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CARBON FOOTPRINT ANALYSIS IN BANANA PRODUCTION

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Summary

Introduction

The universe of environmental assessment is very broad. Methodologies are numerous and their uses in the areas of food and agriculture recent. Indeed, the industrial sectors were the first to develop, decades ago, methods to evaluate their environmental "costs" in order to design or to reengineer their products. The rise of environmental awareness in the consumer societies of the North pushed suppliers and retailers to develop indicators of environmental impact of their production and distribution of products, especially food products.
This has generated an extensive effort to label consumption products, like in France whereby different groups of private retailers have developed their own approaches.

For all this reasons, the working group n°01 (Sustainable Production Systems and Environmental Impact) of the Word Banana Forum decided to promote a study on the development of the Product Carbon Footprint (PCF) analysis methods and the Life Cycle Assessment (LCA) approach in the banana (export) sector.

Carbon Footprint methods

Public authorities have quickly taken over the initiative of suppliers and private retailers on the labeling of environmental impacts, by providing a framework and a common methodology centered on the LCA. Other countries, such as the United Kingdom, have tried, through voluntary initiative (involving public authorities and private companies) to establish a dynamic around the Carbon Trust and Publicly Available Specification (PAS) 2050. Research organizations, standards bodies, consultancy firms, etc., are developing similar concepts and that worldwide. These include: the Carbon Footprint ® (ADEME - France), PCR ID: PA-BJ-O3 (Japan), LCA (Ecoinvent - ISO 14040/14044), etc. Although the approaches and concepts are similar, the different methods do not measure the same kinds of impacts or do not take into account the same scope (perimeters) of activities.

	Carbon Trust	LCA (Ecoinvent)	Bilan Carbone®	PCR ID: PA-BJ-O3 (Japan)
Planting material (in vitro production, hardening)	exclude	ok	ok	ok
Farm : including : - cable-way, machinery, stores, ..	ok exclude	ok	ok	ok exclude
Packaging : including : - stations, tanks, palets, …	ok exclude	ok	ok	ok exclude
Administration (workers & staff transport, international travels (including certification), offices, energy, …)	exclude	ok	ok	exclude
Port departure	ok	ok	ok	ok
Transport oversea	great differences (methodology, data bases, …)			
Port arrival	ok	ok	ok	Ok
Ripening	ok	ok	ok	Ok
Transport logistic & retail	ok	ok	ok	Ok
Consumers	optional			

The conceptual framework of LCA is particularly relevant to assess environmental impacts and input-output flows and powerful in relation to the notions of function (and of functional unit, see next paragraph), life cycle of a function, multi-criteria evaluation, allowing to reveal possible pollution transfers between two stages of the life cycle of a product or between two environmental impacts (eg greenhouse / eutrophication). However, its implementation for systems that are complex and variable such as the systems for agricultural and food production, generate different scientific challenges. The use of this methodology for agricultural systems in tropical environments is a new kind of challenge (shortage of publications on tropical products LCA) and even a more difficult one due to the lack of data on these systems but also to the lack of basic knowledge about their interactions with the environment. For instance, the emissions (air, water, soil) of nitrogen fertilizer are different in the tropics than in temperate areas, these emissions are insignificant on tropical volcanic soils.

In any case, whatever the method used, the results are heavily dependent on the emission factors and therefore on the quality and completeness of the databases used.

Other methods :

- Eco-indicator 99 – Netherland (www.pre.nl/eco-indicator99/)
- EDIP 2003 – Danemark – DK Env. Protection Agency (http://ipt.dtu.dk/~mic/EDIP2003)
- EPS 2000d – Sweden (http://eps.esa.chalmers.se/)
- CML – (Dutch) Handbook on LCA (www.leidenuniv.nl/cml/ssp/projects/lca2/lca2.html)
- Impact (2002)+ - Switzerland (www.epfl.ch/impact)
- JEPIX – Japan (www.jepix.org)
- LIME – Japan (www.jemai.or.jp/lcaforum/index.cfm)

- TRACI – USA-EPA (http://epa.gov/ORD/NRMRL/std/sab/iam_traci.htm)

Data quality

Example of method to qualify the data :

Quality score	1	2	3	4	5
Reliability	*Verified data based on measurements*	*Partially verified data based on hypothesis or non-verified data based on measurements*	*Non-verified data partially based on hypothesis*	*Qualified estimate (for example by expert)*	*Non-qualified estimate*
Completeness	*Representative data from sufficient farms sample on adequate period*	*Representative data from small number of farms sample but on adequate periods*	*Representative data from sufficient farms sample but on shorter periods*	*Representative data from small number of farms sample on short periods or incomplete data from sufficient farms sample and adequate periods*	*Unknown representativeness or incomplete data from small number of farms sample and/or on short periods*
Temporal correlation	*Less than 3 years from the year of study*	*Less than 6 years from the year of study*	*Less than 10 years from the year of study*	*Less than 15 years from the year of study*	*Unknown data age or more than 15 years from the year of study*
Geographical correlation	*Data from the study area*	*Means data from a larger area than the study area*	*Data from an area of similar conditions*	*Data from an area of almost similar conditions*	*Data from unknown area or area with distinct production conditions*
Technological correlation	*Data from the farm enterprise, on process and raw material for the study*	*Process and raw material data for the study but from distinct farms*	*Process and raw material data for the study but from distinct technologies*	*Process and raw material relative data for the study with identical technologies*	*Process and raw material relative data for the study but with distinct technologies*
Sample size	*>100, permanent measurement*	*>20*	*>10*	*≥3*	*Unknown*

