Integration of quality management and industrial metabolism while setting up small and medium agro-industries in Niger, West Africa

Komlanvi Douthe and Ouézou Yaovi Azouma

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Integration of quality management and industrial metabolism while setting up small and medium agro-industries in Niger, West Africa

Komlanvi Douthe1,2 and Ouézou Yaovi Azouma1,2*

Abstract: Quality and environmental standards are not basically taken into account in the management culture of small and medium companies in sub-Saharan Africa. It is due to the “end of pipe” approach utilized by these management systems and the extra-charges involved in their implementation. In order to contribute to solving this problem in Niger we surveyed six small and medium agro-industries (SMAI), to study quality management performances and determine the flow of resources, bases of activities in these industries. The results showed different levels of economic performance: environment/site of establishment: 33–83%; requirements relating to the buildings: 14–43%; equipment and workspace: 0–45%; air supply, water and energy: 29–50%; waste disposal and sewage: 0–68%; suitable equipment: 24–85%; measurements of prevention of the cross contamination: 0–100%; pest control: 0–33%. The main resources used by the industrial system in 2013 are: 137 thousand tons of water, 32.4 thousand tons of live weight of animals, 150 tons of plastic caps, 133 tons of carbon dioxide, 122 tons of plastic films. Rejected waste is: 109 thousand tons of water, 1,116 tons of blood of animals, 9.8 thousand tons of contents of the rumen of the animals, 1,348 tons of plastic bottles. These levels of performance are not up to contributing to the competitiveness of these SMAIs. And we propose an approach centered on the implementation of the ISO 9001, the activities of the industrial metabolism study and the sensitization of the promoters of SMAIs on the sustainable development concepts.

ABOUT THE AUTHORS
Agronomist, Master degree in Food Industry, Douthe Komlanvi is a PhD candidate at “Ecole supérieure d’agronomie” of “Université de Lomé” in Togo (West Africa).

Engineer in agricultural mechanization, DEA in Material Sciences, PhD in Industrial Engineering, Postdoc in Logistics engineering, Associate Professor and Chief of Department of AgriEngineering and Farm machinery at “Ecole supérieure d’agronomie” of “Université de Lomé”, AZOUMA Yaovi Ouézou is President of UNESCO – IHP National Committee of Togo (West Africa). The activities of our research team concern: Process and Industrial Engineering. This paper is related to our research project which goal is to carry out “An approach that integrates the quality management and industrial ecology to new small and medium agro-industries (SMAIs) in West African Economic and Monetary Union (WAEMU)”. 

PUBLIC INTEREST STATEMENT
The quality of products made by small and medium agro-industries (SMAIs) and their practices in relation to protection of the environment and consumer health often do not meet ISO norms, although these are an important factor for competitiveness on the regional and international markets. Many existing SMAIs in West Africa fail to meet these norms and will require new or redesigned plants to do so. These solutions require significant investments that delay or discourage SMAIs from obtaining certification. In order to face this problem, we propose to industry practitioners or leaders an approach to adapt quality management and industrial ecology in the agro-industries for their sustainable development.
1. Introduction
The mass production period has witnessed a significant evolution of the global economy. Today, markets are strongly competitive and globalised. The hedonic principles were then born. This difficult economic context requires excellent management to prioritize new prospects. Therefore environment and quality management are perceived as new and strategic components of the culture of companies trying to make a difference (Belohlav, 1993). Quality management has gone through several variations. Producing only “good products,” based on the standard ISO 9001, is now regarded as out of dates (French Association of Standardization, 2015). Even if it does not cause prohibitory extra charges, it is not guaranteed to be successful. It is therefore out of reach of many companies. Measures to reduce the impact of industrial activities on the environment (the standard ISO 14001) have also quickly proved to have their own limits (Erkman & Bourg, 2003). Pollution treatment approaches based on “end of pipe” system have not developed on a global level, but remained partitioned instead (Erkman, 2004) and have been operating in a sectarian way. Consequently, depollution carried out on a specific sector can lead to further pollution propagation into another sector. Furthermore, de-pollution technologies get more and more expensive as they improve, but do not bring definitive solutions to the whole environment issues.

