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Characteristics and management method of agro-pastoral waste in the agricultural watershed of Sassandra case of the departments of Sassandra, Soubré, Daloa and Issia

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ABSTRACT: The management of agro-pastoral waste remains a major concern in countries with high agricultural potential such as Côte d'Ivoire, due to the pollution of environmental components resulting from its poor management. This work aims to identify the different types of agro-pastoral waste generated in the departments of Soubré, Issia, Sassandra and Daloa. It also aims to provide information on the quantities of residues available and to identify the management method for this waste. To do this, some fields of observations were made to identify the different types of waste then based on agricultural statistical data from the Ministry. The quantities of agro-pastoral residues were estimated. A survey was also conducted from a survey sheet of agropastoral residue holders to identify the management method. It appears that in these localities, we find as crop residues, rice straw and husk, stalks, cobs and pobs of maize and cassava, bunches and palm shells, cocoa fibers and pods, shells of coffes. Livestock waste is made up of slurry, liquid manure, manure, bones, feathers and droppings and comes from animals such as cattle, sheep, goats, pigs and poultry. The quantities of crop residues estimated are 236,123.3 t/year in Daloa, 255,000 t/year in Issia, 290,000 t/year in Soubré and 198,221.4 t/year in Sassndra. Livestock waste is 728.8 t/year in Daloa, 3,606.1 t/year in Issia, 2,442.6 t/year in Soubré and 873.4 t/year in Sassndra. In these localities, 85% of planters abandon their residues in the fields, 12% of planters incinerate them in the open air and 3% compost them.

KEYWORDS: Waste management, agropastoral, Sassandra, Daloa, Issia, Soubré, Cote d'Ivoire.

1 INTRODUCTION

Improving the productivity of agricultural systems is one of the major challenges that countries have focused. Their economic development on the agricultural sector should take up to ensure the food security of populations [1]. The recycling of agro-pastoral residues is considered as one of the most important means of maintaining soil fertility and improving crop productivity [2]; [3]; [4]; [5]. Indeed, crop produces a large quantity of residues that can contribute to the improvement of soil fertility through soil cover and organic restitutions [6] However, most crop residues are incinerated in the open air or left in the fields. Open air burning is a source of significant emissions of polluting substances which, by degrading air quality, have general health consequences. Beyond the nuisance generated by odors and smoke, as well as the risk of fire, open-air burning emits significant levels of gas (CO2, Nox, CO) and particles. These particles carry carcinogenic compounds such as PAHs, dioxins and furans, benzene. Agricultural waste burning contributes significantly to the problem of open waste burning in Côte d'Ivoire. However, open waste burning, is the main source of pollutants harmful to the natural environment. It is the main method available for the majority of African cities, where it is estimated that up to 90% of the waste. It is burned in the open air [7];

[8]; [9]. Emissions from burning waste in the open air have a direct or indirect impact on health include: short-lived climate pollutants (SLCPs) such as black carbon (CB) and methane, particulate matter (PM), persistent organic pollutants (POPs) such as dioxins and furans, and polycyclic aromatic hydrocarbons (Cogut, 2016; PNUE, 2018; Velis and Cook, 2021). In addition, methane generated from the decomposition of organic waste contributes about 20% of global methane [10], while open waste burning is responsible for 11% of black carbon. Methane and black carbon are short-lived climate pollutants that contribute to climate change [11]. This study aims to characterize agro-pastoral waste, to assess its availability, and to determine its management methods.

2 MATERIALS AND METHODS

2.1 STUDY AREA

The departments of Daloa, Soubré, Sassandra and Issia belong to the agricultural watershed of Sassandra, particularly in the center-west (Daloa and Issia) and south-west (Soubré and Sassandra) of Côte d'Ivoire. The departments of Daloa and Issia are located between longitudes 5°75 and 8°16 West and latitudes 5°56 and 9°75 North [12]. As for the departments of Sassandra and Soubré, they are located between longitude 7°08 and 6°12 West and latitude 5°19 and 6°34 North. The areas of these localities are 5,658 km2 for Issia, 38.76 km2 for Daloa, 8,500 km2 for Soubré, and 25,800 km2 for Sassandra. Issia and Daloa belong to the attenuated transition equatorial regime [13]. The departments of Daloa, Soubré, Sassandra and Issia belong to the agricultural watershed of Sassandra, particularly in the center-west (Daloa and Issia) and south-west (Soubré and Sassandra) of Côte d'Ivoire. The departments of Daloa and Issia are located between longitudes 5°75 and 8°16 West and latitudes 5°56 and 9°75 North [12]. As for the departments of Sassandra and Soubré, they are located between longitude 7°08 and 6°12 West and latitude 5°19 and 6°34 North. The areas of these localities are 5,658 km2 for Issia, 38.76 km2 for Daloa, 8,500 km2 for Soubré, and 25,800 km2 for Sassandra. Issia and Daloa belong to the attenuated transition equatorial regime [13]. As for Soubré and Sassandra, they are located in the equatorial transitional regime. The climate of these four localities is characterized by two rainy seasons (between April-June and September-November) and two dry seasons (July-August and December-March) [14]. The departments of Soubré and Sassandra have a relief characterized by vast plateaus surmounted in places by a few elevations made up of hills. The departments of Daloa and Issia have a relief characterized by soils, developed on ancient eruptive rocks, which are mainly ferralitic soils, strongly altered, often very stony in profile, chemically poor, with a texture varying between clayey silt and loamy sand. They are deep, permeable and well drained, very fertile and well suited to all types of food and industrial crops [15].