Life cycle flow chart

Scope of the analysis

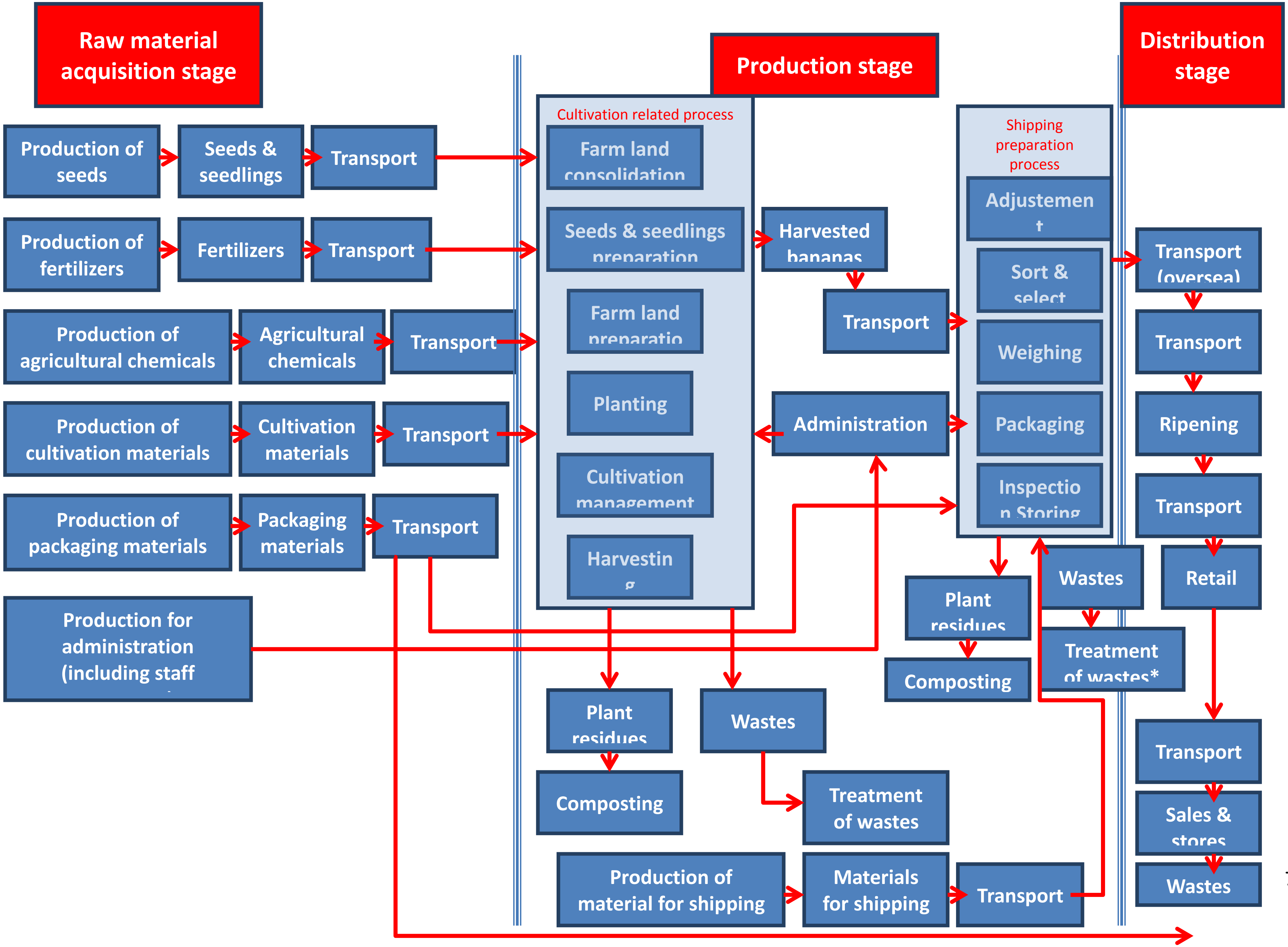
Determining the scope of the study is closely related to the prescriber of the study. For example, a freight shipper (transport company) wishes to finely assess the impacts related to his trade and business. As a result, the company will change some elementary processes and evaluate their environmental impacts. In case of environmental labeling, we have to look at the entire chain of production, distribution and consumption (+ waste), otherwise, we run the risk of having a distorted picture of the reality. In addition, comparisons will be possible only if the boundaries investigated are exactly the same.

In the banana case, we can focus on farm to the import segment (Europe, USA, Japan, …). The next stages (ripening, transport inland, distribution and eventually consumption), are quite similar, for same destinations, for example : East Coast of USA or North Europe.

Function and functional unit studied

If establishing the boundary issue is sensitive, there is, however, a consensus around the functional unit (FU) that is studied which is the same used in all studies: 1 kg of bananas. Nevertheless, the question of the function under study is very closely related to the scope of the study. The studied function can be the production and provision of one Kilogram of bananas for European consumers or only the production of one Kilogram of bananas delivered to the port of shipment.

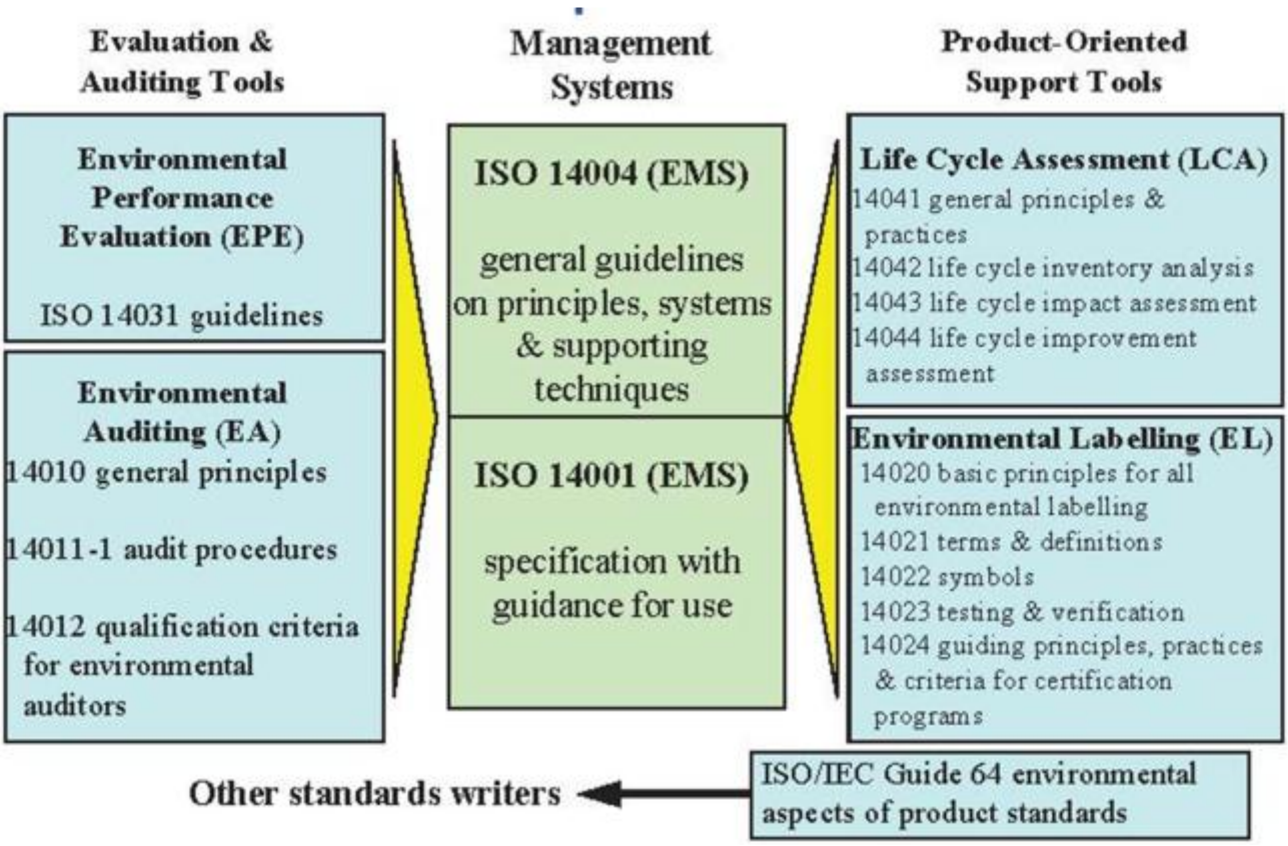
Example of life cycle flow chart for banana production and trade (source : CIRAD compilation, from Japanese CFP Pilot Project. 2011. Product Category Rules (PCR) of "Raw Banana".)



