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STATE OF KNOWLEDGE OF METHODOLOGIES FOR ESTABLISHING “TYPOLOGIES OF PRODUCTION SYSTEMS”

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ABSTRACT

In sub-Saharan Africa, climatic hazards and land pressure have stimulated a search for production intensification methods, adapted to the various environments and types of farming, in a bid to ensure food security in the region. Indeed, this intensification is conditioned by the availability to farmers of innovations that are adapted to their constraints and priorities. Thus, the adaptation of innovations to the diversity of agricultural production systems requires establishment of typologies that reflect the heterogeneity of farms and make it possible to reduce diversity to a manageable scale. In this article, we reviewed the state of knowledge on methods for establishing “typologies of production systems”, based on existing knowledge, in order to examine the extent to which they enable understanding of this reality of the agricultural economy. Faced with current global challenges, such as population growth and climate change, sufficient food supplies and quality will require more efficient and robust production systems, based on good agricultural practices that ensure efficient use of the natural resource base, and within an enabling policy and institutional environment. Improving production systems for sustainability will, therefore, need to be based on the implementation of relevant recommendations derived from typologies built through science-based robust methodology, combining participatory approaches and quantitative and qualitative data analysis methods, “data mining”.

Key Words: Agricultural economy, data mining, robust methodology, sustainability

RÉSUMÉ

En Afrique subsaharienne, les aléas climatiques et la pression foncière ont stimulé la recherche de méthodes d'intensification de la production, adaptées aux différents milieux et types d'exploitation, afin d'assurer la sécurité alimentaire. En effet, cette intensification est conditionnée par la mise à disposition des agriculteurs d'innovations adaptées à leurs contraintes et à leurs besoins. Ainsi, l'adaptation des innovations à la diversité des systèmes de production agricole nécessite la mise en place de typologies qui reflètent l'hétérogénéité des exploitations agricoles et permettent de réduire la diversité à une échelle gérable. Dans cet article, nous avons fait le point sur l'état des connaissances

concernant les méthodes d'établissement de "typologies des systèmes de production", sur la base de connaissances existantes, afin d'examiner dans quelle mesure elles permettent de comprendre cette réalité de l'économie agricole. Face aux défis mondiaux actuels, tels que la croissance démographique et le changement climatique, un approvisionnement alimentaire suffisant et de qualité exigera des systèmes de production plus efficaces et plus robustes, fondés sur de bonnes pratiques agricoles assurant une utilisation efficace de ressources naturelles, et dans un environnement politique et institutionnel favorable. L'amélioration des systèmes de production pour la durabilité devra donc être basée sur la mise en œuvre de recommandations pertinentes dérivées de typologies construites par une méthodologie robuste basée sur la science, combinant des approches participatives et des méthodes d'analyse de données quantitatives et qualitatives, "data mining".

Mots Clés : Économie agricole, exploration de données, méthodologie robuste, durabilité

INTRODUCTION

The diversity of farming systems in sub-Saharan Africa (SSA) remains a challenge for meaningful agricultural research. Indeed, the question of how to propose innovations and policies that adapt to them, persists in any technological improvement initiative. Faced with this, the identification of current production systems is crucial in order to account for the complexity of the operation of farms and to explain the logic behind them, as the entry point to designing effective interventions (Tittonell *et al.*, 2010). The concept of "agricultural system", particularly production, has gradually become essential for the analysis and understanding of the productive practices of farmers in a context where pluriactivity occupies a preponderant place. In this circumstance, the understanding of the relations which are established between the agricultural production systems and the whole encompassing the system of activities, both from the standpoint of the distribution of the labour force (competition or complementarity), and of that of access to and use of capital, requires beginning the study of the activity system by deciphering the agricultural production system, the complexity of which requires the use of multiple skills.