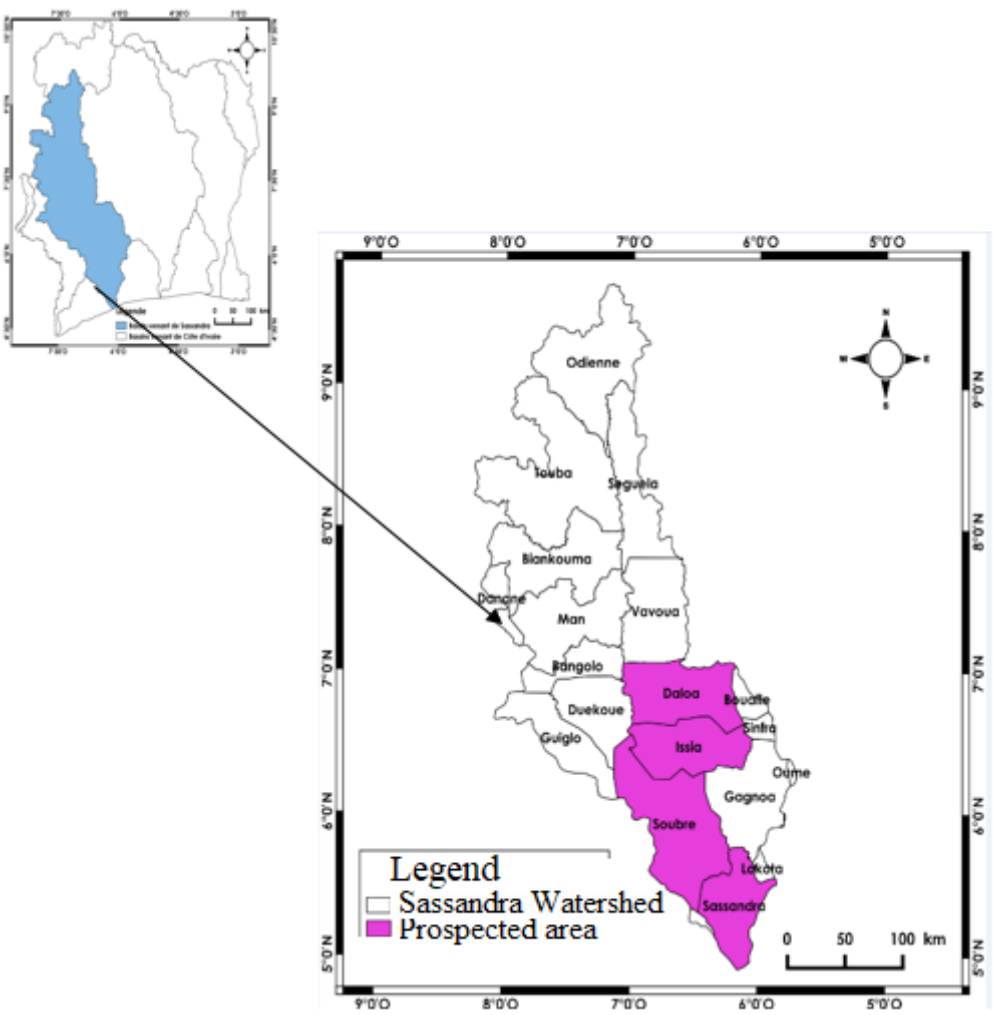

Fig. 1. Study area localisation

2.2 MATERIAL

The material used for the development of this study is agricultural statistical data from 2021 provided by the Directorate of Statistics, Documentation and Information Technology of the Ministry of Agriculture of Côte d'Ivoire. The quantities of agro-pastoral residues generated for each type of residue were estimated using FAO productivity indices [16]. And a survey sheet addressed to waste holders to understand the management method of agro-pastoral waste generated in the localities of Soubré, Issia, Sassandra and Daloa.

2.3 METHOD

2.3.1 IDENTIFICATION OF THE TYPE OF WASTE

The field observation technique provided an overview of the crop waste produced in the departments of Soubré, Sassandra, Daloa and Issia during visits to the various farms.

2.3.2 ESTIMATION OF AGRO - PASTORAL WASTE QUANTITIES

The quantities of residues (QR) from the crops were determined from the relation (1) described according to **FAO** [16]:

$$QR = m\ x\ Cres \quad (1)$$

Where:

m: Mass of the production for the considered crop (kg),

Cres: Coefficient relating to the quantity of residues generated according to agricultural production.

