial and technical partners and their deconcentrated and decentralized (local, regional, and national) offices or representatives	Agricultural policy, programs, and projects orientations; design, financing; supervision; monitoring and evaluation	<ul style="list-style-type: none"> - Data collection and reporting among partners and with researchers and other non-partners upon request - Given reports and publications availed online and upon request

N°	Stakeholders	Interventions or roles in agriculture	Data collection, management, and sharing strategies
8.	NGOs and their deconcentrated and decentralized (local, regional, and national) offices or representatives	Programs and projects - design, financing; implementation; supervision; monitoring and evaluation	
9.	Programs and projects and their deconcentrated and decentralized (local, regional, and national) representatives	Programs and projects' design, implementation, monitoring, and evaluation	
10.	Private companies and their deconcentrated and decentralized (local, regional, and national) representatives	Orientation, financing, and supervision of companies' policy design; financing; implementation; monitoring and evaluation	
11.	Farmers' organizations, and platforms and their deconcentrated and decentralized (local, regional, and national) representatives	Facilitation, and participation in programs and projects -design, financing, implementation, monitoring, and evaluation	

Sources: *Websites review and interviews, 2023*

As mentioned in the previous section, many stakeholders contribute to data collection, management, and sharing in the agricultural sector. However, up to date, to our knowledge, there are no data collection, management, and sharing memorandum of understanding, contract, or obligation among all these stakeholders taken together. There is also no common agriculture data repository where all agriculture-related data may be stored and sourced by users, even if it should be upon specific conditions. The only existing obligation relates to the necessity to get authorization from the Ministry of Development for planning and coordination of government actions, before all large-scale data collection. According to the concerned decree, researchers or data collectors are expected to share reports with the Ministry of Development Planning after completing authorized research activities. Such a decree does not exist specifically for the agriculture sector but for all development sectors of the country. However, in practice and from experience, it is difficult to confirm that this Ministry truly accesses and properly centralizes all large-scale data collected on agriculture in the Republic of Benin.

Thus, with regards to agricultural data, apart from those collected by AEAS agents working for the Ministry of Agriculture, the types of data collected by other stakeholders are not necessarily the same as those from these ministry's agents, and

they are neither centralized nor always easily accessible to potential users.

3.2.2 Poor accuracy and comprehensiveness of data collected

Agricultural data collected within the Ministry of Agriculture and its AEAS system focus much more on technical aspects such as locations, land sizes, crops, livestock, fish species, other commodities or value chains, and yields. Very few standardized details exist on precise geographical references of farms, and farmers' demographics and practices. Therefore, surveys are repeated by all stakeholders for interventions with more and more unprecise details on farmers, giving room for poor quality and inefficient interventions. It follows that most interventions are repeated over time just under varied programs or projects' names by varied or same partners and stakeholders, with poor effectiveness [4,7,8,9]. Meanwhile, with more comprehensiveness, precisions, standardization, and continuity in data collection, use, learning, and adaptation, projects or intervention cycles would gain in efficiency and more and more effective and sustainable development could follow. Doing so, the African Union's comprehensive agriculture development targets [5], could be easily reached in each concerned country.

3.3 The innovative Data Collection, Management, and Use Framework Proposed

Building on the above shortcomings, this paper proposes a much more structured, systematized, and automated monitoring, evaluation, learning, and adaptation framework.

3.3.1 Proposed structuration for agriculture-related data collection

To improve the existing structuration, the paper suggests that all agriculture-related data be collected along commodities or value chains, with at least partly standardized indicators. To this end, we propose the creation and careful management of village, district or *arrondissement*, municipality or *commune*, region or *Département*, and national levels' agricultural commodity or value-chain development groups or platforms. These platforms may be interlinked with a clear distribution of roles, and their overall functioning must be facilitated by the municipality, regional, and national levels AEAS agents, well skilled, and well incentivized for the completion of quality facilitation, monitoring, evaluation, learning, and adaptation (MEL) activities. The AEAS facilitators may be well-capacitated in MEL and geographic information systems (GIS) management. The MEL and GIS data to be collected may be at least partly standardized and adaptive among villages, districts, municipalities, regions, and the national levels, and they may include technical (commodities, value-chains, practices, lands sizes, inputs, outputs, yields, technologies, etc.), key environmental data (rainfall, soils, watercourses, etc.), interventions data (programs, projects, NGOs, financial and technical partners, beneficiaries, etc.), demographics (names, gender, social status, education, training, professional skills, programs and projects engaged with, etc.), geographical (locations' names, geographic references, etc.) details of each farmer. These data may be collected in all kinds of formats to allow every stakeholder (literate and illiterate people for instance) to be able to contribute to the updating of the data. Local, regional, and national GIS databases may be created, and regularly updated based on dynamics and data collected from the commodity or value-chains development platforms. The functional platforms will serve as tools for systematization and automation of data collection. The setting up of this system may be costly at the beginning given the initial

investment (staffing, training, salary payment, etc.), but it may become very cost-effective in the short term, meaning from the second or third year. The cost-effectiveness of this framework will come from the reduction of the money lost in ill-designed and inefficient agricultural interventions, and also from the automation of data collection and management.

With such a structuration in place, all stakeholders willing to intervene in agriculture may be required to link up with the AEAS system to access existing harmonized and up-to-date data. In case partners wish to collect data that were not available in the GIS databases, they may do so, and conditions to share their data with the data managers may be agreed on.

3.3.2 Creation of and sharing of information on repositories for agricultural data

Apart from the AEAS' GIS databases, other repositories for agricultural databases may be created, known, and linked with, and intervention partners may be required to exploit available data in these repositories in addition to the Ministry of Agriculture's data repository before the design and the implementation of programs and projects. Doing so, interventions' formulations would gain in accuracy, and in effects and impacts, because transparency will be enhanced, and qualities of monitoring and evaluations would improve and allow for increasingly accurate programs and projects' design and implementations. These improvements will surely contribute to desirable changes in the overall development of the Republic of Benin, and of other African countries that will adopt the proposed data collection, management, and sharing mechanism.

