# Farm modeling in the Fatick ALL: validation of input data and parameter settings for the main farm types

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# Contents

# I. Introduction

Senegal is a Sahelian country whose economy relies primarily on agriculture and livestock farming (Habanabakize et al., 2022). These sectors contribute decisively to the national economy and the food and nutritional security of rural households (ANSD, 2016; ANSD, 2023). Integrated crop-livestock systems are practiced by nearly 56% of the country's farming households (DAPSA, 2023). This national importance is particularly evident in the Fatick region, where agriculture plays a pivotal role. The Department of Fatick, situated in the southern peanut basin and bordered to the west by the Atlantic Ocean, is a diverse agro-ecological zone incorporating crop production, livestock farming, agroforestry, and fishing. According to the 2022-2023 ANSD regional report, 86% of agricultural households engage in rain-fed farming and 95% practice livestock rearing, underscoring the vital economic significance of these activities in the local economy.

This strong agro-pastoral orientation is supported by significant natural assets: the department receives between 600 and 800 mm of annual rainfall and possesses diverse soil types—including ferruginous, hydromorphic, halomorphic, and mangrove soils. Furthermore, it holds substantial water resources, including groundwater and permanent watercourses such as the Sine and Saloum rivers. Agricultural diversity also benefits from a varied landscape and rich vegetation cover, including several protected forests, all of which provide a favorable environment for agricultural and livestock production (ANSD, 2023).

However, these assets are increasingly undermined by soil salinization, caused by capillary rise and saltwater intrusion from the Sine-Saloum estuary (Habanabakize et al., 2022; Sene, 2024). Between 2000 and 2021, the extent of saline land increased by 42.56%, while vegetation and crop areas declined by 49.79% and 2.39%, respectively (Sene, 2024). The Fatick region also remains one of the poorest in the country, with a poverty index of 67.8% (ANSD, 2019), necessitating urgent, targeted interventions. This situation is further compounded by a dearth of precise data on farm performance (such as yields, labor productivity, and food crop balances), which limits the capacity to anticipate food security risks and plan strategic investments.

The Multifunctional Landscape (MFL) project implemented in Senegal aims to promote sustainable agricultural systems capable of reconciling agronomic performance, economic viability, social equity, and environmental preservation at the territorial level. Within this framework, a farm modeling tool is being developed to assess the multi-dimensional impacts of introducing agroecological systems and to serve as a platform for decision-making among technicians, farmer organizations, and producers.

The tool’s parameters are based on data regarding crop and livestock systems, inputs, labor organization, and production costs. These data were collected through surveys and field interviews conducted between October and November 2025 in the Department of Fatick. Although rich and contextualized, this information required collective validation to ensure its representativeness, consistency, and local ownership. Consequently, a workshop was organized on December 8 and 9, 2025, in Fatick to validate the model's input data and parameters. The primary objective was to enhance the relevance, reliability, and operationality of the MFL project tool by verifying data consistency, adjusting parameters to reflect departmental realities, and integrating local producer knowledge into the modeling process.

This document provides a summary of the farm typologies in the Department of Fatick and presents the key outcomes of the validation workshop.

# II. Synthesis on the typology of farms in the Fatick Departement

## 1) Methodology

The typological synthesis was conducted based on a comprehensive literature review. This review focused exclusively on studies that established a formal farm typology within the peanut basin, with a specific emphasis on the Fatick region. Scientific publications, institutional reports, and dissertations were selected only if they met the following three criteria: (i) a geographical scope encompassing the peanut basin or Fatick; (ii) the application of an explicit statistical classification method; and (iii) a clear description of the resulting farm groups.

Each document was reviewed in its entirety. Data were extracted into a standardized grid covering the statistical methods employed, the sample sizes, the study areas, and the defining characteristics of each typological group.

## 2) Results of the review

### a. Types of agricultural and livestock farms in the Fatick region

A study conducted by Habanabakize et al. (2022) proposes a typology of crop and livestock farms in the Fatick region. Drawing from the regional livestock department's database, 100 livestock farmers across the region were randomly selected for interviews, followed by scheduled on-site visits for each. The researchers employed a stratified random sampling approach to include producers who currently deliver milk, those who have never delivered milk, and those who have ceased deliveries to collection centers.

To establish the typology, forty-three (43) quantitative and qualitative variables were selected, covering biophysical characteristics (farm size, herd size, and composition), socio-economic factors (income, market access, veterinary costs), and management practices (feeding methods, reproduction, animal housing, and use of transhumance). Statistical analysis was based on Multiple Factor Analysis (MFA) adapted for mixed data, followed by Ward's hierarchical clustering and refined by k-means clustering. Chi-square tests and analysis of variance (ANOVA, $\alpha < 0.05$) were subsequently applied to verify associations between variables and groups, while the v-test was used to identify the most discriminating variables.

This approach identified three major groups of rural actors whose production practices, market access, livestock types, and milk production levels differ significantly:

- **Cluster 1: Diversified and Sedentary Agro-pastoralists.** This cluster represents approximately 40% of the farms. These producers integrate crops and livestock within diversified systems where cattle, small ruminants, horses, donkeys, and poultry coexist. Agriculture plays a central role, and crop residues, along with cultivated fodder, are used for animal feed, strengthening the interactions between the two activities. Their production mode is essentially sedentary; they spend an average of 10.1 ± 2.99 hours on pasture per day, well above the general average of 7.55 ± 4.10 hours. Milk production is the lowest in the sample, at only 3.75 ± 3.30 liters per farm (compared to a general average of 8.22 ± 7.94 liters), and the quantity of milk sold remains very low at 1.3 ± 2.05 liters—nearly five times less than the overall average (5.26 ± 7.20 liters). The average selling price is also lower (122.06 ± 179.54 FCFA/liter vs. 289.00 ± 203.81 FCFA/liter). In practice, nearly 88% of farmers in this group do not market their milk, and 89% report no buyers for their products. These farmers also exhibit a higher animal infection rate than the average (5.4 ± 5.96 cases per year vs. 3.25 ± 4.53 for the total sample). These elements reflect diversified but relatively traditional systems, focused on self-consumption and weakly integrated into markets.
- Cluster **2: Transhumant Pastoralists with a Low Agricultural Base.** This cluster accounts for 32% of the studied farms. These producers are characterized by limited access to land, with an average farm area significantly lower than the general average (2.5 ± 2.60 ha vs. 5.2 ± 5.32 ha) and a cultivated area three times smaller (0.90 ± 2.33 ha vs. 3.3 ± 4.84 ha). Agricultural activity is very limited: only 13.6% of producers use fertilizers or crop residues, and only 3.1% truly integrate crops and livestock. Furthermore, 87.5% of the farmers did not respond to questions regarding crop diversity, confirming minimal agricultural participation. Livestock is at the core of their strategy, with a near-systematic practice of transhumance: 93.8% move their livestock during the dry season. Expenditures on artificial insemination are low, averaging 5,789.47 ± 11,783.48 FCFA per farm, roughly half the general average. Conversely, a portion of this group sells milk at prices above the average, reaching 393.4 ± 157.84 FCFA per liter (compared to 289.0 ± 203.81 FCFA for the whole sample). These characteristics describe essentially pastoral, highly mobile farms with almost no agriculture but a marked commercial orientation for milk, reflecting a pastoral lifestyle that, while not diversified, is capable of capitalizing on sales opportunities.
- **Cluster 3: Intensive Market-Oriented Dairy Agro-pastoralists.** The third cluster comprises 28% of the farms and is distinguished by a more specialized and modernized orientation, clearly focused on dairy production. Farmers in this group sell more than 75% of their milk production, with an average quantity of 15.6 ± 0.64 liters per day per farm—nearly double the population average (8.2 ± 7.94 L). Yield per cow is also higher, reaching 3.80 ± 2.33 L per day compared to the general average of 2.22 ± 2.27 L. Approximately half of the producers (50%) also derive income from crops, and their revenues from agricultural activities exceed the average of other groups. Modernization is evident in herd composition, as 67.9% of farmers own at least one crossbred or exotic cow. The use of technical services is also more developed, with an average expenditure of 27,803.57 ± 1,206.49 FCFA for artificial insemination, significantly above the general average (16,715.00 ± 18,134.81 FCFA). Livestock practices are characterized by partial stalling, which reduces grazing time to 4.6 ± 4.10 hours per day (vs. 7.5 ± 4.10 hours for the total sample), and transhumance is almost non-existent, with only 3.54% of producers resorting to it during the dry season. This cluster thus illustrates the emergence of more intensive agro-pastoral farms, better connected to services, integrating complementary crop production and strongly oriented toward the dairy market.