Africa has not reached the same level of industrial development as the rest of the world. However, it experiences the same negative effects of industrial development, because of globalization and growing interdependence of economies. African companies must then combine profitability and environmental protection. Yet, entrepreneurial and industrial economy in Africa, particularly in sub-Saharan Africa, is to a large extent composed of small and medium companies. Generally, they have very limited funding means. In such a context, how can these companies meet the extra charges induced by environment and quality management and the risk of failure? Can they adopt an innovative approach combining economic viability and social and environmental performance for sustainable development? (Payre, 2008). It is due to such a dilemma that this work attempts to analyze quality management performances and to evaluate flows of material and energy crossing in small and medium agro-industries (SMAI) in Niamey. The aim, here, is to open up the strategies to improving the SMAI economic competitiveness and ensure social performance in a preserved natural ecosystem.

2. Material

2.1. Geographical area of the study
This research was carried out in Niger, particularly in the agro-industrial manufacturing units located in Tabla and Niamey (Figure 1). Niamey is the capital of Niger. It is located at the South-Western end of the country with 13°31’ of northern latitude and 2°6’ of Eastern longitude and is divided up in two by the Niger River. This city hosts most of the industries of the country and is home to 1,302,910 inhabitants (National Institute of the Statistics, Ministry for Finances, 2011). The most important part of the city is on the left bank of the River, and hosts the Tabla industrial park. Tabla is a village of the Baleyara County (in the Area of Tilabery), located 107 km to the east of Niamey.

2.2. Small and medium agro-industries surveyed
The data processed for this study comes from six companies which are small and medium-sized undertakings in the agro-industry sector. They do not produce the same products and each one has a permit for installation (Table 1).
3. Method

The literature review provided information on the requirements of quality and food safety standards (ISO 9001 and 22000), and environmental requirements (ISO 14001), as well as local legal requirements governing the sector. It also contributed knowledge on the tools for treatment and supplemented information that could be difficult to reach in the field. The investigations in the field provided data on the performance and the implementation of quality and environmental standards and the observance of legal requirements. The questionnaire used includes a section containing general information about the company and the interlocutor. The second part makes it possible to evaluate criteria related to quality requirements. It is drawn from the questionnaire designed from the requirements of standard ISO 22000:2005 (French Association of Standardization, 2005), and the “International Certification of the System of Management (CISM)” meeting in Ouagadougou (Burkina Faso). Its wording was supplemented to enable us to evaluate performance level of quality management. It takes into account 8 criteria which are requirements of quality management (Figures 2–4, given as examples). Each criterion (C) is composed of a certain number (N) of requirements (or activities) to be respected. The level of performance is expressed as a percentage (r %) for C, and is calculated by the formula:

\[ r = \frac{n}{N} \times 100 \] (Lamboni & Azouma, 2013).

Table 1. Characterization of small and medium agroindustries surveyed

| Enterprise Code | Activities                                 | Production per day | Market            | Number of workers |
|-----------------|--------------------------------------------|--------------------|-------------------|-------------------|
| ENTOA-01        | Production and distribution of fizzy drinks| 6,000 L            | Local market      | 270               |
| ENTSAS-02       | Production and distribution of Natural mineral water | 22,500 L          | Local market      | 45                |
| ENTLS-03        | Production and distribution of yoghourt   | 2,000 L            | Local market      | 26                |
| ENTSN-04        | Production and distribution of carbon dioxide | 6,000 kg          | Local market      | 5                 |
| ENTAR-05        | Refrigerated slaughterhouse                | 55,000 kg          | Local market      | 80                |
| ENTTE-06        | Production and distribution of tanned leather | 500 leathers      | Local and interna tional market | 70                |

Figure 1. Map of Niger showing the study area.
where $N$ is the number of respected points of requirement (activities in conformity), maybe for the “ENTPL-03”, for the criterion “pest control”. Then, using the Excel software, we graphically represented the conformity rate (%) in connection with the totality of quality management.

The third part of the questionnaire is intended to collect information related to environmental consideration of agro-industrial management SME/SMI. This part is extracted from the questionnaire prepared by the Industrial Ecology Council (IEC) together with the National Institute of Applied Sciences (INSA) from Lyon (Sueur, 2007). It is related to the following headings:
• Industrial “ecology–Material” which is related to water use, compressed air, sorting waste and possible mutualizations; these data will not be represented on the diagram of flows but they will be used to assess quality of global flows.