In SSA, owing to prevalence of climatic hazards, coupled with loss of productivity of agricultural land, there is a drop in crop yields. Moreover, traditional, extensive and poorly mechanised production methods that rely on

traditional seeds and inappropriate use of fertilisers still persist (Frossard *et al.*, 2019). Consequently, the search for an appropriate mode of intensification that can ensure food security, becomes the concern of the various actors in rural and research development. Therefore, it appears that an increase in production requires provision of technologies to farmers that are adapted to their constraints and priorities. It is, therefore, natural to begin the study of the determinism of agricultural production with that of the decisions on the farm, which condition its operation. In fact, characterisation of farms refers to the development of an agricultural typology, which according to Capillon (1993), is set up for the purposes of local technical support policies or to improve knowledge of the dynamics of change of a regional agriculture (Doré, 2006). The objective of this study, therefore, was to clarify on the state of knowledge on the typology of agricultural production systems; and the new challenges to be anticipated in the path to improve the robustness of methods for developing more operational typologies.

Production systems. The production system (PS) is a concept that has existed in French studies since the 19th century. Its definition, whether centered on management or the social character, reveals it as a combination of production factors, technical choices, as well as a combination of production and intra- and inter-production unit exchanges (Reboul, 1976; Brossier, 1987). Thus, the PS with

multidimensional definitions, is interlocked in concepts with different objects, types and scales of analysis. The PS can be defined at farmer or regional scale and may include cropping system and/or livestock system (Cochet, 2011). Tafani (2011) proposed a PS model that fits into the design a territorial meta-system. It is, therefore, a question of seeking to account for the articulation between the geographical space organised by and around agricultural activity, and all the actors of the territory involved in this problem at different scales. In other words, the agricultural PS of a family farm is all the agricultural and para-agricultural activities of the members of the household as well as the interactions between the activities and exchanges between the members of the household; which system contributes to the characterisation of a territory. Thus, to reduce diversity to a manageable scale and explore complexity, typologies remain essential instruments.

Significance of typology of agricultural production system. Due to the multiplicity of parameters on which it depends and the equally complex interactions, the farm proves to be a complex object of study. In order to identify it in its dimensionality, the system approach is favoured in the initiating studies of the systemic modeling of the functioning of agricultural holdings (Perrot and Landais, 1993). Consequently, understanding the diversity of agricultural holdings is based on a typology that allows for identification of fairly homogeneous groups within which individuals have similar characteristics. A typology responds to the need to have a representativeness of the diversity of agricultural situations. It consists of a characterisation of the particularisms observed at the level of a subject of interest whose aspect studied presents a variability (Mbetid-Bessane *et al.*, 2003). The development of a typology in agriculture, therefore, aims to implement local technical support policies and improve knowledge of the dynamics of change in regional agriculture (Doré *et al.*, 2006).

Therefore, each type of system is identified on the basis of a selection of discriminating criteria. Approaches to producing the typologies differ according to the objectives sought, the nature of the data that can be used and the discriminating criteria used to characterise the production systems.

Theoretical framework for establishing the typology. From a theoretical point of view, a stable system is one whose productivity fluctuates little over time (Cochet, 2011). Family farms are considered as systems because their performance could be improved from such a model (Friedmann, 2014). On the one hand, the PS approach, which focuses on understanding systems in order to modify them, has taken shape in France (Cochet, 2011). This approach is holistic and non-prescriptive. It is bottom-up based on farmers' practices and requires a multidisciplinary approach. On the other hand, the Farming System Research (FSR), developed in Anglo-Saxon countries, uses a set of tools developed in the form of a Rapid Rural Appraisal (Cochet, 2011).

This method begins with the collection of general information on the region (secondary data) and an informal pre-survey (exploratory survey). Next, hypotheses are formulated for an initial definition of a 'recommendation area'. Finally, based on these elements, a more in-depth survey (formal survey) is carried out on farms selected at random to describe the PSs of the site studied. In last survey of the previously described method, the PS is apprehended in its aspects supposed to interfere with the crops considered important following the first stage (Elloumi, 1994). Basically, these two approaches seem to have been born in quite different circumstances. However, their evolution to a certain extent has ended up bringing them closer, in particular following their implementation by research institutions in developing countries. In any case, they lead to the construction of typologies of production systems; from identifying the constraints to

formulating appropriate recommendations for each type.