## b. Results of HOLPA

### i. The Agroecological Transition and Its Performance: The Case of the Department of Fatick

A survey conducted in 2024 among 200 farms in the Department of Fatick, using the HOLPA (Holistic Localized Performance Assessment) tool, established a typology of the agroecological transition in the area. The study sites were selected to reflect the diversity of agroecological and socioeconomic contexts: urban and peri-urban farms, farms located along major road corridors, and holdings situated in the fossil valleys, the Serer areas of the peanut basin, and the humid rural environments of the south, including fishing and mangrove zones. This selection ensured coverage of a wide range of production contexts, levels of market access, and availability of natural resources.

Statistical analysis based on the thirteen principles defined by the HLPE (High Level Panel of Experts) identified three classes of farms, reflecting different levels of agroecological transition.

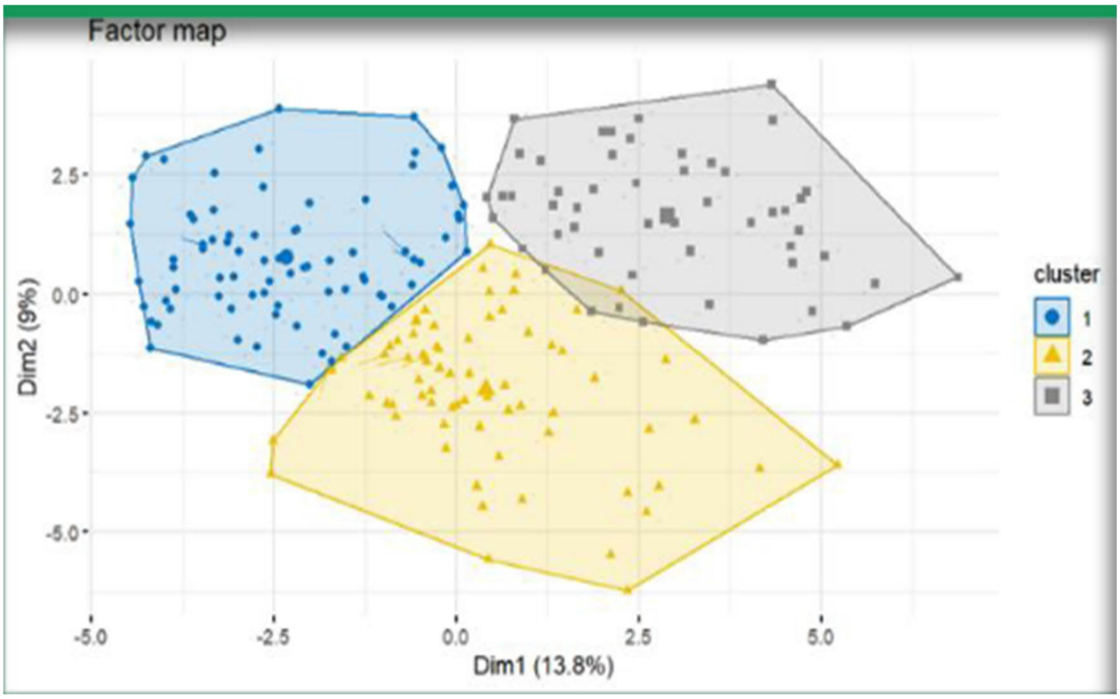


Figure 1: Diversity of Surveyed Farms in Fatick

- The first class comprises small-scale farms with low-intensity livestock systems, heavily dependent on rainfed crops and showing limited diversification. Households average 12 members, manage approximately 3 hectares of land, and own a herd of 2.3 Tropical Livestock Units (TLU). These farmers primarily grow staple food crops and engage only marginally in arboriculture (14% of households) or market gardening (6%). In terms of the agroecological transition, their highest scores relate to equity, social responsibility, and resource efficiency. However, resilience—particularly soil health, production synergies, and economic diversification—remains the weakest dimension and requires strengthening.

- The second class corresponds to medium-sized farms combining rainfed crops, more intensive livestock systems, and significant diversification. These households average 15 members, cultivate around 4.25 hectares, and hold nearly 4.5 TLU. They are more involved in arboriculture (28% of households) and market gardening (24%), while maintaining a strong presence in rainfed cropping (34.5%). As with the first class, the strongest dimensions are social equity and resource efficiency, while resilience remains the weakest aspect, highlighting the need for improvement in soil health, economic diversification, and the co-creation of knowledge.

- The third class includes the largest farms and those most advanced in the agroecological transition. Households average 11 members, cultivate nearly 6 hectares, and possess a larger herd of around 5.6 TLU. Although diversification is slightly less pronounced than in the second class, arboriculture (21% of households) and market gardening (12%) remain significant. This group stands out with an overall transition level of 66%, higher than the departmental average of 62%. Performance is particularly strong in animal and plant health, biodiversity, water management, and socioeconomic outcomes, including climate resilience, dietary diversity, farm income, social inclusion, and human well-being. Areas for improvement mainly concern agrobiodiversity, fertilizer management, landscape protection, climate change mitigation, and the use of renewable energy.

Overall, this typology shows that resilience remains the weakest dimension across the territory, despite relatively strong performance in social equity and resource efficiency. It also demonstrates that progress in the agroecological transition is associated with larger farm size, greater production diversification, and stronger integration into socioeconomic networks, underscoring the importance of access to land, livestock, and producer organizations.

### ii. Assessment of Agroecological Performance in Senegal (Juliette Lairez et al.)

Another study assessed the same 200 farms using the twelve agroecological principles. Farms were classified according to their overall median score across these principles and categorized as more or less agroecological. Farms with a score above 3.3 are considered “more agroecological,” while those scoring below 2.3 are classified as “less agroecological.”

- **More agroecological farms** represent approximately 28% of the sample. They manage an average of 5.6 hectares of land and a herd of 5.5 TLU, significantly higher than other farms. They are characterized by high diversification: 77% practice arboriculture and 51% market gardening, compared with 31% and 13%, respectively, among the less agroecological group. These farmers make greater use of crop residues and organic manure, combine food crops, arboriculture, and livestock, and maintain high levels of biodiversity. They perform better in crop and animal health, crop diversity, and tree diversity. Socioeconomically, their farm incomes are higher, land tenure is more secure, and participation in producer organizations is more frequent, enhancing their climate resilience and capacity for innovation.

- **Less agroecological farms**, representing about 8% of the sample, are characterized by smaller landholdings (around 2 hectares) and limited livestock (0.77 TLU). They engage little in market gardening (13%) and arboriculture (31%), focusing mainly on staple food crops. Their economic integration is weaker: they sell primarily through traditional channels with little direct marketing, and their participation in farmer organizations remains limited, restricting access to credit and technical support. The reduction in chemical inputs is comparable to that of more agroecological farms, but this is largely due to a lack of resources rather than an environmental choice.

In conclusion, the typology highlights that production diversification, crop–livestock integration, and strong embedding in social and economic networks are the main factors distinguishing more agroecological farms.

## c. Characterization of Agricultural Households and Practices in the Three FAIR Sahel Project Zones in Senegal

The diversity of households in the Fatick Department, a project zone, was analyzed using a Factor Analysis of Mixed Data (FAMD) followed by a clustering method on 302 households in the communes of Ndiob (126), Diouroup (91), and Tataguine (85). The preliminary typology was based on a selection of quantitative and qualitative variables across several categories (demographics, labor, land plots, equipment, activities, durable goods score, participation in Farmer Organizations (FOs), advisory services, credit, and the role of livestock). The typology contains four classes distinguished by several criteria.

- **Class 1: Vulnerable Agricultural Households.** This class includes 107 households (38% of the total). These households are smaller than average, with 5.1 adults and 3.2 children, and a dependency ratio of 0.79. They rely almost exclusively on family labor (92% without employees). Land endowment is low, with 3.2 plots on average covering 4.0 hectares; only 11% have access to lowlands (*bas-fonds*) or irrigated land. 78% own their land. Equipment is limited (2.8 implements on average), and only 7% own a cart. Livestock holdings are small (1.78 TLU), and 13% practice fattening. The commercialization rate is low (18.6%), though 13% sell part of their cereal production. This class stands out for having the highest proportion of female-headed households (38%).

- **Class 2: Vulnerable Crop/Livestock Households.** This class comprises 83 households (29%). They are large, with 8.6 adults and 5.4 children (dependency ratio: 0.75). Activity is centered on rain-fed agriculture and livestock. Labor is almost entirely familial (89% without employees). Land holdings remain modest, with 3.4 plots and an average area of 5.1 ha, all rain-fed. Ownership status is high (88%). They possess an average of 3.9 agricultural implements, with 84% owning a cart. The commercialization rate is limited (22.8%) and only 4% sell cereals. Livestock holdings are significant (8.37 TLU), but fattening remains moderate (18%). Access to formal credit is nearly non-existent (1%), agricultural advisory services are very low (2%), and participation in farmer organizations is restricted (6% members, 4% leaders).