• Global flows: we determined raw materials quantity, and secondary material and utilities used during the year 2013 by the factories. We also measured the quantity of finished products, by-products, under products in excess, waste and utilities generated in 2013.

• Industrial “ecology—Energy” evaluates the quantity of power consumed and produced by the manufacturing unit. The power plant facilities and the integration of new technologies, such as renewable energy is also studied; - “skills and know-how” make it possible to know if the site has the capacities or technologies necessary to exchange with nearby companies. In general, it is concerned with physical accounting of flows, realized in the form of a matrix input-output (Ayres & Simonis, 1995) and of life cycle analysis. This approach arises directly from mass and energy conservation principles: “nothing is lost, nothing is created” (principle of Lavoisier). Consequently, any flow of resources which enters a system (a company for instance) sooner or later leaves it, or accumulates itself there in the form of stock. The overall flow balance on the study area is the sum of flows at each production unit in the area. However, for reasons of simplicity, we did not take account of stocks of resources. In the same case, digested foodstuffs are not considered in the estimated outgoing flows. All this information was processed manually to produce the representation of flows and stocks of matter, energy and resources used and rejected by the activities of the considered territory.

4. Results and discussion
From information collected, we established performance levels in each manufacturing unit and total flows of the resources inside the system.

4.1. Performance analysis of small and medium agro-industries

4.1.1 Case of ENTOA-01
Figure 2 shows that the rate of compliance for the requirements related to the implantation site is 83%. This score is good and is explained by the situation of the factory in the industrial park. This zone was selected and delimited by the State of Niger, presumably after suitable studies. Situation within the zone confers a relative advantage to companies with regards the requirements of the standard ISO 22000:2005 (French Association of Standardization, 2005). For adapted equipment, the mark is 65%. In spite of an above average rate, it is nevertheless significant to stress that this point of requirement is strongly related to the maintenance plan. This is missing and could have severe consequences on the performance of the company. It also depends on the availability of local skills and technical documents which match the equipment at the time of their acquisition. Conformity with this action quality will only reach the maximum when time is taken to write a schedule of conditions. It is this which must establish the requirements as regards competences available at the local level and of readable documentation from which a plan of maintenance is built. Conformity rates related to the supply of air, water and energy, then to the settlement and workspace are respectively 47 and 38%. The level of waste disposal and waste water is 33%, because there are shortcomings related to the distinction of the waste bins, and sorting waste and rubbish is not part of the culture of the people. The requirements related to the buildings are 14%, those pertaining to measurement of cross-contamination prevention, is 0%, and to pest control: 0%. The explanations which were given to us on these serious insufficiencies led us to deduce a lack of information and awareness on behalf of the company’s ruling board.

4.1.2. Case of ENNTSA-02
Figure 3 shows that environment of settlement rate is 50%. This factory (107 km away from Niamey) is located in a fundamentally healthy environment. This rate is therefore relatively weak. Lack of know-how is the major reason. Lamboni and Azouma (2013) made the same observation in Togo. The demonstration is operated on this site where employees under the directions of their
supervisors hide waste disposal and non conforming products. One can wonder about the training programs for engineers who work in these companies and their true responsibilities (Diemer, 2012). The realization of quality actions must begin with leaders’ commitment to ensuring maintenance and preserving production sites. Local markets also have a role to play. Ecological movements and pressure groups in favor of society must come out of their inertia. The buildings fulfill the requirements of the standard at 28%, the installations and workspaces at 24%, the air supply, water and energy at 30% and the waste disposal and used water at 25%. Equipment conformity rate is at 43%, because the equipment must be designed in materials authorized to be in contact with food (standard ISO 22000:2005) (French Association of Standardization, 2005). This restriction must remain valid even when it is necessary to make minor repairs on the equipment. For example, in this factory the welding on the tank of storage was not carried out with suitable, stainless material. As a consequence, the points of welding release rust into the final product. This problem was topical at the time of our investigation and required our expertise to detect it and to enable production to be resumed. Measurements of prevention of the cross contamination were respected to 50% because of lack of know-how. Although the line is designed for walking forward, there is no instruction for its implementation. It is the same for the pest control of which the rate is 0%.