Raw material acquisition stage
Production stage
Distribution stage
Production of seeds
Seeds & seedlings
Transport
Production of fertilizers
Fertilizers
Transport
Production of agricultural chemicals
Agricultural chemicals
Transport
Production of cultivation materials
Cultivation materials
Transport
Production of packaging materials
Packaging materials
Transport
Production for administration (including staff
Cultivation related process
Farm land consolidation
Seeds & seedlings preparation
Farm land preparatio
Planting
Cultivation management
Harvestin
Harvested bananas
Transport
Administration
Plant residues
Composting
Wastes
Treatment of wastes
Production of material for shipping
Materials for shipping
Transport
Shipping preparation process
Adjustemen t
Sort & select
Weighing
Packaging
Inspectio n Storing
Plant residues
Composting
Wastes
Treatment of wastes*
Transport (oversea)
Transport
Ripening
Transport
Retail
Transport
Sales & stores
Wastes

Procedure Guidelines

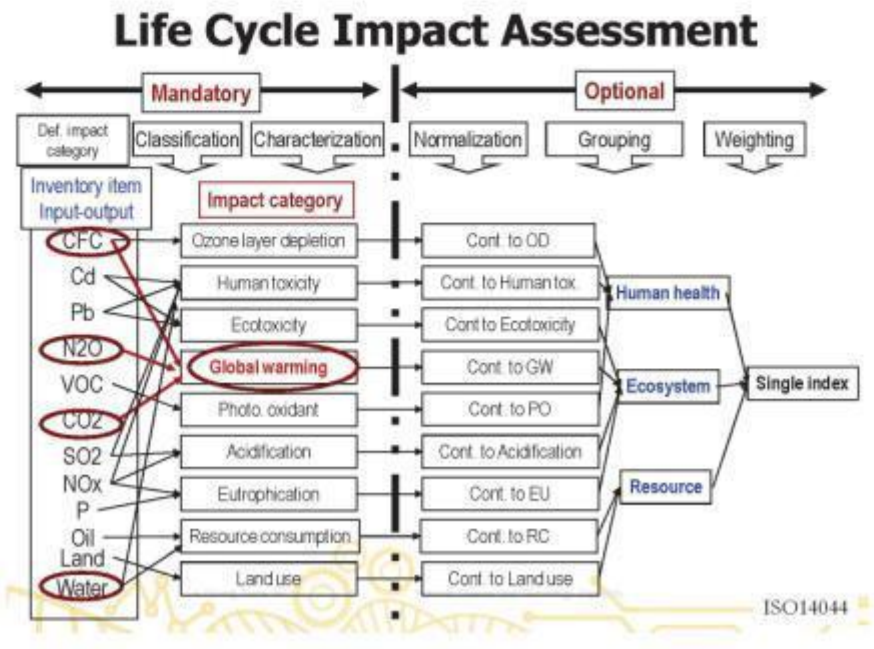
In any case, whatever the method used, the communication to the market (Business to Business or Business to Consumer) will be valid only if a third party independent auditor assesses that that the scope, methods, procedures, characterization factors, the emission models and their correlation to the environment, etc. comply with the state of art, allowing credibility to the process. This review process is a fundamental element of the integrated evaluation process.



Life Cycle Assessment (LCA)

The environmental assessment of agricultural and food is now a strategic issue worldwide. Gaps, but also a strong need for validated references were diagnosed in this field at a national and international level. The LCA represents a conceptual and methodological framework internationally recognized and described by two international standards (ISO 14040 and 14044). It has four stages. The carbon footprint, for example (or greenhouse gas emissions or contribution to climate change), incorporates and expresses a common unit (the CO2-equivalents) of all greenhouse gases emitted over the entire life cycle a product. The carbon footprint is, therefore, an environmental indicator of a series of indicators of environmental impacts (eutrophication, toxicity, acidification, abiotic resource consumption, etc.) included in a LCA.

Still, the notion of sustainability is not only based on the concept of environmental impact assessment but on three pillars: the environment but also the social and economic effects of a production line, sector, or project. The environmental approach is not an exclusive, far from a completed multi-criteria approach. It belongs to public policy makers or private research sponsors to facilitate a balanced analysis of the results and ease the decision among available options.