Analytical framework: Approaches and conclusions. There are different methods for establishing typology of PS depending on the diversity of the objectives pursued. We present action-oriented methods, designed as decision support tools for various actors in agricultural development; the systemic approach to the operation of the farm. In fact, this approach is based on two fundamental principles: the first one is considered as a system; while the second one is that of coherence. Indeed, farming can no longer be considered as the juxtaposition of speculations or unrelated activities. On the contrary, it is a set of elements that interact. The evolution of this set is guided by the objectives assigned to it by the members of the family, the head of the farm or the family group, in a given environment (Osty, 1978). Understanding these relationships is important for transforming the whole system, or even one of its elements. "Farmers have reasons for doing what they do." This principle should not be understood as that of a rationality particular to farmers or to a certain type of farmer; it simply stipulates that the understanding of the functioning of the farm and the decisions of the farmer goes through that of the objectives and purposes of the family, purposes which may have internal contradictions that it is up to the farmer to assume through the conduct of its operation. This coherence must be analysed considering situation and environment of the farm household. In addition to the principles, in the application, the systemic approach consists of two major phases on which the quality and operationality of the typology are based; namely the collection and processing of data.

In general, data collection consists of a series of direct surveys using closed questionnaires and/or interview guides applied to a small sample size, in order to optimise time (30 -100 in most cases) (Oka *et al.*, 2021). However, in Anglo-Saxon approaches, the

emphasis is on rapid diagnosis (Brossier, 1987). The advantages of this method are certainly its speed, its low cost, its apparent ease of appropriation by national research institutions (Norman, 1980). But in the majority of cases, it only leads to fairly crude research and development hypotheses that will have to be refined. Moreover, the differences between the proposed methods are essentially based on the nature of the information collected during the survey, and the way in which it is processed. We can distinguish structural typologies and functional typologies according to the conceptual framework in which we are located and the nature of the variables used (Mbetid-Bessane *et al.*, 2003).

Types of structure. The structure typologies result from a fairly rough description of observations based on the means of production available on the farm. They provide a snapshot of farms in a region at a given time. The differentiation criteria are chosen empirically and two methods are often used to construct these typologies; namely the segmentation and multidimensional analysis (Mbetid-Bessane *et al.*, 2003). In segmentation, the discriminating criteria in reduced numbers are chosen one by one, gradually, starting with the most discriminating until fairly homogeneous types are obtained. Multidimensional analysis is a statistical method that can mobilise several discriminating criteria at the same time. On the one hand, there are principal component analysis (PCA), MCA and multiple factor analyses (MFA), which are used to characterise farms in relation to the variables selected (Oka *et al.*, 2021). Moreover, the hierarchical ascending classification (HAC) or cluster analysis are used to group farms according to the importance of the variables considered. As part of the establishment of structural typologies, PCA and MCA have been widely used to study production systems (Mbetid-Bessane and Havard, 2003; Ayena and Yabi, 2013); nevertheless two main limitations are that they include heterogeneous variables in the analysis and can only be applied either to

quantitative variables or to qualitative variables. This is what leads some authors to opt for AFM (Choisis *et al.*, 2010; Choisis *et al.*, 2012), which makes it possible to carry out the analysis whatever the nature of the variables provided or structured in groups of the same type. Others instead of using MFA, combine PCA and cluster analysis (Kuivanen *et al.*, 2016). PCA for a reduction of variables highlighting correlations and cluster analysis to form groups. In addition, the variables used for the construction of structural typology of agricultural PSs are based on socio-demographic data of the household (household size), areas and production of different crops, inputs, animals, agricultural equipment, labour, teams and non-agricultural activities.