- **Class 3: Households with Strong Social Capital.** This class includes 58 households (20%). It averages 7.6 adults and 3.4 children, with the lowest dependency ratio (0.55). These households make greater use of wage labor (33%) and "sourga" (traditional seasonal) labor (12%). They have larger land holdings: 5.1 plots and 11.8 ha, with 21% being lowlands or irrigated. They own 5.3 agricultural implements, 55% have a cart, and they maintain a dense tree cover (42 trees on average). Their proximity to roads is the highest (1.25 km average). They are better connected to institutions: 16% have access to formal credit, 33% receive advisory services, and their engagement in FOs is high (29% members, 62% leaders). Their durable goods score is the highest (0.286), and they engage in more non-farm activities (2 on average). Livestock holdings are substantial (6.35 TLU), and 16% practice fattening, with an average commercialization rate of 24.8%.

- **Class 4: Households Endowed with Land, Physical Capital, and Livestock Oriented Toward the Market.** This class brings together 54 households (19%). These are large farms with 7.6 adults and 6.2 children (dependency ratio: 0.92). They manage 7.6 plots and 20.3 ha, 46% of which include lowlands or irrigated land. The tree cover is rich (37 trees average). Equipment levels are the highest (6.3 implements), with 89% owning carts and 9% owning motor pumps. Their commercialization rate is the strongest (47%), and 22% sell cereals. Livestock holdings are significant (11.52 TLU), and 39% practice fattening. Formal credit access is 17%, but FO connection remains limited (20% members, 22% leaders), and only 11% receive agricultural advice. They are, on average, the furthest from roads (4.13 km).

## d. A Story of a Missed Connection? Livestock Farmers and the Dairy Collection Industry in Fatick (Senegal) – Koki BA et al.

The study by Ba et al. (2021) provides a detailed description of urban and peri-urban livestock systems in Fatick during the establishment of the Kirène company's milk collection center. The study combines field observations and interviews with approximately one hundred livestock farmers located in and around the city of Fatick to understand the rationale behind milk production and marketing. The authors identify three major livestock farmer profiles: transhumant pastoralists, agro-pastoralists, and specialized dairy farmers.

- **Cluster 1: Transhumant Pastoralists**. This group consists of 41 households, predominantly of Fulani ethnicity. Their herds spend most of the year in transhumance; only a few cows (an average of 5 per household) remain in the city for daily milking. Yield per cow ranges between one and two liters of milk per day, a low quantity explained by the exclusive use of local breeds, specifically the Gobra Zebu. Sales are preferably conducted in local markets at prices ranging from 500 to 600 FCFA per liter, significantly higher than the 350 FCFA offered by Kirène. For these farmers, milk holds significant nutritional, social, and symbolic value, and revenues from direct sales represent daily cash flow and income for the household. They also occasionally engage in livestock trading.

- **Cluster 2: Agro-pastoralists**. This group includes 61 households, mostly of Serer ethnicity. They are subdivided into two types: urban agro-pastoralists and rural agro-pastoralists.

  - ✓ **Urban Agro-pastoralists**. Located mainly in the oldest traditional neighborhood of Fatick, these farmers are often civil servants (retired or active) or traders. They cultivate small plots of 2 to 3 hectares for subsistence farming based on millet and maize. They utilize crop residues for livestock feed and maintain herds of 2 to 15 head, composed primarily of local and crossbred cattle. The small herd size is primarily due to urban space constraints and the difficulty of finding labor. Their milk production varies from 4 to 30 liters per day. A portion of the morning milk is sold to the Kirène dairy industry, but the majority is sold on the more lucrative local market.

  - ✓ **Rural Agro-pastoralists**. These are subsistence farmers cultivating 1 to 20 hectares of rain-fed crops, including millet, peanuts, and cowpeas. They rely more heavily on mineral fertilizers to improve yields. Harvests are primarily for family consumption, with only surpluses—particularly peanuts—being marketed. Crop residues are stored until the lean season (*soudure*) to feed the herd. Labor is mainly familial, though livestock maintenance may require hired workers. These farmers also practice animal fattening, livestock trading, and milk production. Cattle are kept sedentary to fertilize the land and are penned on fallow land during the growing season, then led to pastures near the village and harvested fields during the dry season. Their milk production ranges from 4 to 20 liters per day, a large portion of which is delivered to the collection center.

- **Cluster 3: Specialized Dairy Farmers**. This is a smaller profile, consisting of eight farms. Often established by wealthy traders or high-ranking officials, these farms occupy 2 to 5 hectares. They use European dairy breeds (Holstein, Montbéliarde, Normande, or Jersey) kept in stalls and fed with concentrates and roughage, or crossbred cattle led to pasture during the day and supplemented with concentrates in the evening. Production reaches 15 to 70 liters of milk per day, entirely oriented toward delivery to the Kirène center. These operations rely on wage labor and the systematic use of artificial insemination for reproduction, aligning their strategy with an intensive production model. Alongside livestock, these farmers often practice subsistence agriculture, using crop residues to feed the cattle.

This typology highlights the tensions between an industrial collection model and deeply rooted local practices. Transhumant pastoralists prioritize a local economy with high social value; agro-pastoralists are gradually diversifying their activities by combining crops and livestock and investing in genetic improvement; and specialized farmers provide the essential volumes required by the dairy industry.

### e. Typology of farms and study of the profitability of forage crops in the production systems of the Groundnut Basin of Senegal (Alexandre Diouf)

Alexandre Diouf's thesis (2002) establishes a typology of farms in the Groundnut Basin based on multiple correspondence factor analysis followed by hierarchical cluster classification. This approach, applied to a sample of 60 farmers practicing forage crop cultivation in five villages of the Groundnut Basin, including two in the Fatick region, led to the identification of four distinct groups, labeled V, I, J, and V-.

- **Group V:** Representing 37% of the sample, this group consists of farmers with an average age of 59 years. Annual income from livestock is approximately 92,100 FCFA, while agricultural income reaches 542,000 FCFA and income from non-agricultural activities totals 113,000 FCFA. On average, these farms own 2.5 hoes, 1.58 seeders, 1.47 carts, 6.54 human labor units (HLU), and 10.82 tropical livestock units (TLU). This group represents relatively well-equipped farms with substantial herds, where agriculture remains the main source of income.
- **Group I:** Agro-pastoralists with high animal density, accounting for 17% of the farms. Farm heads are younger, with an average age of 47.3 years. Their annual incomes are higher: 114,000 FCFA from livestock, 576,000 FCFA from agriculture, and 155,000 FCFA from non-agricultural activities. Equipment levels are slightly lower than in Group V, with an average of 1.9 hoes, 1.6 seeders, 1 cart, 6.57 HLU, and 15.72 TLU—the latter reflecting the highest herd density among the four groups. This profile corresponds to farms where livestock plays an important economic role, supported by a family labor force comparable to that of the other groups.
- **Group J:** Representing 33% of the farms, this group is characterized by a relatively young average age of 45.9 years. Incomes are more modest: 45,600 FCFA from livestock, 628,000 FCFA from agriculture, and 169,000 FCFA from non-agricultural activities. Equipment levels are lower, with 1.6 hoes, 1.2 seeders, 0.86 carts, 5.48 HLU, and 4.37 TLU. This group illustrates farms primarily oriented toward crop production, where livestock remains limited.
- **Group V-:** A minority group comprising 13% of the sample, distinguished by the highest average age of 59.8 years. Income from livestock is relatively low (28,500 FCFA per year), but agricultural income reaches 718,000 FCFA—the highest in the sample—while non-agricultural activities generate an average of 250,000 FCFA. Equipment includes 2.5 hoes, 2 seeders, 0.66 carts, 11.42 HLU, and notably 44.13 TLU, reflecting an exceptionally large herd compared to the other groups.

This typology thus highlights four clearly differentiated profiles of family farms in the Groundnut Basin. The contrasts concern farmers' age, income structure, level of equipment, and herd size, illustrating the diversity of production strategies in this region where crop–livestock integration remains central.

### f. Agricultural mechanization and productivity of cereal value chains: the case of the Groundnut Basin (Saer SARR)

This study, conducted in Senegal's Groundnut Basin, established a typology of farms based on a sample of 100 farms distributed across the regions of Diourbel, Kaffrine, Kaolack, Louga, Thiès, and Fatick. The data were drawn from the WAAPP database (ISRA/BAME, 2011) and analyzed using SPSS 19, combining ANOVA to identify factors influencing net income and hierarchical cluster analysis to group farms according to their structural and economic characteristics. The typology distinguishes three clearly differentiated classes.