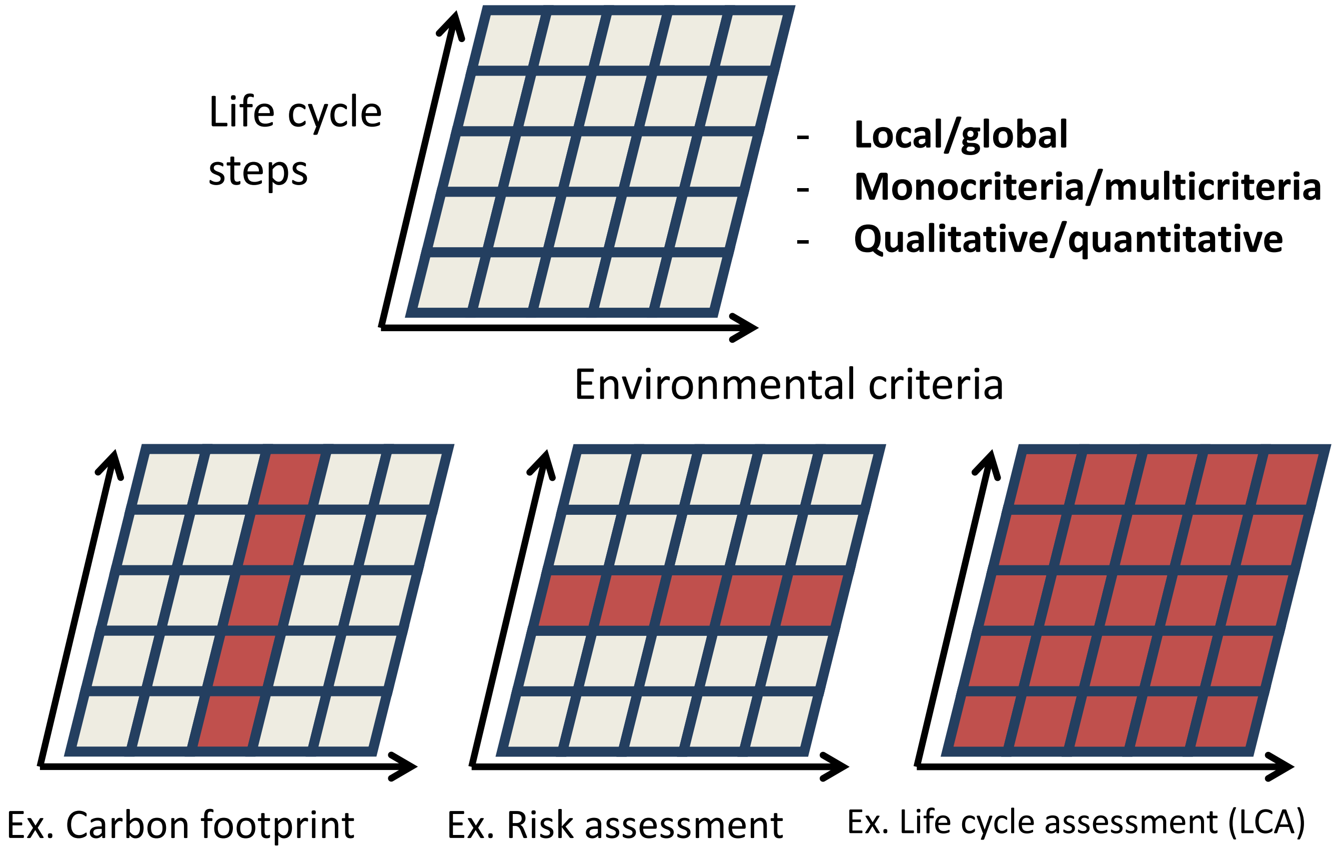
(Source : CEMEGREF/IRSTEA – France, training on LCA)

Assessment Objectives

The benefits of the LCA approach in relation to this approach involve the following components:

- Global: we study all the stages of a production cycle (raw material extraction, production, transportation, ..., treatment and recycling) regardless of the location of activities;
- Multiple Criteria: The evaluation covers a very broad category of impacts;
- Quantitative: assessments provide quantifiable results.

Finally, unlike the Carbon footprint, LCA allows to extend the study to a wide range of impacts (ecotoxicity, acidification etc..) and takes into account the impacts on the entire life cycle of a product, unlike the limited risk analysis process.



Greenhouse Gas Emission

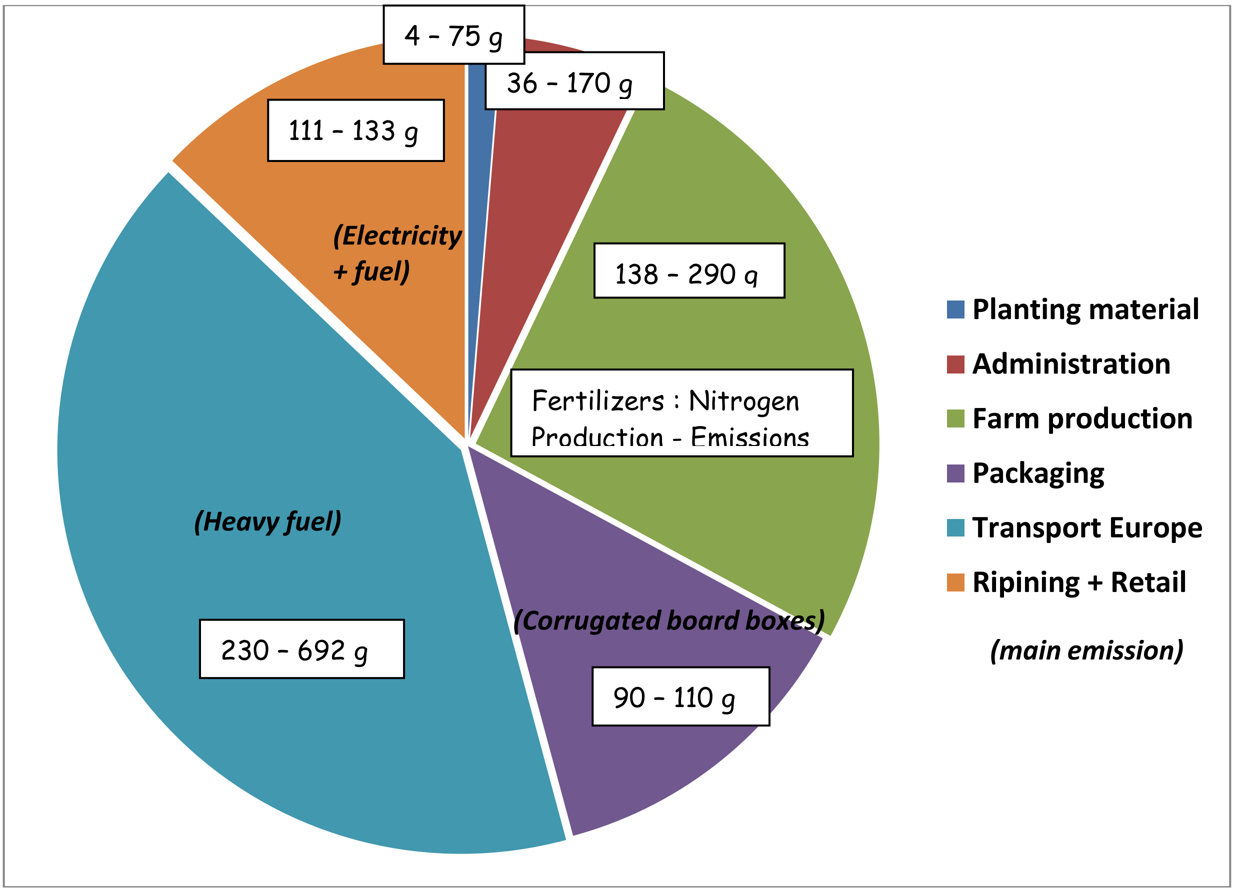
The results presented in this section come from four case studies (banana sector, 3 origins, export to Europe) that CIRAD has carried out. For confidentiality matters, it is not possible to specify neither the sources nor the geographical areas concerned. We can only say that the studies cover very different situations both in terms of production systems, geographical areas (soil and climatic contexts vary) and logistics. The study areas coincide with the European port of arrival. Some case studies cover the supply chain up to the retail stage. Studies do not consider the same impact categories, but include the entire GHG compartment, which represents the comparative baseline.
The methodologies used vary from each other and databases to characterize the impacts are also different. Furthermore, even though the lowest common denominator in terms of structure and function are well studied as Kg. of bananas returned to the port of shipment, various elements, processes or pieces of process are not necessarily taken into account. In two of the four studies, the supply of tissue culture plants (generation, transmission and transition nursery) is not taken into account. Finally, only one study includes the transport of personnel (workers, managers, etc.), in the scope.