The values of Cres and Ip used are consign in Table 1.

Table 1. Cres values FAO [16],

Crops	Wastes	Cres
	Straw	1.757
Rice	*Husk*	0.267
	Stalk	0.20
Maize	*Cob*	0.273
	Stem	2.00
	Cluster	0.23
Palm oil	*Fiber*	0.14
	Shell	0.065
Cocoa	*Pods*	1.00
Coffee	*Shell*	2.10
Cassava	*Stem*	0.62

The annual quantities of animal manure (ADQ) were calculated using the relation (2).

$$QDA\ (kg) = POPan\ x\ QMO\ x\ n \quad (2)$$

With:

POPan: Animal population of the type of breeding considered;
QMO: Daily quantity of organic matter (kg/head);
n: Number of days in the year.

The QMO values used to perform the calculations are recorded in Table II.

Table 2. Mean QMO values used to calculate manure amounts [16]; [17]

Type of animals	Cattle (250-400 kg)	Sheep (45 kg)	Goat (45 kg)	Pigs (30-80 kg)	Poultry (0,5 kg)
QMO (kg/head)	2	0,6	0,6	0,32	0,04

2.3.3 DETERMINATION OF THE AGRO-PASTORAL WASTE MANAGEMENT METHOD

To collect data relating to the mode of management of agro-pastoral waste in the localities of Sassandra, Issia, Soubré and Daloa, a survey sheet was sent to the planters. The size of the sample of the surveyed population was constituted using the simple random sampling method [18]. This sampling method is characterized by an equal probability of selection of all sampling units, each unit being chosen independently of the others [19]. A total of 680 planters, including 170 in each of the four (4) localities concerned, were interviewed in this study. More plantations were visited to observe the methods of waste management practiced by the planters. A total of 52 plantations were visited, including 10 in Daloa, 16 in Issia, 12 in Soubré, and 14 in Sassandra. The choice of plantations was made randomly. The data collected has been digitally processed. These data were coded and the relative frequencies of each variable were calculated in relation to the number of growers surveyed according to formula 3:

$$F = \frac{nj}{n} \times 100 \quad (3)$$

With:

F: Frequency (%);
nj: Modality workforce (the variable);
n: Total workforce of the variable.

3 RESULTS

3.1 TYPOLOGY OF AGRO-PASTORAL WASTE OBSERVED IN THE LOCALITIES OF DALOA, ISSIA, SASSANDRA AND SOUBRÉ

3.1.1 TYPOLOGY OF CROP RESIDUES OBSERVED IN THE LOCALITIES OF DALOA, ISSIA, SASSANDRA AND SOUBRÉ

Crop residues are made up of cluster, fibre, shell, pod, straw, husk, cobs, cob and stalk. This waste comes from cocoa (pod), coffee (hull), oil palm (cluster, fibre, hull, straw), cassava (stem), corn (cob, stalk, stalk) and rice (straw, husk) crops, stem) (Table III).

Table 3. Type of residues observed depending on the crops

Cultures	Type de résidu
Cassava	*Stem*
Rice	Straw Husk
Cocoa	*Pods* *Shell*
Coffee	*Shell*
Palm oil	Cluster Fiber *Shell*
Maize	Stalk Cob *Stem*

3.1.1.1 TYPOLOGY OF LIVESTOCK RESIDUES OBSERVED IN THE LOCALITIES OF DALOA, ISSIA, SASSANDRA AND SOUBRÉ

Livestock waste is made up of slurry, sewage, manure, bones, feathers and animal waste and comes from animals such as cattle, sheep, goats, pigs and poultry (Table IV).

Table 4. Type of residues according to the type of animal

Type of animals	Type of residue
Poultry	droppings
Cattle	manure
Pigs	pig manure
Sheep	sheep manure
Goat	Goat weed

3.2 QUANTITIES OF AGRO-PASTORAL RESIDUES

3.2.1 QUANTITIES OF AGRICULTURAL RESIDUES AVAILABLE IN THE LOCALITIES

The quantities of agricultural waste available in the localities visited are shown in Figure 2. It can be seen that the locality of Soubré has the highest quantities of agricultural residues with a quantity of 290,000 t/year. This locality is followed by that of Daloa with 236,123.3 t/year of waste, then that of Issia with 255,000 t/year of waste. The locality of Sassandra has the lowest

quantities of tailings with 198,221.4 t/year. The total annual quantity of agricultural residues that can be mobilized in these localities is 930,220.8 t/year.