- **Class 1** (35% of the sample) groups farms with a high level of motorized equipment but low profitability. These farms own on average more than two tractors or power tillers and a very complete set of post-harvest equipment: seeders, Sine hoes, threshers, etc. They also use more chemical inputs, with average expenditure per hectare nearly 40% higher than that of the other two groups. Cultivated areas are large—approximately 6 ha for dry cereals (4 ha for millet, 1 ha for maize, and less than 1 ha for sorghum)—yet economic results remain disappointing. Despite a high level of mechanization, this group records the lowest net income, averaging around 300,000 FCFA per year. This underperformance is attributed to a mechanization strategy focused mainly on post-harvest operations and insufficient use of equipment during the cropping cycle.

- **Class 2** (42% of the sample) corresponds to intermediate farms that rely primarily on rented equipment. Nearly 70% of the equipment used is rented rather than owned. These farms cultivate an average of 6 ha and make moderate use of inputs, with expenditure approximately 20% lower than in Class 1. However, they achieve the best economic performance, with an average annual net income of 450,000 FCFA—approximately 50% higher than the overall average. Their per-hectare productivity is also the highest, confirming that cost optimization through equipment rental can be more profitable than owning heavy machinery that is underutilized.
- **Class 3** (23% of the sample) is characterized by low mechanization and strong reliance on animal traction and manual tools. More than 60% of the equipment is borrowed or shared among households. Cultivated areas are smaller, averaging 4 ha, and input costs are the lowest in the sample. Although their income is lower than that of Class 2, these farms manage to cover their costs through prudent management and minimal reliance on expensive mechanization services. Their average annual net income is around 250,000 FCFA, but the margin per hectare remains relatively stable.

Overall, this analysis highlights a paradox: the most mechanized group is not the most productive, while intermediate farms relying on rented equipment achieve the highest profitability. The third class illustrates the capacity of small, minimally mechanized producers to maintain economic balance by controlling their costs.

### 3) Partial Conclusion

This literature review highlights the great diversity of farms in the Fatick region while revealing strong convergence among existing typologies. The studies by Diouf; Ba, Ninot, and Corniaux; Saer Sarr; Habanabakize et al.; FAIR Sahel; and the HOLPA project, although conducted at different times and using different methods, describe very similar profiles. They consistently distinguish small subsistence farms with limited capital; medium-sized crop and livestock households, often practicing transhumance; diversified farms with strong social capital; and a final group of farms with substantial land, animal, and equipment capital oriented toward the market. These works rely on a common set of variables such as household size, farm area and number of plots, level of equipment, herd size, access to credit and farmers' organizations, and commercialization rate, which explains the similarity of their results.

From the perspective of the CIAT Multifunctional Landscape project, the four-class typology proposed by ANSD and FAIR Sahel—which builds on and updates these recurring characteristics—provides a solid foundation for preparing a field survey. By drawing on these four profiles, which broadly correspond to the groups identified in the other studies, it will be possible to identify the specific needs and constraints of each type of farm and to develop a decision-support tool tailored to the agricultural and pastoral realities of Fatick.

## III. Validation of input data and farm model parameterization

### 4) Data collection methodology

Data collection consisted of building tables to populate two databases: one on the performance of cropping systems (CSPD) and the other on the performance of livestock systems (LSPD) for farm types in Senegal, and compiling various references for calculating the indicators of a farm model. Data were collected from October to November 2025. This process involved an in-depth literature review, as well as surveys and interviews with experts and field actors in the Fatick department.

### 5) Data validation steps

Data validation was carried out through a stakeholder workshop. The workshop for validating input data and farm model parameters was part of a participatory action-research approach aimed at combining scientific, technical, and experiential knowledge to strengthen the relevance and ownership of the tool developed. The methodological approach adopted was based on the principles of co-construction of model parameters, collective learning, and territorial anchoring, ensuring that the validated data reflect the realities of the Fatick department.

#### a. Preparation and organization of the workshop

On the eve of the workshop, a preparatory meeting was organized among members of the technical team, including field facilitators as well as researchers from CIRAD and ISRA. This meeting made it possible to:

- refine the methodological approach to be followed over the two days;

- clarify roles and responsibilities;
- harmonize facilitation tools and materials.

It was agreed that each working group would be supervised by a facilitator (to guide discussions) and a rapporteur.

### b. Participants and diversity of stakeholders

The workshop brought together 44 participants from the municipalities of Diouroup, Tataguine, Diarère, Niakhar, and Ndiob, representing a wide range of stakeholders: producers, technical services (ANCAR, SDDC), local authorities, farmers' organizations (notably DYTAEL and the Consumers' Association of the Fatick department), research institutions (CIRAD, ISRA), as well as facilitators and field animators.

### c. Facilitation approach

The work was organized around four thematic groups, covering the main components of the production systems being modeled. The "World Café" method was used to enable participants to contribute to all themes, thereby encouraging the circulation of ideas, cross-cutting data consistency, and collective ownership of the results.

### d. Proceedings of the workshop

#### i. Opening ceremony of the workshop

The opening ceremony was moderated by Mr. Ibrahima Faye from the National Agency for Rural Agricultural Advisory Services (ANCAR). After a brief reminder of the workshop's context and objectives, the moderator highlighted the relevance of the project and the strong participation of stakeholders before inviting the speakers to take the floor.

Mr. Ousmane Diouf, representing the Director of CEDAF and also President of the Fatick Consumers' Association, first welcomed the participants and expressed his pleasure in hosting the workshop at their premises. He emphasized the relevance of the project, which will undoubtedly contribute to revitalizing local territories and developing the rural economy that largely depends on the primary sector. Mr. Diouf concluded by inviting participants to take ownership of the project.

Next, Mr. Adama Diouf, Deputy Mayor of Diarère, speaking on behalf of the local authorities, thanked CIRAD, ISRA, and DYTAEL of Fatick for initiating this highly beneficial project for farmers. He reaffirmed the commitment of local authorities to the co-construction of such tools for the benefit of communities. Mr. Diouf also stressed the importance of synergy of actions and the participatory approach.

On behalf of DYTAEL of Fatick, Mr. Made Diouf emphasized the importance of this workshop for the organization. DYTAEL of Fatick had previously conducted a diagnostic study on the environmental situation of the department, which led to the formulation of a vision to make Fatick an agroecological territory by 2035. This vision calls for a paradigm shift toward sustainable agricultural practices, hence the importance of these discussions and the tool under development.

Speaking on behalf of the technical services, Mr. Djibril Faye, Head of the Departmental Community Development Service (SDDC), expressed his satisfaction with the presence and diversity of participants, as well as the involvement of technical services. As representatives of the State, these services have a duty to engage in all development initiatives. He concluded by highlighting the relevance of the tool for producers and expressing the technical services' willingness to support the project.

Dr. Moussa N'diénor, researcher at ISRA, thanked the participants for their presence and emphasized the participatory approach used in this research. This approach ensures the involvement of all stakeholders in the co-design of the tool, promoting consideration of diverse ideas and concerns and fostering ownership of the model.

Dr. Patrice Kouakou, researcher at CIRAD, presented the tool under development and its usefulness for users. This is a farm modeling tool that will be computer-based and, after data entry and calculation, will help inform decisions regarding the adoption of changes in farming practices at the farm level. Following the field data collection phase, the current step consists of discussing and validating the data collected before proceeding to modeling. He concluded by thanking all participants for their presence.

Following these speeches, the moderator officially declared the workshop for validating input data and farm model parameters open.

### ii. Framing and thematic deepening

The first day began with an introductory presentation by Dr. Moussa N'diénor. This presentation reviewed the data collected during field surveys conducted between October and November 2025, including the types of crops grown in the department, cropping systems (intercropping and crop rotations), and herd composition.

This collective validation step provided a common foundation before the start of group work. Participants were then divided into four thematic groups:

- Livestock systems
- Cropping operations, tools, labor time, and costs
- Inputs (seeds and fertilizers)
- General aspects (family labor, organic matter, livestock systems)

## e. Reporting back, discussions, and collective validation

The second day was devoted to reporting back on the group work, followed by plenary discussions.

✓ **Group 1: Livestock systems**

The group's work helped to refine the costs of herd management by distinguishing:

- fixed costs independent of herd size,
- seasonal variations (dry season / rainy season).

Grazing costs for cattle were estimated at approximately 50,000 FCFA per month during the dry season and 60,000 FCFA per month during the rainy season. Sheep, which generally graze together with cattle, incur higher costs, while goats are managed on the basis of a cost proportional to the number of animals (approximately 1,000 FCFA per head). See livestock systems table.

These discussions made it possible to incorporate cost seasonality and local herd management specificities into the model.