Types of operation. Operating typologies focuses on the analysis of production and decision-making processes on farms. The constructions of operating typologies are reasoned and require the existence of a synthetic model, which orients and guides the operating mode to be adopted to observe and account for the diversity of farms (Kuivanen *et al.*, 2016). Four variants of operating typologies are most often encountered. First, there are the types centered on the farmer’s projects and situation; which typology defines the objectives, strategies and production constraints (Brossier and Petit, 1977). Then the types based on farmers’ “systems of practice”. This practice analysis option, often used when it is impossible to identify the farmer’s project, makes it possible to group together various operating logics. Then, typologies can be linked to the evolution trajectories of farms, the stages in the evolution of farms in the region. The possibility of highlighting these trajectories and their explanatory value can be considered as elements of validation of the operating concept and its heuristic value. The fourth variant is elaborated according to an expert on the basis of a reading grid (Gasselin *et al.*, 2014).

Internal interactions to be considered.

Cochet *et al.* (2006) in an iterative approach, builds a typology in which each successive step makes it possible to verify and refine the hypotheses established during the previous step. Indeed, the idea is to identify the PSs beforehand, even before embarking on a detailed study of their operation. Such a method allows at the same time to choose the farms which will be studied in detail. Thus, in a qualitative approach, at the scale of the study area, a deciphering of the landscape and the use of history make it possible to identify the mechanisms of differentiation and to clearly identify the agricultural PSs. This approach makes it possible to identify relevant variables to be integrated for the construction of types because the microeconomic analysis of PSs cannot be holistic from accounting results alone. Moreover, recent studies are trying to develop dynamic typology for a better knowledge of the environment as a prerequisite for future studies. Choisis *et al.* (2010) uses multiple factor analysis to understand the regional dynamics of mixed crop livestock farms to support rural development in southwestern France. The multiple factor analysis carried out on the structural and operational data of 52 farms, provide a more diversified picture than what the examination of the statistical data suggests. Diversified PSs reflect contrasting family strategies. Six types are distinguished according to criteria related to their productive orientation, their size and their level of intensification (Choisis *et al.*, 2010). Moreover, the participatory approach is not on the sidelines; there is a transition from stratification to a construction of operating typologies organised around the project of an operator. This project is often identifiable by the evolution over time of its system of activities, or of its cropping systems and their techniques; or organised around the aggregate effects of individual strategies at the scale of a territory. This qualitative and inductive construction of explanatory or systemic

models in interaction is carried out with surveys.

An analysis of territorial dynamics of France, Brazil, Uruguay and Senegal is based on a comparison of political, economic and ecological contexts (Ickowicz *et al.* 2010). Global factors (demography, environment, markets) weigh on all livestock territories, but their impacts are specifically modulated by local factors: culture, history, isolation, local projects and public policies. On the basis of a reading grid, five groups of variables are retained in the analysis; namely characteristics of the territories, context, characteristics of farming systems, current territorial dynamics and issue of territorial development. The criteria considered for the characterisation of the territories are: history of the populations, land status, land use. Then, those considered for the context are: political, economic, ecological, and local research and development issues. Furthermore, the characterisation of farming systems is based on: farm structures, types of activities, importance and type of commercial products. To define current territorial dynamics, the criteria used are ecological, social, economic. Finally, the criteria used for issue of territorial development are: maintaining landscapes, biodiversity, preserving ecosystems; viability of farms.

Typologies as an exploration of complex systems. The implementations in the wave of Rapid Rural Appraisals (RRAs) suggest methods based on the knowledge that producers stratify their peers according to a theme and to explain the classification criteria used (Perrot and Landais, 1993). Thus, producers having good reasons for doing what they do (rationality), bring out the determinants of the actions of each stratum (life projects, constraints, opportunities). Subsequently, new hypotheses can be generated. This approach, which is increasingly used in the context of development research, admits comparative analysis. A quantitative method, statistical typology based on a survey data set and

multivariate analysis, is compared to a qualitative participatory typology method based on informal group sessions and activities with local actors from three communities in northern Ghana (Kuivanen *et al.*, 2016). Statistical typology resulted in six clusters, with farming households classified on the basis of structural (resource endowment) and functional (production objectives/subsistence strategies) characteristics. Therefore, steps of typology of PS described in Figure 1 combines qualitative and quantitative approaches.