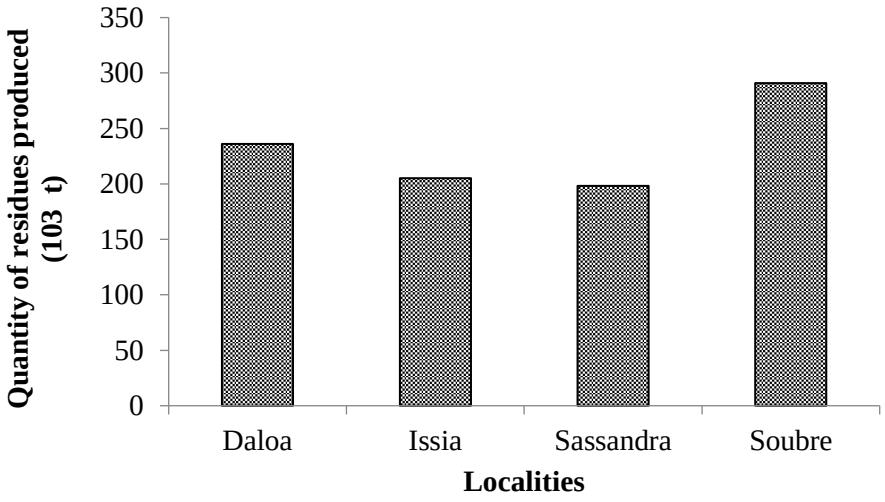

Fig. 2. WS Quantities of agricultural waste available by locality

3.2.1.1 QUANTITIES OF WASTE BY TYPE OF RESIDUE

The quantities of waste vary according to the type of residue considered. The pods and the stems are the most available residues with respectively 465,266 t and 175,000 t/year. While bales (12,000 t/year) and graphs (10,987 t/year) are the least available (Figure 3).

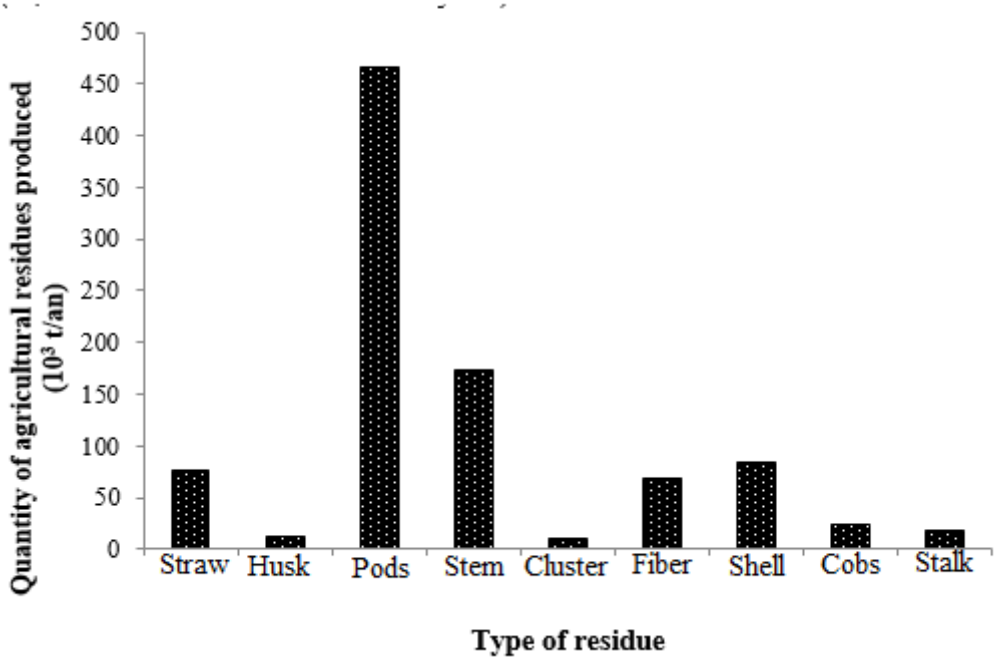

Fig. 3. Annual quantities of agricultural residues available in the localities investigated by type of residue

3.2.1.2 AVAILABILITY OF AGRICULTURAL RESIDUES BY TYPE OF RESIDUE AND BY LOCALITY VISITED

The quantities of residues available by type of residue and by locality are shown in Figure 4. It appears that pods are available in large quantities (272,295.6 t/year) in Soubré and Issia (132,244 t/year). As for stems (145,058.2 t/year), cobs (19,671 t/year), stalks (14,411 t/year) and straw (33,383 t/year), the highest quantities are recorded at Daloa. However, hulls (41,900.4 t/year) are more important at Issia. The fibers are only available in the locality of Sassandra. The highest quantities of bunches are recorded in the locality of Sassandra (8,910.2 t/year).