✓ **Group 2: Cropping operations, labor time, and costs**

Participants agreed on more than 90% of the data presented, confirming the reliability of the information collected during field surveys.

At the beginning of the discussion, some participants expressed reservations, pointing out perceived discrepancies between the data presented and their own experiences. These differences mainly referred to extreme scenarios that are rarely observed in the Fatick department. Recalling the precise context of data collection helped clarify these points and refocus discussions on the most common practices, leading to collective validation of the proposed parameters.

The main difficulty encountered by the group concerned estimating the costs of cropping operations in a context where agricultural work relies largely on family labor and local solidarity arrangements, such as *santané*. In order to translate these practices into economic values usable in the modeling tool, participants agreed on two reference methods: daily wages for operations requiring limited labor, and lump-sum payments (waxalé or waxtane ba jubo) for more labor-intensive operations.

- ✓ **Group 3: Inputs (seeds and fertilizers)**

The work of Group 3 focused on agricultural inputs, particularly the prices and quantities of seeds and fertilizers to be applied per hectare. The analysis covered all crops in the area.

Overall, fertilizer doses used in market gardening were maintained and not modified compared to those found in the literature. However, the recommended fertilizer quantities for sorghum and maize were reviewed and adjusted.

In general, fertilizer application rates for major crops were revised downward, mainly due to fertilizer availability constraints. Fertilizers are used more in market gardening than in other crops.

Regarding fertilizer prices, some variations were observed due to the existence of different product types. However, the prices of the most commonly used types in the area were retained for each crop.

Finally, the prices of organic manure were not modified and remain identical to those observed in the field.

- ✓ **Group 4: General aspects and cross-cutting dimensions**

The work of Group 4 addressed essential cross-cutting elements for understanding and modeling farms, particularly family labor, availability of organic matter, and the organization of livestock systems. Discussions helped to better characterize the composition of family labor, including the father, mother, children over ten years old who are able to work, seasonal visitors, as well as pupils and students. Participants highlighted the variability of this labor force throughout the year, particularly due to the seasonal mobility of young people at the end of the school year.

Regarding organic matter, discussions highlighted the near absence of plots dedicated exclusively to biomass production for organic amendments. Crop residues and forage are mainly used for animal feed and sometimes sold to meet households' daily needs. Although significant quantities of organic matter have been mobilized through agroecology promotion initiatives, particularly by DYTAEL, these remain insufficient to meet the soil fertility needs of the entire department.

Discussions also addressed crop–livestock integration and issues related to transhumance, particularly recurring conflicts between farmers and herders when herds return in October. Possible solutions were identified, such as the development of local agreements, the establishment of monitoring committees, the creation of protected areas, and the definition of livestock corridors, often in collaboration with support organizations.

## 6) Points for further consideration and outlook

### a. Points requiring further consideration

Despite the significant progress made during the workshop, several points warrant further consideration in order to strengthen the robustness and operationality of the modeling tool:

- ✓ The issue of water, considered central by several participants, particularly for market gardening systems, and whose integration into the model will need to be clarified;
- ✓ Access to and cost of market gardening seeds, the high price of which is a major constraint for producers;
- ✓ The availability of organic matter, which is insufficient at the departmental level despite advocacy efforts and existing initiatives;
- ✓ The consideration of labor mobility dynamics, particularly among young people at the end of the school year;
- ✓ Conflicts related to transhumance, which directly influence production systems and livestock farming strategies.

### b. Outlook

Following this workshop, several prospects were discussed, including:

- ✓ Final adjustment of the model parameters based on validated data;
- ✓ Continued discussions with local stakeholders to refine certain sensitive parameters;
- ✓ Testing of the tool with technicians from farmers' organizations and producers;

- ✓ Capacity building for local stakeholders on the use of the tool as a discussion and decision-making aid;
- ✓ Exploration of structural solutions, such as the establishment of a composting unit at the departmental level.

## 7) Partial conclusion

The workshop to validate the input data and parameters for farm modeling, held on December 8 and 9, 2025, in Fatick, was a key step in the development of the Multifunctional Landscape project's modeling tool. Thanks to the strong mobilization of local stakeholders and a rigorous participatory approach, it helped to consolidate the quality of the data, reinforce its legitimacy, and promote collective ownership of the tool. Beyond technical validation, this workshop provided a space for collective learning and dialogue among producers, farmers' organizations, technical services, and researchers, thereby contributing to a better understanding of the complexity of agroecological systems in the department of Fatick.

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# Annex 1 : Synthesis of typology of farm in Fatick Department

| Reference / Method | Nb of classes | Identified classes | Main characteristic variables |
|---|---|---|---|
| Alexandre Diouf (2002) Groundnut Basin, forage crops. Multiple Correspondence Analysis (MCA) + Hierarchical Cluster Analysis | 4 groups : J, V, I, V- | • Group J: young, poorly equipped farmers.<br>• Group V: medium-sized farms with a livestock orientation.<br>• Group I: diversified, well-equipped farms.<br>• Group V-: large, highly capitalized farms. | Age of farm head, farm size, number of plots, herd size, level of equipment (seeders, carts), fertilizer use, adoption of forage crops. |
| Ba, Ninot & Corniaux (2021) Livestock keepers and dairy collection industry in Fatick. Regional survey and descriptive grouping based on livestock and marketing practices | 3 profiles | • Transhumant pastoralists: seasonal mobility, low market integration, rare milk sales.<br>• Urban agro-pastoralists: 2–3 ha, 2–15 head of cattle, partial milk sales to the Kirène center but preference for direct sales.<br>• Rural agro-pastoralists: 1–20 ha, semi-stall feeding, feed supplementation, regular deliveries to the collection center. | Farm size and location, number of livestock, milk destination (local market or industrial collection), livestock practices (transhumance vs. semi-stall feeding), use of crop residues for animal feed. |
| Saer Sarr et al. (2020) Groundnut Basin, typology of family farms. Multiple Correspondence Analysis + Hierarchical Classification | 4 groups | • Small subsistence farms: limited land and equipment capital.<br>• Mixed farms with moderate livestock.<br>• Diversified, well-equipped farms.<br>• Large, capitalized farms. | Total area, number of plots, herd size (TLU), level of farm equipment, labor (family/paid), commercialization rate, access to credit and farmers' organizations. |
| FAIR Sahel (2023) Typology of agricultural households in Fatick. Mixed Data Factor Analysis + Hierarchical Classification | 4 classes | • Class 1: vulnerable farming households.<br>• Class 2: vulnerable agro-pastoral households.<br>• Class 3: households with strong social capital.<br>• Class 4: households with strong land, physical, and animal capital. | Demographics (household size, dependency ratio, gender of head), land (area, number of plots, lowlands/irrigated areas), farm equipment (cart, motor pump), durable asset score, commercialization rate, access to credit, participation in farmers' organizations, herd size (TLU), fattening practices. |
| Habanabakize et al. (2022) Dairy farming systems in Fatick. Multiple Factor Analysis + Hierarchical Classification + k-means | 3 clusters | • Cluster 1: diversified agro-pastoralists weakly integrated into markets.<br>• Cluster 2: transhumant pastoralists with a limited crop base.<br>• Cluster 3: intensive agro-pastoralists oriented toward the dairy market. | Grazing time, milk production and sales, milk price, herd size and composition (exotic/crossbred), use of transhumance, insemination expenses, associated farming practices. |
| HOLPA (2021) Agroecological transition in Fatick. Agroecological indicators + classification | 3 groups | • Group with low adoption of agroecological principles.<br>• Intermediate group.<br>• Group with high adoption. | Level of application of agroecological principles, crop diversity, use of chemical inputs, crop–livestock integration, tree cover, organic fertilization. |
| Habanabakize et al. (2022) Dairy farming systems in Fatick. Multiple Factor Analysis + Hierarchical Classification + k-means | 3 clusters | • Cluster 1: diversified agro-pastoralists weakly integrated into markets.<br>• Cluster 2: transhumant pastoralists with a limited crop base.<br>• Cluster 3: intensive agro-pastoralists oriented toward the dairy market. | Grazing time, milk production and sales, milk price, herd size and composition (exotic/crossbred), use of transhumance, insemination expenses, associated farming practices. |