Example of Carbon Footprint analysis (Banana)

		Site A	Site B		Site C
		from Carbon balance study		from LCA	
Steps		Kg Eq CO2/ton (banana export)			
External planting material	In vitro plants (lab production, transport, hardening)	exclude	3,8	75,0	exclude
	Land preparation				4,4
	Phytosanitary products		5,0		0,0
	Fertilizers	137,8	266,1		161,0
Farm practices	Aerial fumigation		2,6	290,0	0,2
	Irrigation (drainage)				22,7
	Pre-harvest & harvest process				3,3
	Farm production (& packaging + transport local port)		86,1		
Processing stage	Packaging	89,6			110
	Storage (& 'precooling')				
Transport from packaging facility to terminal	Transport from packaging facility to terminal	14,1			10,6
	Packaging + transport local port			98,0	
Administration	Administration		170,5		4,3
	Personal & workers transport	exclude	exclude	exclude	36,0
Ports of departure	Terminal and port operations	25,8			13,2
Oversea transport	Oversea transport	691,7	258,9	230,0	287,0
Ports of arrival (EU)	Destination port logistic (& transport to ripening)		17,2	exclude	exclude
Ripening	Ripening	84,5		exclude	exclude
Transport from ripening facility to retail	Transport from ripening facility to retail	26,6		exclude	exclude
	Destination transport		44,8	exclude	exclude
	Ripening and transport to final destination		70,8	exclude	exclude
Extra due to exclusion (5%)	Extra due to exclusion (5%)	53,5	exclude	exclude	exclude
	Total :	1 123,6	925,8	693,0	648,2

The analysis of raw results shows that there is a very high variability, which spans from 324 to 1124 g equivalent CO2/kg banana. If for some compartments or processes (excluding fuel and energy transport), there is a convergence of results, for others such as fertilizers, administration or shipping, the study reports are not accurate enough to say whether the differences methodologies are attributable to the use of different databases or changes of practices (eg. fertilization). For the shake of reliability, we should refer to the inventory data that are confidential.

Specifically for shipping, it appears that the data used to characterize GHG emissions range from 1 to over 3. If we consider that this would be a process which is the main contributor in terms of GHG (from 230 to 692 g), we understand the extreme caution that must be paid of when attempting comparisons.



Although, as we have just shown, the uncertainties are large between the four cases studied, we can still identify the three main contributors :

- Maritime transport (including refrigerants);
- The manufacture and use of fertilizers, especially nitrogen sources;
- The manufacture and provision of the shipping carton boxes in the packing station.

These findings lead operators to think about designing their production line and then to consider alternatives to the most polluting process. Various solutions or innovative practices are being explored, including the conveyance or packing (see examples), knowing that the problem goes well beyond the banana sector but also relate to agricultural sector.

The problem of fertilization is more specific to banana production (important need in nitrogen and potassium). The alternatives are few and those are also sources of CO2 emissions such as the use of compost. Concerning factor characterizations and emission models, we should benefit from data improvements and more accurate information sources in the coming years. CIRAD has developed a strong activity in this area, but it is needed more international capacity research on this area (appropriate emission models in tropical contexts).

Progress is still needed but will only be made if an innovation process involving research organizations, support organizations to producers and development, begins. The main lines of improvement revolve around the production and use of compost, installing service plants (legumes, etc..) or promote crop rotation and fallow periods.

1st Source of Emission : Maritime shipping

The 1st source of emission of CO2 is the specific fuel consumption of transoceanic vessels, but there is a great variation on data bases references :

Sources	Specific Fuel consumption	CO_2 eq. emission
Ecoinvent (LCA)*	**2.50 gram/ton/km**	**7.79 gram/ton/km**
Private overseas transport study**	**8.86 gram/ton/km**	**27.61 gram/ton/km**

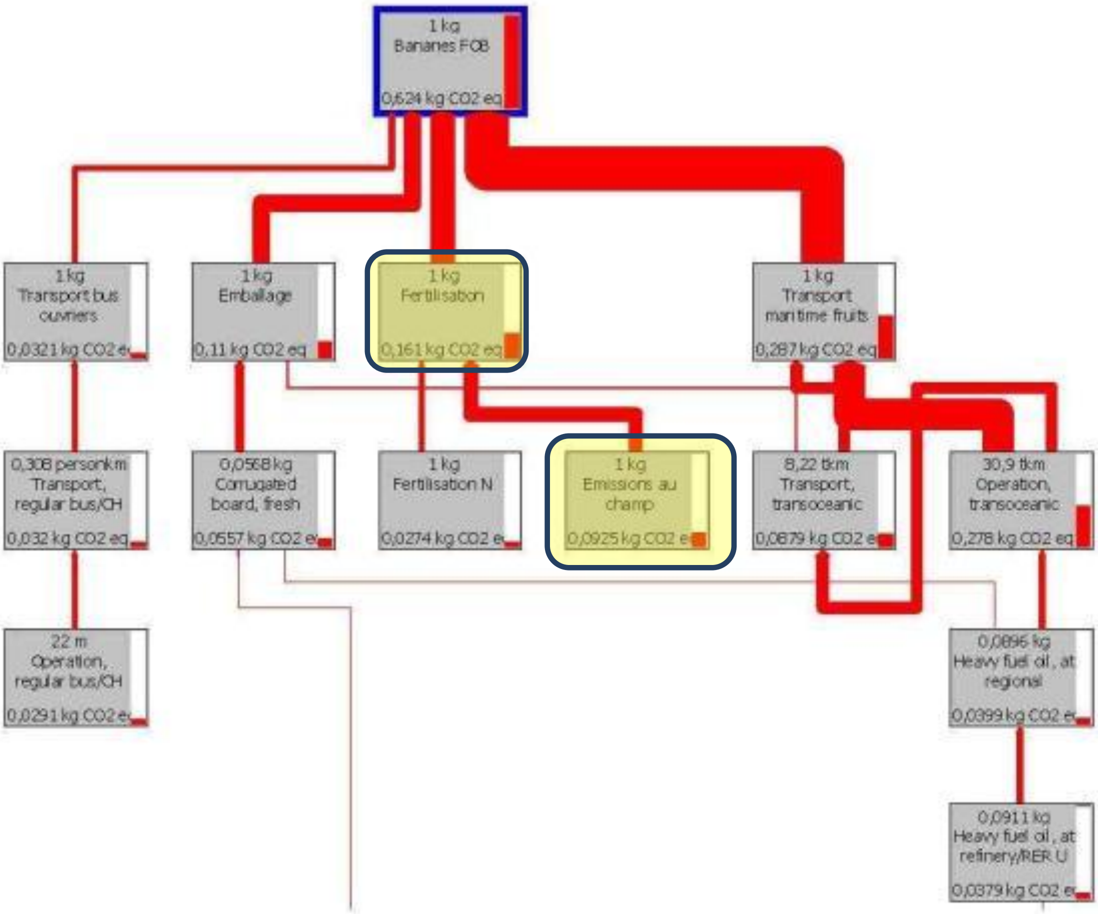
**Inputs for sea transport were based on the Ecoinvent processes 'Transport, transoceanic freight ship/OCE U' ('Transport, transoceanic tanker/OCE U')*
***Source : 'Study on greenhouse gas emissions for reefer cargo transportation on AEL vessels', 2009, by private consultancy (not public/confidential)*