Methodological limits and prospects for innovation. Due to the small size of the samples, they are often not very representative, and cover a very limited area, which causes a spatial restriction in the exploitation of the results. Moreover, the elaboration of typology providing a static image of the exploitation, privilege the structural variables, easier to apprehend than the dynamic variables and farmers practices, which would make it possible to understand the logic of operation. These variables are exposed to sampling bias and the resulting typologies have a fairly high rate of obsolescence (Perrot and Landais, 1993). For the limits related to the processing of information, it is important to underline those of the factorial analyses.

In automated methods, the information collected by survey is processed by multivariate analysis methods, which can be influenced and therefore controlled by the choice, coding and weighting of the variables to be analysed (Kuivanen *et al.*, 2016). The classification is totally contingent on the nature of the information that is provided to the machine (therefore, on the sampling and the choice of variables), and sometimes proves to be extremely unstable. Different results affect the relevance of the resulting types for the stakeholders involved. Overall, in quantitative analysis, when it comes to classifications from multivariate analyses, the high share of inertia of the first factor and the impossibility of

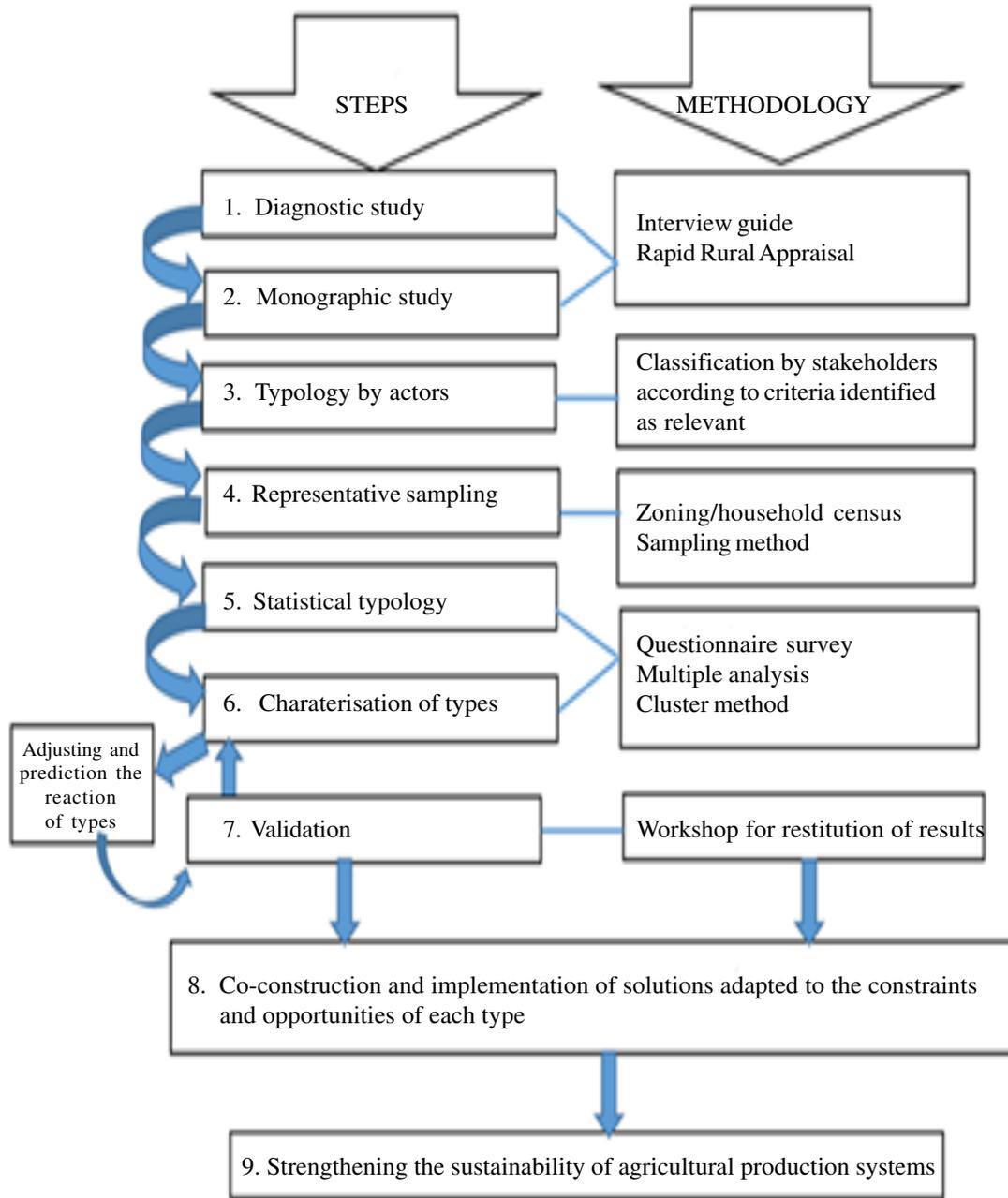


Figure 1. Steps for the elaboration of agricultural typologies. Source: Oka *et al.* (2023).

clearly interpreting the following axes are generally the symptoms of an unconstructed approach (Pierret *et al.*, 1996).

From stratification to typology by stakeholders themselves.

The actor-based classification method turns out to be the one that makes it possible to consider fairly long temporal dynamics not captured in surveys (life histories). It brings out phenomena *hitherto* unknown and, therefore, not considered (Cisse *et al.*, 2007). Its subjectivity is reflected in the non-homogeneous classification criteria from one community to another because the judgment is subject to the frame of reference of those concerned. Indeed, the constructed typology must be defined as a particular combination of multiple attributes, and necessarily be located in a multidimensional space. Hence, it is essential to consider the interlocking of systems at different scales (agrarian system, activity system, production system, and crop and/or livestock system) in order to carry out an analysis that makes sense. In particular, for the production system, we are interested in the structure, organisation and operation of farms. It is a question of finding answers to questions such as; how do farmers combine several agricultural activities and practices within their farm? What is the rationality of their practices? What technical and economic constraints do they face? What is their level of technical and economic performance? The specificity of the answers will lead to the elaboration of the types according to a qualitative and/or quantitative methodology. Even more, the choice can be made on the participatory typology emphasizing the context-specific aspects of the complexity of the farm and likely to reinforce the local relevance and the socio-cultural sensitivity of the interventions. It is a question of starting from the qualitative, explanatory of reality, by elaborating the differentiation to say of actor, to identify the mechanisms of discrimination of the systems therefore a first theoretical