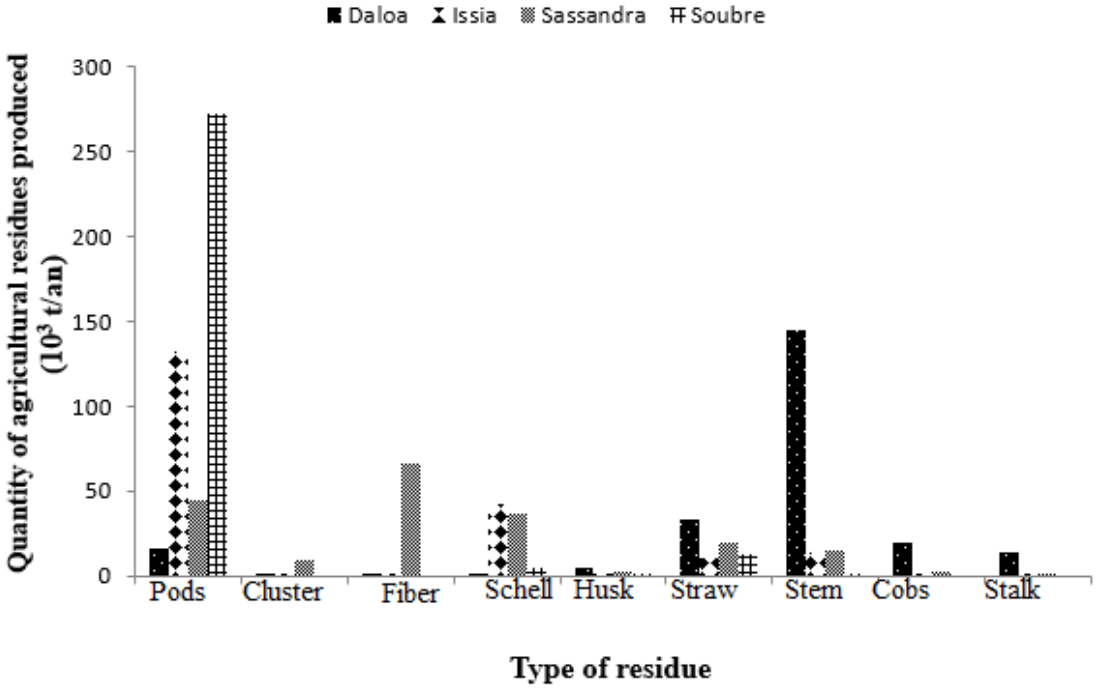

Fig. 4. Annual quantities of agricultural residues available by type of residue and locality studied

3.2.2 QUANTITIES OF LIVESTOCK WASTE

3.2.2.1 QUANTITIES OF LIVESTOCK WASTE AVAILABLE BY LOCALITY

Animal droppings are unequally distributed in the localities investigated. Issia has the highest quantities of waste (3606.1 t). This locality is followed by that of Soubré with 2442.6 t, then that of Sassandra (873.4 t) and finally the locality of Daloa (728.8 t) (Figure 5).

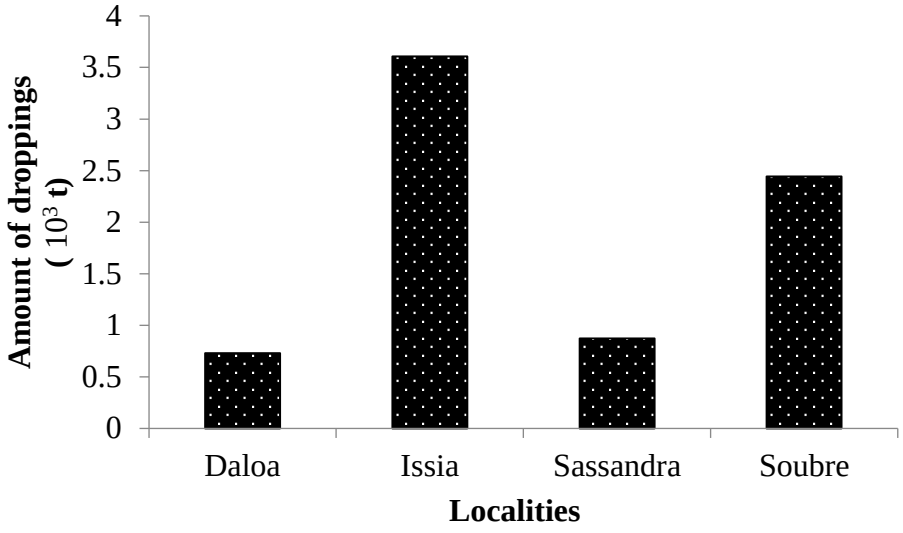

Fig. 5. Quantities of animal waste by WS locality

3.2.2.2 QUANTITIES OF WASTE AVAILABLE BY TYPE OF LIVESTOCK

Figure 6 shows the quantities of waste available by type of livestock in the agricultural watershed of Sassandra. These quantities of waste vary according to the type of farming practiced, namely the farming of cattle, sheep, goats, pigs and poultry. The highest quantities (2,469.5 t/year) are provided by cattle breeding, while the lowest are obtained with pig breeding (354.7 t/year). Sheep, goats and poultry farming produce 2,267.5 t/year respectively; 1,847.0 t/year and 712.1 t/year of waste. In total, the Sassandra agricultural basin has 7,651.0 t/year of livestock waste.