Ways of solutions ? :

Overseas transport is not banana specific, but is common for billions of tons of goods shipped daily around the world. Technical alternatives to reduce fuel consumption using solar or wind complement energy are in study, with some prototype model proposed.


2rd Source of Emission : Fertilization practices (scope of WBF – WG 01)

Example of CO2 analysis from banana production by ACV method (Ecoinvent) :

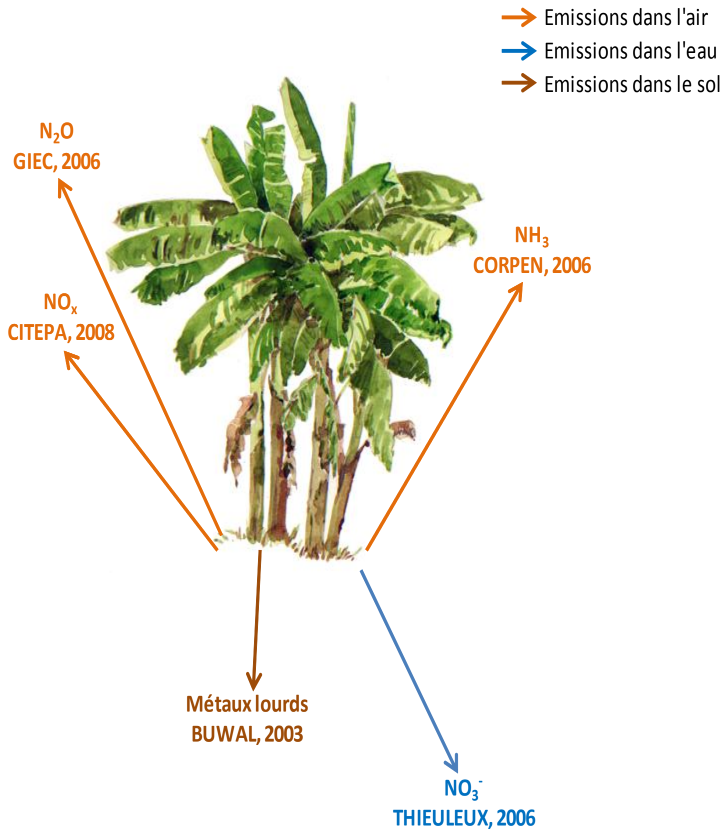


Emission factors for Fertilizers

In the definition of indicators :

Fertilizers used in the production cycle of the banana contain the elements N, P, K and Ca and heavy metals which are emitted into the air, water and soil.
The main impacts generated by these fertilizers, in addition to their production phase, corresponding to emissions:

- N2O, NH3 residue nitrogen and NOx in the air;
- NO3 and PO4_3 in water;
- Heavy metals in soil.



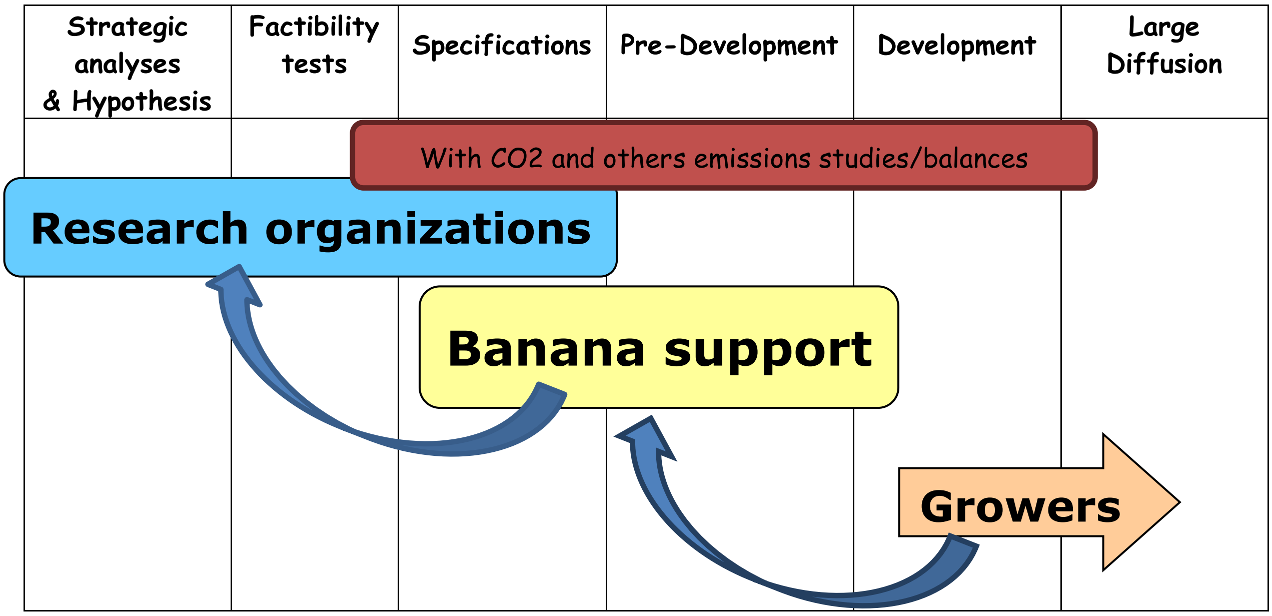
Air emissions		
NH_3 (CORPEN 2006)	N_2O (GIEC 2006)	NO_2 (CITEPA 2008)
Urea : 0,15 kg N-NH_3/ kg N MAP : 0,02 kg N-NH_3/ kg N Potassium nitrate : 0,02 kg N-NH_3/ kg N Ammonium sulfate : 0,1 kg N-NH_3/kg N Diammonium phosphate : 0,05 kg N-NH_3/kg N Calcium nitrate : 0,02 kg N-NH_3/kg N	Directs emissions factor : 0,01 kg N-N_2O/ kg N brought in 1 year or present in residuals Indirects emissions factor : 0,75 % kg N-N_2O/ kg N-NO_2 de l'azote lessivé, et 1 % kg N-N_2O/ kg N-NH_3 de l'azote volatilisé	0,6 % kg N-NO_2/ kg N, soit 1,97 % kg NO_2/ kg N