## Annex 2: Table: Urban livestock system of Fatick Koki Ba et al.

| | Éleveurs pasteurs | Agro-éleveurs urbains | Agro-éleveurs ruraux | Éleveurs spécialisés en lait |
|---|---|---|---|---|
| **Conduite** | Troupeau de brousse en transhumance Noyau laitier en ville | Sédentaire Vaches métisses en semi-stabulation | Transhumance Vaches métisses en semi-stabulation | Races pures en stabulation permanente Métisses en semi-stabulation |
| **Races exploitées** | Locales (zébu gobra) | Locales Métisses | Locales Métisses | Races exotiques Métisses |
| **Alimentation** | Pâturages Un peu de concentrés aux laitières | Pâturages Résidus de récolte Apport de concentrés | Pâturages Résidus de récolte Apport de concentrés | Recours régulier aux concentrés Distribution de grossier (paille, résidus...) |
| **Production laitière** | 3 à 4 litres/jour | 4 à 30 litres/jour | 4 à 20 litres/jour | 15 à 70 litres/jour |
| **Principale débouché** | Marché parallèle | Marché parallèle | Centre de collecte | Centre de collecte |
| **Destination des revenus** | Ménage Alimentation des laitières | Alimentation des vaches Besoins personnels | Entretien du troupeau Besoins de la famille | Alimentation des laitières Main-d'œuvre salariale |

## Annex 3 : Technical references and summary of farming and livestock practices

Table 1: Seed and fertilizer rates for cereal crops

| Crop | Source | Spacing (cm) | Seed rate (kg/ha) | Fertilizers used (type and rate) |
|---|---|---|---|---|
| Millet | DAPSA 2021 | — | 5 kg/ha | NPK 102 kg/ha; Urea 62 kg/ha |
| | FAO Senegal | 80 × 40 cm | 3–10 kg/ha: 4–5 seeds per hill | NPK 15-10-20: 150 kg/ha; Urea: 100 kg/ha |
| | ISRA 2020 | 90 × 90 cm | 3–5 kg/ha | NPK 159 kg/ha; Urea: 100–150 kg/ha; 5–10 t organic matter |
| Sorghum | DAPSA 2021 | — | 10 kg/ha | NPK 74 kg/ha; Urea 29 kg/ha |
| Maize | DAPSA 2021 | — | 17 kg/ha | NPK 106 kg/ha; Urea 84 kg/ha |
| | SAED 2020 | Mechanized ridging: 80 × 20 cm; Manual ridging: 60 × 25 cm | 15–20 kg/ha | NPK 106 kg/ha; Urea 84 kg/ha |
| Rainfed rice | DAPSA 2021 | — | 83 kg/ha | NPK 121 kg/ha; Urea 105 kg/ha |
| | Gueye et al. 2022 | Hill planting: 25 × 20 cm | 40–60 kg/ha: 4–5 grains per hill | NPK 100–200 kg/ha; Urea 100–150 kg/ha |
| | | Row planting: 25–30 cm | 70–80 kg/ha | — |
| Irrigated rice | FAO/ISRA 2022 | 30 × 30 cm | 80–100 kg/ha | NPK 15-15-15: 200 kg/ha; Urea: 100 kg/ha |
| | DAPSA 2021 | — | 95 kg/ha | NPK 133 kg/ha; Urea 199 kg/ha |
| Sesame | DAPSA 2021 | — | 5.5 kg/ha | — |
| Sesame | — | 0.75 × 0.30 cm | 80–150 kg/ha | PK: +25 kg/ha; 1 bag DAP; 1 bag Urea |

Table 2: Seed and fertilizer rates for legume crops

| Crop | Source | Plant spacing (cm) | Seed rate (kg/ha) | Fertilizers and inputs (type and dose) |
|---|---|---|---|---|
| Groundnut (Peanut) | ISRA–FAO | 25–30 between rows | 70–80 | NPK: 100–200 kg/ha Urea: 100–150 kg/ha Basal organic manure: 7–10 t/ha |
| Groundnut (Peanut) | ISRA–FAO | 4–5 seeds per hill | 40–60 | – |
| Groundnut (Peanut) | DAPSA 2021 | – | 66 | NPK: 103 kg/ha |
| Forage cowpea | CNRADA, 2023 | 20 × 15 | 40–50 for forage production 10–12 for seed production | – |
| Cowpea | DAPSA 2021 | – | 14 | NPK: 104 kg/ha |
| Cowpea | Agrivision Sahel | – | 20 | Organic manure: 20 cartloads/ha Herbicide: 1 L/ha Pesticides: 4 L/ha |
| Cowpea | Ahonssou et al. | On ridges: 60 × 40 (2–3 seeds per hill) | 20–30 | Urea: 35 kg/ha Triple superphosphate: 100 kg/ha Potassium: 50 kg/ha |

Table 3: Seed and fertilizer rates for vegetable crops (Source: ISRA CDH, 2022)

*All quantities refer to* **100 m²** *of cultivated area unless otherwise stated.*

| Crop | Phase | Seed quantity | Fertilization and inputs (per 100 m²) | Plant spacing (rows × plants) |
|---|---|---|---|---|
| Tomato | Nursery | 3 g on 3 m² nursery | – | Nursery rows 20 cm apart |
| | Main crop | – | Basal: 200–300 kg organic matter (OM) + 4 kg NPK 10-10-20 Top dressing: 2 kg at 15, 30, 50, 80 days | Double rows: 0.5 m (determinate) / 1 m (indeterminate); 0.4–0.5 m in-row (staggered) |
| Lettuce | Nursery | 3–5 g on 3–5 m² | – | – |
| | Transplanting | – | Basal: 150–250 kg OM + 2.5 kg NPK Top dressing: 2.5 kg at 20 days, 4 kg at 40 days | 25–35 cm between and within rows |
| Chili pepper | Nursery | 4 g on 2 m² | – | – |
| | Main crop | – | Basal: 150–200 kg OM + 3 kg NPK Top dressing: 1.5 kg every 3–4 weeks | Double rows: 0.4–0.8 m; 0.4–0.8 m in-row |
| Bean (dwarf / climbing) | Direct sowing | 0.5–1 kg (dwarf); 0.25–0.3 kg (climbing) | Basal: 100–150 kg OM + 2 kg NPK Top dressing: 1.5 kg at 20 & 40 days | Dwarf: 3 rows at 0.4 m/bed Climbing: 2 rows at 0.7 m; 0.5 m between hills |
| Eggplant | Nursery | 3 g on 1 m² | – | – |
| | Main crop | – | Basal: 200–300 kg OM + 5 kg NPK Top dressing: 2.5 kg at 40, 60, 80 days | Double rows: 0.5 m; 0.75 m in-row (staggered) |
| Onion | Nursery | 60 g on 12 m² | – | – |
| | Main crop | – | Basal: 100–200 kg OM + 2.5 kg NPK Top dressing: 2–3 kg at 35 days | 5–7 rows/bed at 20 cm; 10 cm in-row |
| Roselle (Bissap) | Direct sowing | 30–50 g | Basal: 100–200 kg OM + 3 kg NPK Top dressing: 2 kg at 30, 50, 90 days | Single rows: 0.8–1 m; 0.4–0.6 m between hills |
| Sweet pepper | Nursery | 2 g on 2 m² | – | – |
| | Transplanting | – | Basal: 150–250 kg OM + 5 kg NPK Top dressing: 2 kg at 15, 30, 50, 80 days | 2 rows/bed at 0.4–0.5 m; 0.4–0.5 m in-row |
| Watermelon | Direct sowing | 25–50 g (3–4 seeds/hill) | Basal: 200–300 kg OM + 2.5 kg NPK Top dressing: 2.5 kg at 40 days | Rows 2 m apart; 0.75–1.5 m between hills |
| Okra | Direct sowing | 50–100 g (3 seeds/hill) | Basal: 100–200 kg OM Top dressing: 2 kg at 30, 50, 70 days | Rows: 0.9 m; 0.4–0.5 m in-row |
| Sweet potato | Cuttings | 200 (dry season) to 330 (cool season) cuttings | 50–150 kg OM + 5 kg NPK Top dressing: 4 kg after 1 month | Rows: 1 m; 0.3 m (dry) / 0.5 m (rainy) |
| Potato | Tubers | 16–46 kg tubers | 150–200 kg OM + 2.5 kg NPK Top dressing: 2.5 kg at 2 & 5 weeks | 2–3 rows at 0.6 m; 0.3 m in-row |

| | | | | |
|---|---|---|---|---|
| Carrot | Direct sowing | 1–3 g per 10 m row | 100–200 kg OM + 5 kg NPK Top dressing: 3 kg at 20 & 40 days | Rows: 0.2–0.3 m; beds 1 m wide |
| Zucchini | Direct sowing | 40–60 g (2–3 seeds/hill) | 150–250 kg OM + 3.5 kg NPK Top dressing: 2.5 kg at 3, 5, 8 weeks | 2 rows/bed at 0.75–1 m |
| Pumpkin | – | 5,000–9,000 plants/ha | – | 90 × 120 cm |
| Cauliflower | Sowing | 6–7 g on 2 m² | – | – |
| | Transplanting | – | 200–300 kg OM + 3 kg NPK Top dressing: 2 kg at 20–35 days | 3 rows/bed at 0.4–0.5 m; 0.5 m in-row |
| Turnip | – | 30 plants/m² | – | – |
| Cassava | Planting | – | Basal: 50–100 kg OM + 6 kg NPK | Rows: 0.85–1 m; 1 m between cuttings |
| | – | 10,000 plants/ha | – | 1.33 × 0.75 m or 1 × 1 m |
| Cucumber | Direct sowing | 10–25 g (2–4 seeds/hill) | 300–400 kg OM + 4 kg NPK Top dressing: 2 kg at 4–8 weeks | 2 rows at 1.5–2 m (1 m if staked); 0.4–0.5 m in-row |