model from which the identification of the relevant variables is carried out.

CONCLUSION

The typology constructed is only the result of a scientific work back and forth between induction and deduction. By proceeding with the identification of relevant variables from the typology of actors, obsolete typologies are avoided, in particular surveys that are often long, complex, expensive and when the processing has been carried out, the situation has changed. Consequently, in order to quantify certain variables, resorting to quantitative typology, which is data mining, proves to be adequate without advancing without a preconceived idea which would not lead to types out of phase with reality.

Faced with current global challenges, such as population growth and climate change, adequate and quality food supplies will require more efficient and robust production systems, based on good agricultural practices that ensure efficient use of the natural resource base, and embedded in an enabling policy and institutional framework. Productivity improvement and diversification must be supported by sustainable livelihoods, enhanced food security and value chain approaches. Value chain approaches for agricultural products that are to be part of a circular economy must be based on sustainable agricultural production systems. Therefore, building a typology of farming systems is not only a starting point for diagnosis but also the aim is to identify assets, constraints and opportunities to enhance the sustainability of systems while preserving diversity. To address these challenges, FAO Strategic Objective recommends intensification of agricultural production based on an ecosystem approach, including technical and policy assistance in four key directions. These should guide the development of typologies and the improvement of farming systems:

- (i) Increasing agricultural productivity through better resource use, to achieve higher yields while promoting sustainability of farming systems and the transition from subsistence to commercial farming, supported by conservation agriculture and integrated nutrient management;
- (ii) Promote sustainable crop protection through integrated pest management and the implementation at the national level of internationally accepted instruments, such as the International Plant Protection Convention and the Rotterdam Convention, to minimise pest problems, pesticide abuse and environmental pollution;
- (iii) Manage biodiversity and ecosystem services, through the identification and use of mechanisms to enhance agricultural biodiversity and ecosystem services, and sound agronomic practices (efficient crop, soil, nutrient and water management); and Strengthen livelihoods through the benefits of improved productivity and increased diversification within the value chain, including by providing the conditions for access to agricultural knowledge and good practices, quality seeds, post-harvest and agro-processing techniques, food safety systems, markets and credit.