Water emissions	
NO_3^- (THIEULEUX 2006)	$PO4^{3-}$
Banana plantation : 0,35 kg N-NO3-/ kg N Greenhouse : 0,3 kg N-NO3-/ kg N	unsignificant

Soil emissions			
Emissions in mg/kg of fertilizers Fertilizers Heavy Metals (BUWAL 2003)	Ammonium sulphate	Urea	Potassium nitrate, potassium chloride, diammonium phosphate, monoammonium sulphate, calcium nitrate
Arsenic	0.41	0.4	0.405
Cadmium	0.05	0.05	0.05
Cobalt	2	2	2
Chromium	2	2	2
Copper	4	6	5
Fluor	18	5	11.5
Mercury	0.01	0.01	0.01
Molybdum	0.25	0.25	0.25
Nickel	1.8	2	1.9
Lead	1.1	1.1	1.1
Selenium	0.25	0.25	0.25
Zinc	30	44	37

Innovation Process in Banana Production (Fertilization practices)

Some initiatives exist to reduce the use of chemical fertilizers using organic matters, cover crop or oriented fallow, but the target is mainly to improve the soil biology and sanitary to get better roots system with better nutrition capacity, and never to reduce the CO2 emission …
It will be necessary in this innovative process to include CO2 emission (and others emissions) balance in comparative studies with only chemical fertilizers.
The selection of kind of fertilizers (especially for nitrogen) is also important.



Alternatives to fertilizers emissions

1. Compost

Development of compost from organic wastes from several local agricultural industries, including banana wastes, but the process is also, in a lower proportion, source of CO2 emission (great variation between numerous distinct process).

2. Cover cropping

Introduction of specific 'services' plants, alone or mixed, non-hosts of pathogens (nematodes), with different agronomic traits (roots system, shadows exigencies, water, nutriments and weeds competition, etc.).

Diversified production system with cover crop

Conventional production system

3. **Crop Rotation and fallow periods**

Fallow aims to :

Improve soil fertility (organic matter rate, better efficiency of chemical fertilizers = possibility of its volume reduction) + clean nematodes from soil (avoid use of nematicides).

Or direct plantation under mulching to avoid soil tillage :

4. **Partial substitution by organic fertilization**

Example of substitution of a part mineral fertilization by organic : 10 kg/plant/year of local compost + 0.2 kg/plant/year of chicken manure.
Mineral composition of local compost by 100 g : 1.07 g of N, 0.95 g ofe P2O5, 2.36 g of K2O.
Mineral composition of chicken manure by 100 g : 4.85 g of N, 1.70 g of P2O5, 1.90 g of K2O.

Kg/ha/year	Mineral fertilization	Mineral & organic fertilization	substitution
Calcium nitrate	**495**	**210**	**- 57 %**
Monoammonium phosphate	**207**	**153**	**- 26 %**
Phosphate rock	**573**	**239**	**- 58 %**
Urea	**110**	**78**	**- 29 %**
Potassium chloride	**188**	**40**	**- 79 %**
Potassium nitrate	**1,382**	**686**	**- 50 %**
Local compost	**0**	**18,000**	**+ 100 %**
Chicken manure	**0**	**360**	**+ 100 %**

Carbon impacts :

Indicator	Unit	Mineral fertilization	Mineral & organic fertilization	Variation
GGE emissions	kg CO_2 e (/Ton)	200	182	- 9 %

3rd Source of Emission : Corrugated board boxes

Carton boxes are commonly used to ship bananas around the world

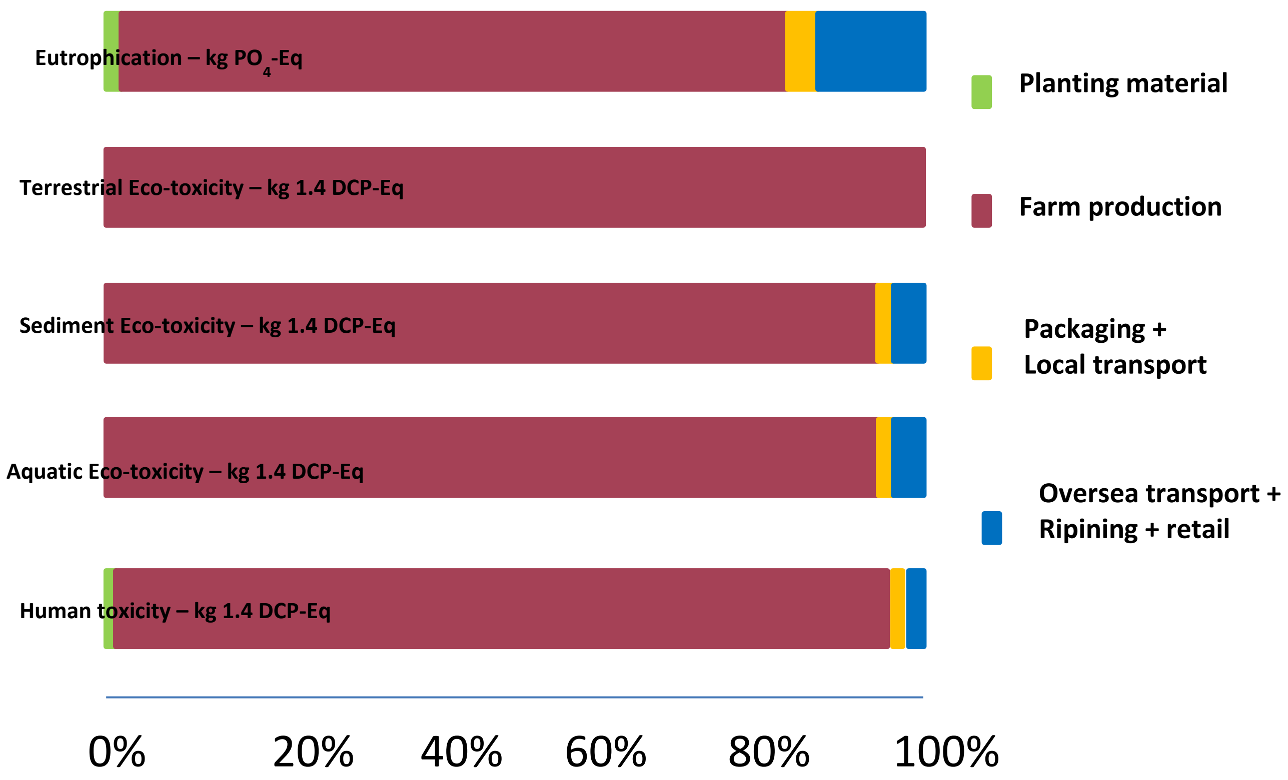
What are the options ? :

Very few alternatives to reduce CO_2 emissions, mainly on production and transport of the corrugated board boxes: local versus imported production, quality versus volume of paper used (even recycled)
Only one technical alternative exists: returnable plastic boxes, but their utilization in the supply chain would depend on economic and sustainability criteria such as costs and volume to return the boxes, cleaning and disinfection costs, CO_2 emissions comparison between plastic boxes and corrugated board boxes…) That could present some real challenge for the majority of commercial products.