4.1.3. Case of ENTLS-03

The level of the environment/site of establishment performance is 33%, because the owner of the company hosts the manufacturing unit in his residence. In fact, this company cannot avoid pollution of all kinds coming from the neighborhood, and consequently pest control rate is only 33%. The reasons that explain the situation at this site are economic and raise a serious problem which is the lack of, or little influence of the state and the financial institutions in the business world in sub-Saharan Africa. The conditions of establishment of this company considerably influence the requirements related to the buildings at 28%, and generate an insufficiency on the level of ergonomics and the weak respect of prevention of the cross contamination is 0%. The rate of settlement and work space is 45% and that of air, water and energy supply is 48%. The waste water and waste disposal rate is 68%, and that of the suitable equipment is 67%.

4.1.4. Case of ENTSN-04

This factory produces carbon dioxide incorporated in foodstuffs (aerated beverages for example). The site of establishment is well studied and shows a quality rate of 100%. The actions related to “adapted equipment” are in 85% compliance with the requirements because the factory has a labor force which receives technical support from the head office in France. Is that support appropriate? The answer is not simple to put forward. Nevertheless, this technical support makes it possible to have production material with a constant return for 5 years. Yet, cross contamination prevention measures and pest control are nil. Non conformity compared to these requirements is explained by the operations of manufacture of carbon dioxide processed in closed loop. Temperature inside the circuit (approximately 1,000°C) insures failure. The requirements related to the buildings have a performance rate of 43%, and the settlement and workspace: 34%. The reasons that explain these scores are a priori economic, but indicate at the same time a certain negligence of standards. It is the same for water, air and energy supply (34%) and the waste disposal and waste water, 35%. Here, water is not used directly in product manufacturing but as cooling element. For this reason it comes directly from drilling to feeding without any restriction. However, bad water quality can cause clogging of the cooking circuit, the consequences of which can lead to the explosion of the production system.

4.1.5. Case of ENTAR-05

For the environment/site of establishment, the criteria are respected to 33%. It was built in the colonial era. It overflows a little compared to the industrial park and is limited on both sides by two large dumps and, on the third side by the Niger River into which blood is continuously poured from the slaughterhouses. This river constitutes a major source of pollution for industry. The buildings are
in conformity to 43%, the settlement and workspace rate is 28% and adapted equipment is 24%. These weak performances are related to the structure as a whole, which is old and exiguous compared to the requirements of the activities’ growth. Air, water and energy supply are at 50%. Waste water and waste disposal is 44%. If solid waste finds the way to the market-gardening exploitations, the liquid effluents (blood) are a source of pollution for the Niger River and poison the neighborhood. Cross contamination prevention is in conformity at 100%, fittings of the building system, being such as walk ahead is compulsory. The proximity of the dumps does not help the workers to avoid the pests against which measures of control are insufficient (33%).

4.1.6. Case of ENTTE-06
Figure 4 shows that the site of establishment in conformity is at 33%. This site located between the River Niger and a hill is easily flooded and does not meet quality standards. Quality actions related to the buildings, water, air and energy supply, and suitable equipment rate is 29%. A total absence of conformity is observed for settlements and workspace and cross contamination of prevention measures. These prerequisites, however, have their value in food factories because of their importance to the health safety of consumers. But when they come to be sorely lacking in other agro industries as is the case of this tannery, they reveal themselves as factors against productivity leading to poor economic performance. Occurrence of a flood can degrade the products which will be sold only under exemption (low cost) or will be recycled using additional resources. Waste water and waste disposal are conforming at 29%. A large discharge is created just behind the fence of the factory, and generates unpleasant odors on the site and constitutes obstacles to suitable elimination of waste coming from production processes.

4.2. Metabolism analysis of the agro industrial system studied
Figure 5 summarizes the whole flows of resources which enter and leave the agro industries selected during the year 2013. We will not take account of material which we consider marginal. We do not represent the part of food digested and eliminated in various forms by the body.