In short, a participatory approach, combining qualitative and quantitative would be more robust for the construction of typologies more representative of reality, more exploitable for more targeted actions promoting the sustainability of agricultural production systems.

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REFERENCES

- Ayena, M. and Yabi, J.A. 2013. Typologie et rentabilite economique des exploitations Agricoles participant au conseil a l'exploitation familiale. 2013 AAAE Fourth International Conference, September 22-25, 2013, Hammamet, Tunisia.
- Brossier, J. 1987. Système et système de production note sur ces concepts system and farming system -A note on these concepts. *Cahiers des Sciences Humaines* 23:377-390.
- Brossier, J. et Petit, M. 1977. Pour une typologie des exploitations agri-coles fondée sur les projets et les situations des agriculteurs. In: *Économie rurale* N°122, pp. 31-40. doi : <https://doi.org/10.3406/ecoru.1977.2520>
- Capillon, A. 1993. Typologie des exploitations agricoles, contribution à l'étude régionale des problèmes techniques. Thèse Ina Pg, tomes I et II.
- Cissé, I., Bélières, J.-F., Maïga, A. Y., Traoré, A. et Koukantji, B. 2007. Croissance démographique, développement de la culture du coton et gestion durable des ressources naturelles en zone Mali sud. http://agritrop.cirad.fr/543458/1/document_543458.pdf
- Choisis, J.-P., Sourdril, A., Deconchat, M., Balent, G. et Gibon, A. 2010. Comprendre la dynamique régionale des exploitations de polyculture élevage pour accompagner le développement rural dans les Coteaux de Gascogne. *Cahiers Agricultures* 19(2), 97–103. <https://doi.org/10.1684/agr.2010.0375>
- Choisis, J.P., Thévenet, C. and Gibon, A. 2012. Analyzing farming systems diversity: a case study in south-western France. *Spanish Journal of Agricultural Research*