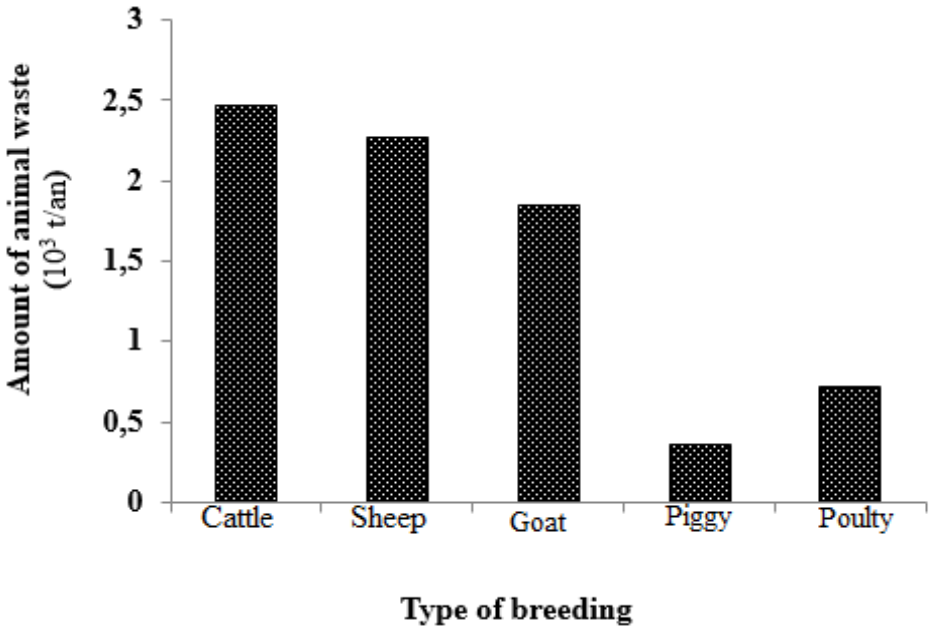

Fig. 6. Annual quantities of waste available by type of livestock in the localities considered

3.2.2.3 QUANTITIES OF WASTE AVAILABLE BY TYPE OF LIVESTOCK AND BY LOCALITY

The quantities of waste available by type of livestock farming and by locality in the agricultural basin of Sassandra are shown in Figure 23. It appears that the largest quantities of waste from cattle farming are recorded in Soubré (892.7 t /year) and Issia (842.4 t/year) while the lowest are recorded in the department of Daloa (332.8 t/year). Regarding sheep waste, the highest quantities come from the departments of D'Issia (1946.6 t/year) and the lowest are recorded in the department of Daloa (75.5 t/year). As regards goats, the quantities are higher in Soubré (1243.4 t/year) and lower in Sassandra (76.65 t/year). As for manure from pig farming, the quantities are substantially identical in all the localities investigated. With regard to manure from poultry, the highest quantities are recorded in the departments of Issia (305.54 t/year). The lowest are recorded in the department of Soubré (129.9 t/year).

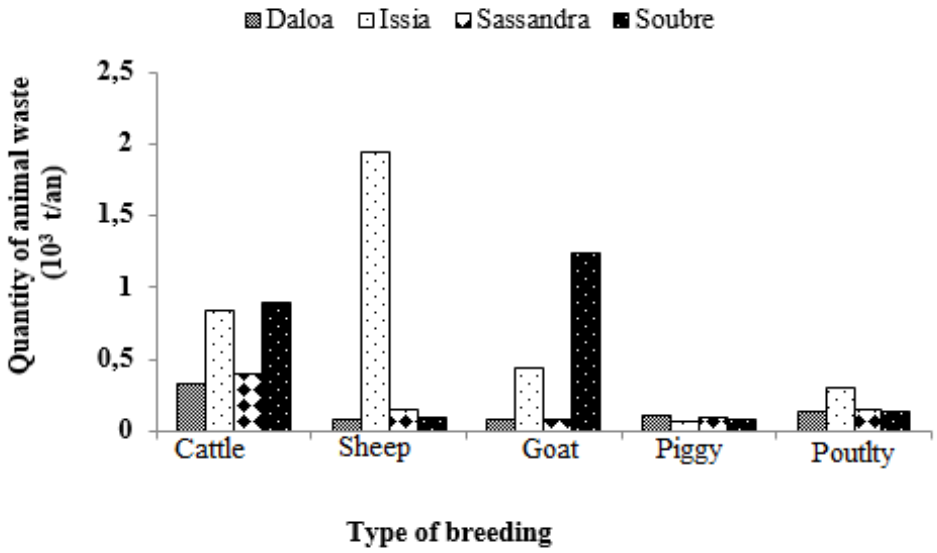

Fig. 7. Annual quantities of waste available by type of livestock and by locality

3.3 PROPORTION OF PLANTERS ACCORDING TO THE MANAGEMENT METHOD OF AGROPASTORAL RESIDUES PRACTICED IN THE DEPARTMENTS OF SOUBRÉ AND ISSIA

Figure 8 shows the proportions of planters according to the agropastoral residue management method practiced in the departments of Daloa, Issia, Sassandra and Soubré. It appears that in the department of Daloa 89% of growers abandon their residues in the fields. 10% of growers compost them and 1% of growers incinerate them in the open air. As for the department of Sassandra, 3% of planters compost it. 17% incinerate them in the open air and 80% of planters abandon their waste in the fields. In the departments of Soubré and Issia, 5% of growers recycle their waste in compost. 10% are incinerated in the open air. 85% abandon them in the fields.