3.3.3 Overview of the proposed framework

Fig. 1 presents the proposed transformative data collection, management, and sharing system.

This figure indicates that data collection may happen within commodity or value-chain development platforms or groups under the facilitation of AEAS agents, to feed GIS from level to level. The overlaps among the platforms are to mean that the boundaries may not necessarily be neat, and collaboration among them might take place. In Platform or group n , n corresponds to the total number of commodities or value chains, this means that there may be as many platforms as commodities or value chains in each country. These same AEAS agents are

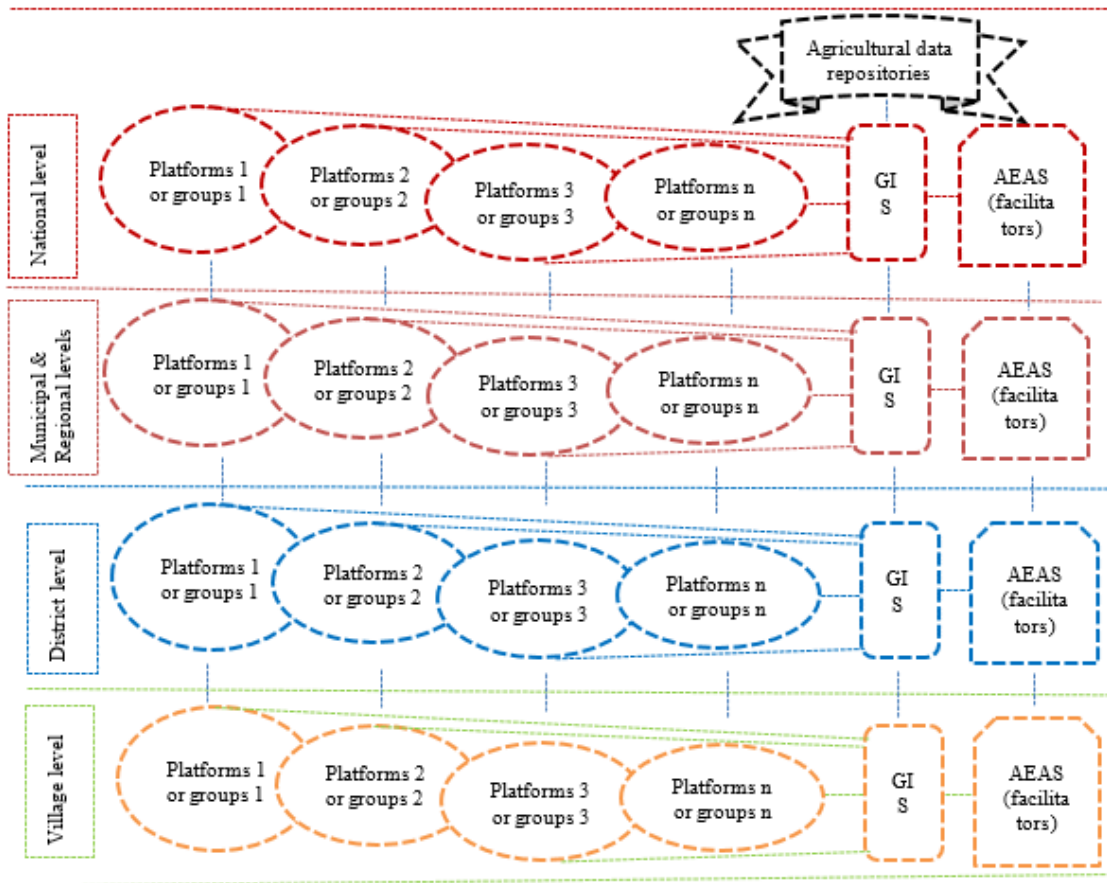


Fig. 1. A framework for systematic, automated, and comprehensive agricultural data collection and management

expected to also facilitate the creation and management of GIS from the village level to the national level. The different levels of GIS should be interconnected so that all data be represented in the national level's GIS. All the GIS will represent repositories for comprehensive and updated agricultural data. Platforms and their members together with AEAS facilitators should automatically contribute to the updating of the databases along with their daily activities.

4. CONCLUSION

This paper discusses the agriculture-related data collection and management system that exists in the Republic of Benin, analyses the shortcomings of this system, and proposes a transformative agricultural data collection and management framework. It built on the authors' field, research, and lecture experiences, on the literature, on websites of key agricultural development institutions, and some triangulation interviews and observations. The findings revealed that agricultural data collection and

management is completed by various stakeholders with uncommon standards, and with poorly harmonized collaboration. Therefore, a lot of money, time, and human resources have been invested in these activities, and programs, projects, and other interventions have been repeated over time, with poor effects on the agricultural development of the country. Based on this assessment, the paper proposes a framework that is expected to contribute to the standardization, systematization, and automation of agricultural data collection, storage, management, and sharing among interdependent stakeholders. This framework is constructed around commodities or value-chain platforms or groups, with farm-level comprehensive data collection, including geographic references. AEAS agents are the extension, the monitoring and evaluation and learning (MEL), and the geographic information system (GIS) facilitators of the framework. Such a layered but interconnected system will be time, finance, and human resources consuming at the beginning, but it should become cost-effective in

the short term because once established, it will become a routine activity that will help reduce the high cost expended for ill-data acquisition, and for inefficiency of each new ill-designed and implemented interventions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:

The peer review history for this paper can be accessed here:
<https://www.sdiarticle5.com/review-history/112949>