Table 4: Seed/planting density and fertilization for fruit trees

| Crop | Source | Spacing | Planting density | Fertilizers used (type and rate) |
|---|---|---|---|---|
| Mango | Ndiritu – Mango fertilization | 10 × 10 m | ~150 trees/ha | – |
| Mango | FAO Senegal | 80 × 40 cm | 3–10 kg seed/ha; 4–5 seeds per hill | NPK 15-10-20: 150 kg/ha; Urea: 100 kg/ha |
| Mango | ISRA, 2020 | 90 × 90 cm | 3–5 kg/ha | NPK: 159 kg/ha; Urea: 100–150 kg/ha; 5–10 t organic matter (OM) |
| Guava | Martinique Chamber of Agriculture, 2014 | 6 × 6 m or 7 × 5 m | 278–286 trees/ha | – |
| Soursop (Corossol) | Agroconseilong, 2025 | 6 × 6 m | ~275 plants/ha | – |
| Pomegranate | Habi et al., 2023 | 5 × 5 m | ~400 trees/ha | – |
| Lemon | CIRAD, 2008 | – | 285–416 plants/ha | – |
| Papaya | Technisem | 60 × 70 cm | Nursery: 300 g seed/ha | – |
| Citrus (general) | Citrus crop guide | – | ~555 plants/ha | – |

OM = Organic matter

Table 5: Citrus – Crop Technical Sheet

| Age des Plants (ans) | N | P205 | K20 |
|---|---|---|---|
| 1 | 40 | 12 | 25 |
| 2 | 60 | 18 | 30 |
| 3 | 70 | 20 | 40 |
| 4 | 80 | 25 | 70 |
| 5 | 90 | 25 | 80 |
| >5 | 100-140 | 35-50 | 80-140 |

Table 6: Cashew – Mineral NPK fertilizer formulas for improved cashew nut yields according to plantation age in Central and Northern Benin (N'Diolossè et al.)

| Cashew tree age | NPK formula | Dose per tree per year | Fertilizer sources used | Urea (46% N) | TSP (46% $P_2O_5$) | $K_2SO_4$ (50% $K_2O$) |
|---|---|---|---|---|---|---|
| 7–9 years | N12P12K25 | 1.0 kg | Urea, TSP, Potassium sulfate | 544 g | 544 g | 1000 g |
| 3–5 years | N15P15K17 | 0.80 kg | Urea, TSP, Potassium sulfate | 580 g | 580 g | 533 g |

Table 7: Pesticides by crop (active ingredients from the Senegalese Standard APNS-03-024)

| Crop | Pesticide Type | Active Ingredients (APNS-03-024) | Source | Crop |
|---|---|---|---|---|
| Tomato | Insecticides | Lambda-cyhalothrin; Cypermethrin; Acephate; Chlorpyrifos-ethyl; Imidacloprid | APNS-03-024, Annex 6 | Tomato |
| | Fungicides | Mancozeb; Metalaxyl; Propiconazole; Difenoconazole | APNS-03-024 | |
| Onion | Insecticides | Cypermethrin; Lambda-cyhalothrin; Chlorpyrifos-ethyl; Imidacloprid | APNS-03-024 | Onion |
| | Fungicides | Mancozeb; Metalaxyl; Difenoconazole | APNS-03-024 | |
| Chili / Sweet pepper | Insecticides | Lambda-cyhalothrin; Cypermethrin; Acephate; Chlorpyrifos; Imidacloprid | APNS-03-024 | Chili / Sweet pepper |
| | Fungicides | Mancozeb; Metalaxyl | APNS-03-024 | |
| Eggplant | Insecticides | Lambda-cyhalothrin; Cypermethrin; Acephate | APNS-03-024 | Eggplant |
| | Fungicides | Mancozeb; Difenoconazole | APNS-03-024 | |
| Cucumber / Melon / Watermelon (Cucurbits) | Insecticides | Lambda-cyhalothrin; Cypermethrin; Imidacloprid | APNS-03-024 | Cucumber / Melon / Watermelon (Cucurbits) |
| | Fungicides | Mancozeb; Metalaxyl | APNS-03-024 | |
| Carrot | Insecticides | Cypermethrin; Lambda-cyhalothrin | APNS-03-024 | Carrot |
| | Fungicides | Mancozeb; Difenoconazole | APNS-03-024 | |
| Groundnut | Insecticides | Chlorpyrifos-ethyl; Cypermethrin; Lambda-cyhalothrin | APNS-03-024 | Groundnut |
| | Fungicides | Mancozeb; Metalaxyl | APNS-03-024 | |
| Millet / Sorghum / Maize | Insecticides | Acephate; Lambda-cyhalothrin; Cypermethrin; Imidacloprid | APNS-03-024 | Millet / Sorghum / Maize |
| Cowpea | Insecticides | Lambda-cyhalothrin; Cypermethrin; Acephate; Imidacloprid | APNS-03-024 | Cowpea |
| Leafy crops (roselle leaves, cabbage, lettuce) | Insecticides | Lambda-cyhalothrin; Cypermethrin; Acephate | APNS-03-024 | Leafy crops (roselle leaves, cabbage, lettuce) |
| | Fungicides | Mancozeb; Difenoconazole | APNS-03-024 | |

Table 8: Pesticides used on crops in the Sahel zone

| Nom commercial | Substances actives et concentrations | Type | Classe de toxicité OMS | Statut d'homologation | Domaine d'utilisation autorisé |
|---|---|---|---|---|---|
| CONFIDOR | Cypermethrine | Insecticide | | NON | - |
| DECIS 12 E | Deltamethrine 12 g/l | Insecticide | | NON | - |
| DECIS 25 | Deltamethrine 25 g/l | Insecticide | II | NON | - |
| DICOFOL | Dicofol 480 g/l | Insecticide | | NON | - |
| DURSBAN | Chlorpyriphos-ethyl 480 g/l | Insecticide | II | NON | Insecticide contre les ravageurs des agrumes, du caféier, du cotonnier et des cultures maraichères |
| FONGEX C | Metalaxyl<br>Chlorotalonil<br>Cuivre | Fongicide | | NON | - |
| FURADAN | Carbofuran 50 g/kg | Nématicide | II | NON | - |
| KELTHANE | Dicofol 480 g/l | Insecticide | | NON | - |
| MALATHION | Malathion 500 g/l | Insecticide | | NON | - |
| MALATHION 500 | Malathion 500 g/l | Insecticide | | NON | - |
| MANÈBE | Manèbe 800 g/kg | Fongicide | | NON | - |
| METOFOS 600 | Méthamidophos 600 g/l | Insecticide | | NON | - |
| ROCKY 500 EC | Endosulfan 500 g/l | Insecticide | Ib | NON | - |
| SOUFRE 80 | Soufre 800 g/kg | Fongicide | | NON | - |
| SUNEEM 1% EC | Azadirachtine 10 g/l | Insecticide | III | NON | Insecticide biologique utilisé contre les insectes du cotonnier |
| TERSEN 426 | Cyperméthrine 36 g/l<br>Dimethoate 240 g/l<br>Triazophos 150 g/l | Insecticide | II | NON | - |
| DIMETHOATE | Dimethoate 400 g/l | Insecticide | | NON | - |
| BOMEC | Abamectine | Insecticide | | NON | - |
| PASCHMINE | | | | NON | - |
| K-OPTIMAL | Lambdacyhalothrine 15 g/l<br>Acetamipride 20 g/l | Insecticide | II | NON | Insecticide utilisé contre les insectes ravageurs du chou |
| TRIFLUROLINE | Trifluralin 480 g/l | Herbicide | | NON | - |
| GALLONFORT | | | | NON | - |
| ALLIGATOR 400 EC | Pendimethaline 400 g/l | Herbicide | III | OUI | Herbicide autorisé contre les adventices en prélevée du maïs |
| GLYPHOSATE 41% | Glyphosate | Herbicide | | NON | - |
| HERBEXTRA 750 | 2,4 D sel d'amine | Herbicide | | NON | - |
| OXADIAZON 25% | Oxadiazon | Herbicide | | NON | - |
| BENSULFURON METHYL | Bensulfuronmethyl 60% | Herbicide | | NON | - |
| ATRAFOR 500 SC | Atrazine | Herbicide | | NON | - |
| MICLO | Myclobutanyl | Fongicide | | NON | - |
| ORTIVA | Azoxystrobyne | Fongicide | | NON | - |
| PACHA 25 EC | Acetamipride 10 g/l<br>Lambdacyhalothrine 15 g/l | Insecticide | II | NON | Insecticide utilisé contre les chenilles, les mouches blanches et les pucerons des cultures maraichères |
| CALLIDIM 400 EC | Dimethoate | Insecticide | II | NON | - |
| DIMEX 400 EC | Dimethoate | Insecticide | | NON | - |
| TRANOX | Chlorothalonil | Fongicide | | NON | - |