- 10(3):605. doi: 10.5424/sjar/2012103-533-11.
- Cochet, H. 2011. Origine et actualité du « Système Agraire » : Retour sur un concept. *Revue Tiers Monde* 207(3):97-114. doi: 10.3917/rtm.207.0097.
- Cochet, H. et Devienne, S. 2006. Fonctionnement et performances économiques des systèmes de production agricole/ : Une démarche à l'échelle régionale. *Cahiers Agricultures* 15(6):578-583. doi: 10.1684/AGR.2006.0028.
- Doré, T., Le Bail, M., Martin, P., Ney, B. et Roger-Estrade, J. 2006. L'agronomie aujourd'hui. Editions Quae. 384pp. Synthèses (Quae), 978-2-7592-0000-9. e`hal-01829191é'
- Elloumi, M. 1994. Les approches systémiques. *Cahiers Options Méditerranéennes* 2:67-76.
- Friedmann, H. 2014. Préface. In: Bosc, P., Sourisseau, J., Bonnal, P., Gasselin, P., Valette, E. and Bélières, J. (Eds.), *Diversité des agricultures familiales : Exister, se transformer, devenir*. Éditions Quæ. Tiré de <http://books.openedition.org/quae/29460>
- Frossard, E., Aighewi, B., Aké, S., Barjolle, D., Bernet, T., Dao, D., Diby, L.N., Floquet, A., Hgaza, V. K., Ilbudo, L.J., Kiba, D.I., Mongbo, R.L., Nacro, H.B., Nicolay, G., Oka, E., Ouattara, Y. F., Pouya, N., Six, J. and Traoré, O.I. 2019. Biophysical, institutional and economic drivers of sustainable soil use in yam systems for improved food security in West Africa. *Research for Tropical Agriculture* 12(2):114-116. <https://doi.org/10.11248/nettai.12.114>
- Gasselin, P., Vaillant, M. et Bathfield, B. 2014. Le système d'activité. Retour sur un concept pour étudier l'agriculture en famille. In F. Sciences, ed. *L'agriculture en famille/ : travailler, réinventer, transmettre*. INRA-SAD.384pp. doi: 10.1051/978-2-7598-1192-2.c007.
- Ickowicz, A., Bah, A., Bommel, P., Choisis, J.P., Etienne, M., Gibon, A, Lasseur, J., Morales, H., Touré, I. et Tourrand, J.F. 2010. Facteurs de transformation des systèmes d'élevage extensifs des territoires/ : étude comparée des dynamiques locales sur trois continents. *Cahiers-agricultures* 19(2):127-134. doi: 10.1684/agr.2010.0382.
- Kuivanen, K.S., Alvarez, S., Michalscheck, M., Adjei-Nsiah, S., Descheemaeker, K., Mellon-Bedi, S. and Groot, J.C.J. 2016. Characterising the diversity of smallholder farming systems and their constraints and opportunities for innovation: A case study from the Northern Region, Ghana. *NJAS - Wageningen Journal of Life Sciences* 78: 153-166. <https://doi.org/10.1016/j.njas.2016.04.003>
- Mbetid-Bessane, E., Havard, M., Nana, P.D., Djonnewa, A. and Djondang, K. 2003. Typologies des exploitations agricoles dans les savanes d'Afrique centrale : Un regard sur les méthodes utilisées et leur utilité pour la recherche et le développement. Jean-Yves Jamin, L. Seiny Boukar, Christian Floret, Cirad - Prasac, 10pp. <hal-00140823>
- Norman, D.1980. La méthode de recherche sur les systèmes d'exploitation agricole : Son applicabilité au petit exploitant. *Cahiers MSU sur Le Développement Rural* (5):1-27.
- Oka, E., Floquet, A., Dao, D., Hounnakoun, C.O. and Mongbo, R.L. 2021. Diversity of yam-based production systems and sustainable soil management: The case of Tiéningboué in Ivory Coast. *Managementjournal. Usamv.Ro* 21(3):601 - 616 http://managementjournal.usamv.ro/pdf/vol.21_3/Art69.pdf
- Oka, E, Floquet, A. and Mongbo, R.L. 2023. State of knowledge of methodologies for establishing "typologies of production systems". *African Crop Science Journal* 31(1):121-131.
- Osty, P.L. 1978. L'exploitation agricole vue comme un système. Diffusion de l'innovation et contribution au

- développement. *Bulletin Technique d'Information Ministère de l'Agriculture*, 326:43-49.
- Perrot, C. and Landais, E. 1993. Exploitations agricoles/ : Pourquoi poursuivre la recherche sur les méthodes typologiques/ ? *Cahiers de La Recherche Développement* 33:13-23. http://cahiers-recherche-developpement.cirad.fr/cd/CRD_33_13-23.pdf
- Pierret, P., Perrot, C., Thinon, P., Joly, D. and Landais, E. 1996. De l'activité agricole au paysage. Une démarche de modélisation. *Renc. Rech. Ruminants* 3(2):1-12.
- Reboul, C. 1976. Mode de production et syst?mes de culture et d'?levage. *Economie rurale* 112(1):55-65. doi: 10.3406/ecoru.1976.2413.
- Tafani, C. 2011. Pour une approche systemique de l'évaluation de la durabilite de l'agriculture/ : une synthese des approches agro-economiques et geographiques/ ? <http://www.oeconomia.net/private/colloqueddiufm/33.colloquedd-tafani.pdf>.
- Tittonell, P., Muriuki, A., Shepherd, K.D., Mugendi, D., Kaizzi, K.C., Okeyo, J., Verchot, L., Coe, R. and Vanlauwe, B. 2010. The diversity of rural livelihoods and their influence on soil fertility in agricultural systems of East Africa - A typology of smallholder farms. *Agricultural Systems* 103(2):83-97. doi: 10.1016/j.agsy.2009.10.001.