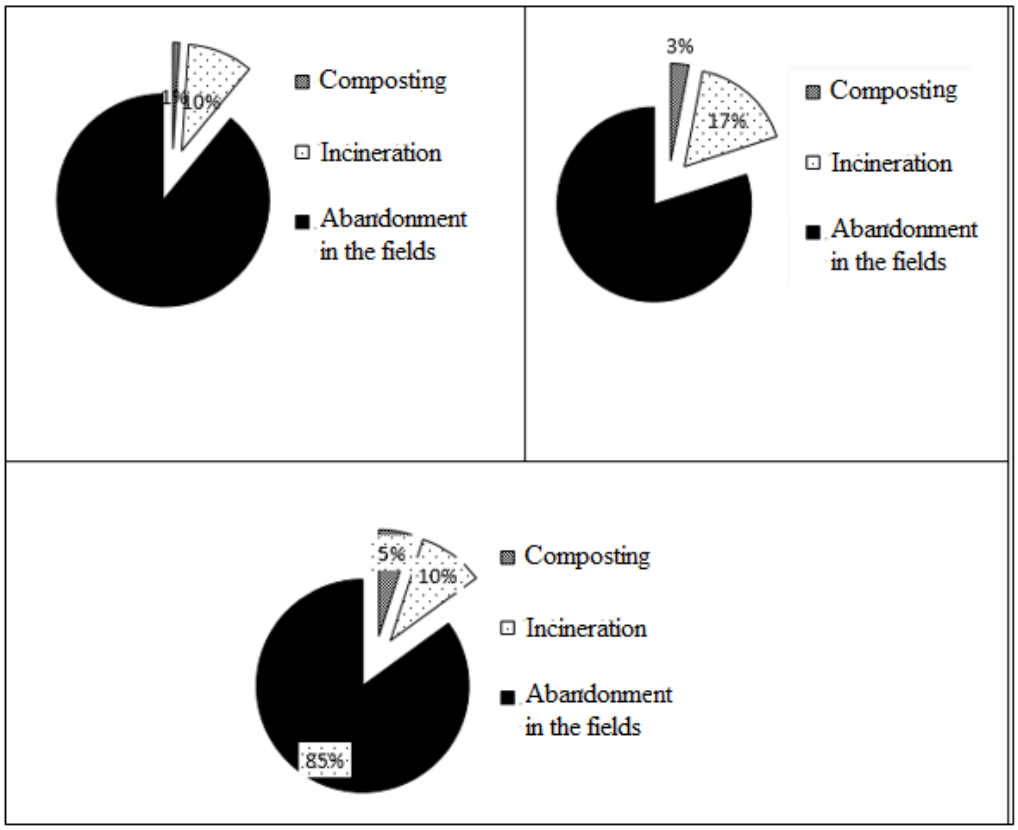

Fig. 8. proportions of planters according to the agropastoral residue management method practiced in the departments of Daloa, Issia, Sassandra and Soubré

4 DISCUSSION

The characterization of agro-pastoral waste made it possible to highlight the composition of waste in the localities (Daloa, Issia, Soubré and Sassandra) studied in the agricultural basin of Sassandra. This waste consists of bunches, fibers, hulls, pods, straws, husks, ears, stalks and stalks. These residues come from cash crops such as cocoa (pod), coffee (husk) and oil palm (bunches, fibers), food crops, namely rice (straw, husk), maize (cobs, cob and stems) and cassava (stems). Livestock waste is made up of slurry, liquid manure, manure, bones, feathers and animal waste and comes from animals such as cattle, sheep, goats, pigs and poultry. This type of waste identified is similar to that characterized in the work of Coulibaly [20] in the Comoé watershed. Of this typology, crop residues present the largest quantities in this agricultural watershed. For the quantities of residues by type of crop, we note that the residues from the cultivation of cocoa for perennial crops and maize for food crops are the highest. The high production of pod residues would be due to the high production of cocoa in the agricultural watershed of Sassandra, also to the agricultural policy of Côte d'Ivoire which encourages the practice of this crop. In addition, by the fact that the agricultural watershed of Sassandra offers pedoclimatic conditions favorable to agriculture [14] and by the population of the agricultural watershed of Sassandra which is mainly rural and agricultural [21]. Moreover, the Sassandra agricultural watershed is today the new intensive coffee and cocoa growing area in Côte d'Ivoire [15]. The production of residues of bunches and shells from the cultivation of oil palm and coffee compared to cocoa are low. The results concerning the quantities of crop residues by locality show that the town of Soubré has the highest production of residues of cocoa with more pods. This result confirms the CCC report [15] which showed that cocoa production in Soubré represents 19% of national production. This production of cocoa waste would also present avenues of recovery for composting and/or the production of biogas [22]. This city could be considered as a waste warehouse where recovery units can be set up. The low production of bunches and fibers for the palm tree would be linked to the fact that it is only in the Sassandra sector that palm plantations have been identified. Besides, this locality is the home of palm oil processing units. The low production of coffee hulls could be explained by the very low selling price of this product which does not encourage its cultivation, and also by the effect of climatic conditions which impact it. As for residues from food crops, the high production would be due to the fact that the south of the Sassandra watershed is an agro-ecological zone favorable to these types of crops [22]. In terms of livestock residues, availability varies