Table 9: Mortality Rates of Livestock (EAA 2022–2023, DAPSA 2023)

| Livestock Type | Cattle | Sheep | Goats | Chic ken | Pigeon | Pigs | Rabbits | Donkeys | Horses |
|---|---|---|---|---|---|---|---|---|---|
| Mortality Rate | 39% | 34% | 40% | 22% | 23% | 33% | 63% | 76% | 76% |

Table 10: Birth Rates of Livestock (EAA 2022–2023, DAPSA 2023)

| Livestock Type | Cattle | Sheep | Goats | Chic ken | Pigeon | Pigs | Rabbits | Donkeys | Horses |
|---|---|---|---|---|---|---|---|---|---|
| Birth Rate | 93% | 88% | 95% | 37% | 83% | 95% | 70% | 88% | 77% |

Table 11: Sheep Birth and Mortality Rates (ANSD, 2025)

| Indicators | 2020 | 2021 | 2022 |
|---|---|---|---|
| Average number of live-born animals per livestock household | 3.3 | 4.9 | 3.8 |
| Average number of dead animals per livestock household | 1.6 | 2.9 | 3.2 |
| Total number of live-born animals | 1,581,291 | 1,486,804 | 1,295,587 |
| Total number of dead animals | 742,397 | 328,950 | 449,175 |

Table 12: Conversion Rates of Straw into Manure/Compost by Crop Biomass Type (Chamber of Agriculture)

| | Prix unités fertilisantes/prix des engrais | | | Valeur agronomique | | |
|---|---|---|---|---|---|---|
| | Prix unités N (€) | Prix unités P2O5 (€) | Prix unités K2O (€) | Paille (€/t) | Fumier (€/t) | 1 tonne de paille équivaut |
| 2021 | 1,10 | 1,03 | 0,50 | 24,1 | 18,3 | 1,32 t fumier |
| 2022 | 2,25 | 1,25 | 0,92 | 39,4 | 28,3 | 1,39 t fumier |
| 2023 | 1,26 | 1,13 | 0,89 | 31,5 | 21,8 | 1,44 t fumier |
| 2024 (mai)* | 1,07 | 1,03 | 0,64 | 24,4 | 18,1 | 1,35 t fumier |
| Moyenne** | 1,18 | 0,78 | 0,64 | 28,1 | 20,4 | 1,38 t fumier |

Equivalence

**Straw → Manure Conversion Coefficient**: Based on the linear relationship: Manure DM=k×Straw DM\text{Manure DM} = k \times \text{Straw DM}Manure DM=k×Straw DM and according to the work of Hamon (1972, Senegal) and Berger (1996, Burkina Faso), the range for kkk is: 1.5<k<1.71.5 < k < 1.71.5<k<1.7. This means that 100 kg of straw DM added to animal excreta produces between 150 and 170 kg of manure DM.

**Manure Yield (R) per Livestock Unit (LU):** R is expressed in t DM of manure per LU per year. Stabling / Stall feeding: R = 0.65 t DM (Hamon, 1972); R = 0.50 t DM (Fernandez-Riviera, 1995) → 1 cow produces 650 kg DM of manure/year in a stall. Wintering yards: R = 1.20 t DM (Berger, 1996) → 1 cow produces 1,200 kg DM of manure/year.

**Source: CIRAD, 1996 – Organic Fertilization: Improved Techniques for Sustainable Agriculture**. Examples of Crop Residue Conversion: For a sorghum crop yielding 600 kg/ha of grain, the field produces on average 1 t of straw, which can be transformed with appropriate techniques into 1.5 t of manure at 30% organic matter (dry matter basis). 2 t of maize stalks yield 1 t of humified residues after mixing and composting, which produces 1.5 t of manure.

**EquuRES Label:** Managing manure from production to application according to regulations. Equines – Horses: If straw is used as bedding, the annual manure production can be estimated as: Amount of straw consumed×3=Amount of manure produced\text{Amount of straw consumed} \times 3 = \text{Amount of manure produced}Amount of straw consumed×3=Amount of manure produced.

Table 13 : To recapitulate

| Biomass / Crop | Quantity (t DM) | Product Obtained | Product Quantity (t DM) | Conversion Type | Reference |
|---|---|---|---|---|---|
| Sorghum straw | 1 | Manure | 1.5 | Straw + animal excreta → manure | CIRAD, 1996 |
| Maize stalks | 2 | Humified residues / manure | 1 | Composting / humification (no animal manure) | CIRAD, 1996 |
| Straw + animal excreta (general) | 0.1 | Manure | 0.15 – 0.17 | Straw → manure conversion coefficient: k = 1.5–1.7 | Hamon, 1972 (Senegal); Berger, 1996 (Burkina Faso) |

Table 14: Composition of Groundnut (Peanut) Foliage and Concentrates

*FAO Study – Peanut Foliage: Effect of watering frequency and cereal supplementation of peanut foliage on feed intake, nutrient digestibility, and nitrogen and phosphorus balance in Sahelian sheep.*

| Parameter | Groundnut Foliage | Concentrate |
|---|---|---|
| Dry Matter (% of feed) | 93.42 | 91.97 |
| Crude Protein (% of DM) | 13.6 | 14.35 |
| Fat (% of DM) | 2.42 | 5.67 |
| Crude Fiber (% of DM) | 31.95 | 4.1 |
| Ash / Mineral Matter (% of DM) | 5.19 | 2.14 |
| Calcium (% of DM) | 0.78 | 0.17 |
| Phosphorus (% of DM) | 0.14 | 0.25 |

Table 15: Feed Composition and Nutritional Values

*Growth-Fattening Performance and Carcass Characteristics of Lambs of Ladoum, Touabire, and Peul-peul Breeds Fed Ad Libitum in the Niayes Region of Senegal, Ayssiwede et al., 2023*

| Parameter | Concentrate | Groundnut Foliage |
|---|---|---|
| Dry Matter (% of total feed) | 89.8 | 87.1 |
| Ash / Mineral Matter (% of feed) | 3.6 | 8.7 |
| Crude Protein (% of feed) | 15.3 | 11.1 |
| Fat (% of feed) | 4.2 | 0.6 |
| Crude Fiber (% of feed) | 4.9 | 24.0 |
| Calcium (% of feed) | 0.6 | 1.1 |
| Phosphorus (% of feed) | 0.6 | 0.2 |
| Sodium (% of feed) | 0.1 | 0.02 |
| PDIN (g/kg DM) | 119.4 | 89.7 |
| PDIE (g/kg DM) | 131.9 | 107.1 |
| Energy (UFL/kg DM) | 1.13 | 0.72 |

Table 16: Protein, Energy, Calcium, and Phosphorus Requirements of Broiler Chickens

*Small Livestock Rearing Manual for the PANA ASA Project Intervention Areas*

| AGE | PB( %) | Lysine (%) | Méthionine (%) | Méthionine + Cystine | EM kcal/Kg | Ca (%) | P (%) |
|---|---|---|---|---|---|---|---|
| Poussins 0 à 21 jours | 23 | 1,2 | 0,47 | 0,92 | 3100 | 1,1 | 0,7 |
| Poulets 21 à 28 jours | 20 | 1,03 | 0,44 | 0,82 | 3200 | 0,9 | 0,68 |
| 28 à 56 jours | 18,5 | 0,94 | 0,38 | 0,77 | 3200 | 0,8 | 0,62 |

Table 17: Feed Consumption of Broiler Chickens

| AGE EN SEMAINE | QUANTINTE D'ALIMENT /POULET/SEMAINE (g) |
|---|---|
| 1 | 90 |
| 2 | 230 |
| 3 | 465 |
| 4 | 735 |
| 5 | 845 |
| 6 | 1065 |
| 7 | 1085 |
| 8 | 1150 |
| 9 | 1225 |

# Annex 4: Highlights of the workshop

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