4.3. Analysis of the entering flows
We can note from Figure 5 that the most consumed resource is water (approximately 137 thousand tons). Water is primarily used for food production, for cooling, processing and cleaning. The most important part of water used comes from the public distribution network of water, Water Development Company of Niger (SEEN). Of secondary importance, these companies use water collected by drillings and water from the River Niger (ENTTE-06). The results show that company “ENTAR-05” is the largest water consumer of the zone with a quantity of 66 thousand tons per year. This is to say, 73% of the total quantity of water consumed. Second in rank, is “ENTOA-01” which consumes 44 thousand tons of water annually, and third ranked is “ENTSA-02” which makes use of 22 thousand tons of water. The company “ENTLS-03” comes in the fourth position in using 13 thousand tons of water per year. With regard the solid matter flow, Figure 5 shows that the livestock resources are most important (32,400 t). They are mainly made up of cows, sheep and goats. There are also camels and to a lesser extent the equines. These major animal byproducts are created through the activities of production of the company “ENTAR-05”. It has created 22 thousand tons of these animal byproducts. This is to say that 76% of the 29 thousand tons of solid matter are exported by nature into 2013 towards the agro industries on the territory of study. This figure is impressive, but Niger is a Saharan country where the most significant primary production (agricultural matter) is livestock. The Polyethylene consumption of terephthalate constitutes the second solid matter flow (2.5 thousand tons) used in the zone. Indeed the Polyethylene materials are raw resources for factory “ENTOA-01” which takes on the whole, 3.9 thousand tons of solid matter for their activities which constitutes 13% of the whole of solid flows which was necessary to bring for the operation of the industries surveyed in 2013. It is perhaps significant to note that with the difference of water and the animal resources, Polyethylene are not local resources, but are imported from abroad, out of the territory of Niger. The total quantity of energy used is 4,226 MWh of electricity and 221 tons of fuel. To ease the comparison between the electric powers and other flows, we used equivalence with the
primary energy which is expressed in ton oil equivalent (toe). Thus the consumption of energy resources is in third position with the 1,160 toes used. We can point out that the industry “ENTOA-01” is the largest consumer of energy with 750 toes, accounting for 68% of the 1,160 toes spent in the year. Then by far, come the other matters such as seeds from acacia and the stoppers (150 tons each), carbon dioxide (CO2) (133 tons), plastic films (122 tons), essences from which drinks are produced, commonly called the “bases” (115 tons) and the acids (101 tons). Other consumptions: paper, wood, oil, greases, and sugar ... do not exceed 40 tons.

4.4. Analysis of the outgoing flows

The Figure 5 shows that water constitutes the largest liquid waste (109 thousand tons). Water thus rejected mostly comes from “ENTAR-05”. The rejected water quantity (66 thousand tons) accounts for 74% of the total quantity of rejected liquid effluents. That led to the conclusion that almost the totality of water taken is rejected. It therefore constitutes waste. Factory “ENTSA-02” is second ranked in emitting 17 thousand tons of water, and “ENTSN-04” is in the third position in releasing 3 thousand tons of water into the nature. The solid pollutant which comes in the first position is the contents of animal stomachs (3.4 thousand tons) resulting from the activities of production of the company “ENTAR-05” (Figure 5). This solid waste constitutes 46% of the 7.4 thousand tons of solid waste intended for rubbish discharge. Contents of animal stomach waste load at the doorway of “ENTAR-05” along the roads are stored on the standby only to be bought by the market-gardeners. That poses a problem of environment with the unpleasant odors which it generates. The company “ENTOA-01” comes in second position and rejects 2 thousand tons of solid waste (28%) made up primarily of plastic bottles (1,348 tons) resulting from the transformation from Polyethylene imported from abroad. The greenhouse gas (GES) emissions are a major subject of environmental concern.
These gases are generated during the manufacture of the products, the transport and distribution of the products, and the elimination of the products at the end of lifetime. Carbon dioxide (CO2) is the most substantial generated gases. The emissions of carbon dioxide related to transport and elimination at the end of lifetime could not be evaluated because of absence of available data.

Still, we could evaluate the emissions related to the electric consumption of power in accordance with the lawful methodologies recommended for the Saharan zone (Le Moux & Herrmann, 2008). Figure 6 shows that the “ENTOA-01”, is in the first position with 1.4 thousand tons of emitted equivalents-CO2. It only generates 64% of CO2 rejected into the atmosphere while coming in second position (453 tons of equivalents-CO2), it emits less than half of the first factory. (Which one?) The company ENTAR-05 is in third position (130 tons of equivalents-CO2). The third most consumed resource is energy, being produced from fuels and from fossil fuels exploited on the territory of Niger. The 2,117 tons of equivalents emitted CO2 and are charged to the use of energy in the zone of study. Therefore, with regards energy, the activities in the zone cannot ensure sustainable development.