depending on the type of livestock (cattle, sheep, goats, pigs and poultry). Waste from cattle farming has the highest quantities, while the lowest quantities comes from pig farming. The high quantities of cattle waste could be explained by the fact that these animals produce enormous quantities of droppings consisting of manure (80%) and slurry (20%) compared to other animals. Furthermore, the low production of pig waste would be due to the fact that this area is an area with high agricultural activity. Also, certain religious groups who do not consume pork at the population level prevent its massive breeding. This same observation was made by ITEBE **[**23], in Senegal where the religious question influences breeding practices. As a result, we have the number of cattle which is much higher than that of pigs. Large quantities of sheep waste are available in the departments of Issia and Soubré due to the strong presence of non-natives who practice this type of farming the most, unlike the natives who are mainly planters. Furthermore, these areas would be favorable for this type of livestock farming [13]. Besides, the Sassandra region is a forest area with high rainfall and hilly, which makes livestock farming unfavorable [13]. The quantities of available poultry farming waste are low and approximately the same in all localities. The low quantities of poultry waste would be due to the absence of modern poultry farming sectors [24] and to the theoretical calculation of the coefficient making it possible to determine the quantity of waste from poultry farming. This coefficient is 0.04 kg/t/d compared to the coefficient for cattle (2kg/t/d), sheep (0.6 kg/t/d), goats (0.6 kg/t/d) and pigs. (0.32 kg/t/d) [17].

As for the management method of agro-pastoral waste, it appears that more than 85% of planters abandon their crop residues in the fields, 12% incinerate them in the open air. Although the planters are informed about the methods of recycling residues, they abandon them in the fields. The reasons which would explain this situation would be the lack of money and time for their development [25]. Waste abandoned in the fields represents potential raw materials which can be made available to companies wishing to transform them. Furthermore, the husks produced during rice husking are estimated at between 15 and 20% of the total weight of the paddy. The work of Pénot [26] showed that the production of bio-coal from rice husks is an alternative recovery option. Rice husks have made it possible to reduce the use of firewood, limiting pressure on the forest, thus slowing down deforestation and, in turn, greenhouse gas emissions [27]. Regarding composting, only 3% of planters practice it. According to [27] this result can be explained by the low income of populations for the valorization of residues produced for composting because of their implementation cost. Also for them, abandoning waste on the plots would be a way to improve the quality of the soil or to compost. Indeed, Zadi et al., [28] showed that the use of rice straw and others would constitute a contribution of “natural” organic matter such as composts or manure, to cultivated soils. This waste will constitute a better fertilizer for cultivated soils and will have a stabilizing effect on the structure of the soil [29]. In relation to incineration, it is the second most practiced mode (12%). It was also signified by [30] as a practiced waste management model. However, in the open air, the incineration of waste could lead to bush fires which would devastate the surrounding plantations, the vegetation cover as well as biodiversity. In addition, the smoke emitted would cause respiratory problems in the population. In addition, the total availability of waste (from livestock) is about 7651 t. This production seems interesting for the establishment of biogas production units from livestock excrement, especially in the town of Issia which has the highest production. This same observation was made in the Touba department, where the high biogas potential of livestock droppings was due to the significant contribution of cattle waste which represented nearly 82% of the total volume of biogas emanating from animal droppings [31].

5 CONCLUSION

At the end of this study, it appears that in the localities of Daloa, Issia, Sassandra and Soubré, there are several types of agropastoral waste. As crop residues, we note, straws, bunches, stems, ears, hulls, pods, husks and fibers. Regarding livestock waste, we note slurry, manure, manure and animal droppings. The quantities of perennial crop residues are 465,266.3 t/year for cocoa residues, 82,022.7 t/year for oil palm, and 81,175.0 t/year for coffee residues. As for food crop residues, they are 212,493.9 t/year for corn, 212,493.9 t/year for rice and 1,732.7 t/year for cassava. Agricultural waste are unevenly distributed between the localities of the watershed. Overall, the department of Soubré has more waste (290,668 t/year) followed respectively by the departments of Daloa (236,123 t/year). In terms of animal waste, the highest quantities (2,469.5 t/year) are provided by cattle breeding, while the lowest are obtained with pig breeding (354.7 t/year). Sheep, goats and poultry farming produce 2,267.5 t/year respectively; 1,847.0 t/year and 712.1 t/year of waste. In total, the Sassandra agricultural watershed has 7,651.0 t/year of livestock waste. As for the management method, 85% of planters abandon their crop residues in the fields, 12% incinerate them in the open air and 3% of planters recycle their waste.

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