What about pesticides ?

We have seen how it was complicated and uncertain to measure even with a common methodology for impact categories such as greenhouse gases, acidification, etc. What about pesticides? Currently, the usual methods take only into account the manufacturing process of plant protection products, excluding their use and fate in soil, air and water.

Example of pesticides impact with the same Life Cycle Assessment (LCA) method for 1 kg of banana production :



For this LCA analysis, the references in ‘Ecoinvent’ database are about few pesticides used in agriculture in temperate north countries (ex. Switzerland). Very few scientific references about toxicity and emissions from pesticides exist, and less in tropical agriculture contexts.
CIRAD is charged to get information on toxicity and emissions of pesticides in tropical contexts for ‘Ecoinvent’ database, but the delay for better and generalized information will be important (5-10 years ?).

Conclusions

This study does not aim to make a comprehensive review of the issue of the environmental impacts in the banana sector. Indeed, the key goal is to open a debate about the progress and limits of this type of study. As a matter of fact, we were able to see that the methodologies used are multiple or still under construction. Furthermore, they do not factor in the local production conditions: the emissions of a particular fertiliser in a tropical environment, transport of production players, etc. Without this geolocation, we can even observe results that are misleading and outliers. This raises the fundamental research question of the creation of references specific to tropical environments. This type of general interest work must be carried out by public research centres, because ultimately the results would be available for all.

Finally, based on the few studies available, it emerged that the three items with the greatest impact in terms of CO2 are, in order of importance:

- Sea transportation (three distinct production zones to Europe);
- Use of fertiliser (mainly nitrogen-based);
- Packaging (cardboard boxes).

According to expert opinion, these are the main sources of emissions found in similar studies (other agricultural products). However, a recent and very well documented study on pineapple exports from Costa Rica to the United States indicates slightly different relative weights (Ingwersen, 2012).

The main usefulness of these approaches is their ability to identify ‘hot spots’, thereby enabling a review or promote eco-design such as alternatives, innovations, research, adaptation to contexts and transfer of good practices, etc.

There is also the issue of the lifetime of the studies already completed. Since the methodologies are in constant development, the results for a given year may be greatly affected by database updates, especially for emission factors in tropical environments, or the arrival of new impact measurement methodologies.

Furthermore, access to data is very difficult. This study was made possible thanks to the cooperation of a limited number of banana sector operators who did not wish to publish the primary data, but only aggregated results and some indications about the methodologies used.

Moreover, it is extremely complicated or even risky to compare the few studies presented here, considering that the scope are all different, with some partial overlaps only.

As in any survey process, some of the data are collected directly from the field and some is derived from expert opinion. The precision and time spent collecting primary data are linked to the resources dedicated to this process. Therefore there will be a possibly non-negligible degree of subjectivity due to the survey process. Furthermore, it appears important to set up a good practice guide system for LCA or Carbon Footprint, especially for the acquisition of primary data (see table on page 5). That would accrue more importance if the results are used in the framework of environmental labelling of mass consumption products (process in progress in France).

Regarding sea transportation, one of the biggest items contributing to the carbon footprint, the data remains very sparse, heterogeneous or even surprising. Again, there is a lack of specific data about emissions from propulsion (i.e. according to ship types, but not specific to the banana sector) and from cooling (temperature) the holds and containers (specific to fresh products and the banana).

The generalisation of this type of study seems difficult both because of the limits set out above, but also in terms of financial resources to mobilise for the most modest structures (e.g.: family farms). There is indeed a risk of imposing a new constraint along the lines of certifications (private or public) on players already under great pressures.

We need to bear in mind that this type of study (carbon footprint) evaluates only part of the environmental effects. Like all production systems or more generally human activities, banana production and exporting generate other categories of impacts, due to pesticide use for example.

Recommendations

Sea transport. In conjunction with the sea transport industry, working group 01 should offer the industry players the collection of reliable and verified data about emissions (e.g. on the unit basis of one nautical mile or one kilometre) from propulsion and from cooling. The issue of heterogeneity must be sorted out with key stakeholders.

Scope (perimeter) of study. A strong recommendation of this study relates to the scope. It seems that arrival at the unloading port in Europe should be taken as the farthest point downstream, in the consideration that the subsequent processing stages (forwarding, ripening, distribution, consumer purchase and recycling) are the same regardless the nature of the study.

Along the same lines, it would be desirable for working group 01 to be able to provide a precise scope to be factored into any carbon footprint, as well as the specific list of primary data to be collected. On this basis, comparisons will be easier to make, and recommendations more relevant.

This is also the way to factor in the effects on the eco-footprint of a modification to technical procedures. This initiative could be offered by working group 01 to the various research and development centres (public or private).

Alternatives. Working group 01 could mobilise its networks to pull their experience and current guidelines in terms of research into alternative solutions, reducing CO2 emissions, and in the fields of sea transport and packaging (cardboard), alternatives not specific to the banana sector. As for the fertiliser factor, exhaustive literature studies must be conducted in order to obtain reliable comparative data between use of synthetic fertilisers and use of composting (or other alternatives to oil-derived fertilisers). If necessary, the working group must be able to question operators in order to complete studies of these alternative solutions, to ascertain their environmental value.

Table of key acronyms

- CIRAD : Centre de Coopération Internationale en Recherche Agronomique pour le Développement (France)
- WBF : Word Banana Forum (WG01 : Working Group n°01 – Sustainable Production Systems and Environmental Impact)
- LCA : Life Cycle Assessment
- ADEME : Agence de l'Environnement et de la Maîtrise de l'Energie (France)
- PCR ID : Product Category Rules (Japan)
- SSP 2050 : Shared Socioeconomic Pathway (up to 2050)
- PAS 2050 : Publicly Available Specification, developed by the British Standards Institute (sponsored by Defra and Carbon Trust) – United Kingdom
- ISO : International Organization for Standardization
- GHG : GreenHouse Gas
- N2O : Nitrous oxide
- NH3 : Ammonia
- NO3 : Nitrate
- NOx : Nitric oxide
- PO4_3 : Phosphate
- GGE : Greenhouse Gas Emission

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