Moreover, the major issue with the use of energy in the area is poor planning of the subscription to electrical power supply. This fact leads to, in the case of undersizing, penalties which may entail costs more than double what is normally required from the electricity supplier.

Our study area is a technological scope consisting of 6 factories. On this territory there is no recycling process, re-use nor other reconsideration for by-products. All the resources used by the studied economic system, arise entirely from waste. This report differs a little from the results from the studies of Allen (2004); carried out in the United States (compared to the advanced level of the industrial development of these countries) (Allen, 2004). In this case, the results showed that nearly 80% of the resources used by industries are rejected in the form of waste. The results obtained from the analysis of flows reflect the point of view of (Lifset, 1999). Indeed it is not so much the toxicity of waste which poses the ecological problem, but rather their volume which exceeds the capacity of the environment to contain them. Thus industrial ecology wanting to copy its principles on the operation of the biosphere is concerned with the elements of the latter. So the use of the prospects for the systems, the role of change of technology, the role of the companies, eco-design and the dematerialization (Lifset & Graedel, 2002) are as many tools to evolve towards the looping of flows. The flow loop is a path to industrial symbiosis which requires the possibility to appeal to companies outside the considered area without disregarding the critical mass (Porter, 1998), for productivity and competitiveness of the economic system of the territory.

4.5. Proposals for the improvement of quality and environment management during the setting up of small and medium agro-industries

Globally speaking, the realization of quality actions in companies is low. To improve quality, we propose that the setting up SMAI should be conditional to actions compliant with ISO 9001, ISO 22000 and ISO 14001 (French Association of Standardization, 2005, 2015; International Standard
Organisation, 2004) standard implementation and as recommended by UEMOA directives N°07/2007/CM/UEMOA (Compaoré, 2007). Concretely, the set-up requirements for agro-industries processing are not exclusively a complete identification form by the promoter; verbal lawsuit of constitution, statutes of the company, list of the members of the Board of Directors, certificates of lease, etc. In the field of environmental quality, an environmental compliance certificate must be provided, consecutive to a study of the impacts environmental and social industrial activities have on environment. This study should include an identification of all the major environmental and social risks, their evaluation and a clear definition of corrective and preventive action plans. As far a quality is concerned, we should identify: (1) the real Added Value for the customer and the technical specification schedule of conditions of the product and in order to define the processes to consolidate them, (2) activities not justified by technical reasons related to customer’s requirements, actions with non necessary added value, actions of “not quality” (times of sorting, resumption, repair of the equipment, etc.) and put forward measures to eliminate them. It makes sense that a quality expert be committed by a public authority to accompany the promoter like what the chambers of commerce and industry in Western countries do: the case of France.

4.5.1. Water use
The study of the metabolism showed that water waste does occur in the industrial park of Niamey. It therefore follows that each industry wishing to establish an internal system for an optimal water management during or along the project should: (1) separate processing water from cleaning water on the one hand and determine used water characteristics on the other, to facilitate its treatment; (2) reduce water losses in particular to reduce volume of wasted water by increasing its output pressure; (3) recover rainwater if possible. According to the idea of (Zeng, 2008), a coordinated project must implicate all the entities of the zone, for water supply mutualization and treatment of water deriving from their processing (Figure 7).

4.5.2. Material use
The most significant solid pollutant in mass: the stomach contents of animals from “ENTAR-05”. In Niger, the agricultural ground is very poor in organic matter (Saharan country): the waste can be stored in a place especially designed to prevent the loss of fertilizing elements. The management of this organic material could be entrusted to “Centrale d’Achat des Intrants et des Matériels Agricoles” (CAIMA), the office of farm equipment and agricultural input where they could deal with distribution (Figure 7). Just like the results of the undertaken studies on the one hand, in Liberia by (Alfaro & Miller, 2014) and on the other hand, in Nigeria and Senegal by (Blavot, 2011), the agriculture of Niger could profit from the fertilizing impacts of this waste. In fact, waste coming from the slaughter-house, ENTAR-05, (3.4000 tons) could annually provide 5 tons of nitrogen, 5 tons of phosphorus and
13 tons of potassium (Aure, Barbet-Massin, Bourgault, et al., 2010). Moreover, this waste could be methanized to produce biogas. The biogas produced from livestock waste could provide energy equivalent to 126 Megawatt hours (MWh) (Saidi & Abada, 2007), almost half of the electric power used by the “ENTAR-05” in 2013. Company “ENTAR-05” also produces raw hides as by-products. For these under products, company “ENTTE-06” settled not far from the “entar-05” to develop the raw hides by producing approximately 550 tons of tanned leathers each year. The output of this agroindustry must be increased to absorb all the raw hides produced by the “ENTAR-05”. It is worth re-structuring “ENTTE-06” so that it operates with the spirit of industrial ecology. Finally, blood is also a waste from “ENTAR-05” and blood drying factories (which had operated in the past) rehabilitated, will use the blood from the slaughter to produce food stuff to feed the poultry on livestock farms. Polyethylene terephthalate (PET) are derived from oil products, a nonrenewable source of energy. PET bottles become waste coming from the “ENTOA-01” and “ENTSA-02”. Therefore their use can raise environmental drawbacks. This is why, it is significant to evolve to the recycling of such material in the zone, to avoid the consecutive emission of 3.6 thousand tons equivalent CO2 to the manufacture of these bottles (Harald, Bernd, & Roland, 2010) (Figure 7). More than that, it seems that their incineration is the best option with valorization of the heat released during combustion (Service cantonal de gestion des déchets, 2004), which could be useful in the production of vapor for the boilers.

### 4.5.3. Energy use

Our first proposal is to mutualize electric power furnishing to prevent the risk of oversizing (Figure 7), i.e. high costs for power greater than their real need. They can carry out functionality economics (Service cantonal de gestion des déchets, 2004) in energy. Moreover, they have the possibility, if necessary, to make the energy surplus available to other actors. Secondly, the State should encourage the emergence of renewable energies such as the production of biogas.

Globally, our researches aim to determine a model of production which might consider both the quality of product and the evaluation of the flow of resources. Due to that fact, we are proposing the upstream creation of an agro-industry, tasked with the determination of the industrial metabolism as recommended by OECD in 2014 to its member states (Service cantonal de gestion des déchets, 2004). The study of industrial metabolism is the technical base of the construction of an eco-industrial park (see Figure 7 of the case of Niamey). The functioning of this industrial park is susceptible to generate the quality due to the optimization of resources. In addition, the industrial symbiosis which is the principle intimately linked to the study of industrial metabolism, utilizes mutual proceeding facilitating the reduction of resources and wastes, preserving, therefore, the biosphere.

The mutualization of waste and stock management could be carried out by introducing a modification into the current management of the companies in the area. This means that leaders will be organized by setting up a common management platform. This ruling body will allow a climate of confidence, proximity, communication and transparency. And it should implicate all the companies within the area. It must have all competences and all the resources enabling the co-operation between the companies in order to constitute a data base in connection with the resources and waste. This will contain geopositioning information and will organize the contacts between the provider of waste and the purchaser of waste, and this within an adequate lawful framework. This type of co-operative management is of primary importance for the implementation of synergy between the companies.

### 5. Conclusion

The integration of quality and industrial metabolism in the setting up SMAI supposes the evolution towards another economic vision of the world, that of sustainable development. It recommends the use of the concept of industrial ecology to make the system of production cyclic, which must enable it to combine economic performance and environmental viability. The requirement analysis to evaluate the quality actions and the physical flow analysis to benefit from the bonds between industrial systems offer prospects for optimization of the resources and eco-reorganization of the industrial system. However, this step must on the one hand, integrate the financial accountancy of flows and on the other hand, determine an exploitable durable quantity for each resource.
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Author details
Kamlanvi Douthe1,2
E-mail: martindouthe@gmail.com
Ouézou Yaovi Azouma1,3
E-mail: azouma@yahoo.com

1 Département de Génie Rural et Machinisme agricole, Ecole Supérieure d’Agronomie, Université de Lomé, 01 BP 1515, Lomé 01, Togo.
2 Centre de Recherche sur la Mécanisation de l’Agriculture au Togo (CRMAT), 01 BP 1515 ESA/UJ, Lomé 01, Togo.

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