ENVIRONMENTAL LABELING: AN EVALUATION OF THE SCIENTIFIC PRODUCTION IN THE LAST DECADE

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ABSTRACT:
This study analyzed the scientific production on environmental labeling from the last decade, aiming to verify opportunities for action and trends around the world. It was considered the articles published in English and Portuguese available in the Scopus, Web of Science and SciELO databases. The relevance of the articles was verified analyzing their titles and abstracts. Following were selected the articles from journals with SJR≥0.5, according to the Scimago Journal & Country Rank (SJR) classification. The selected papers were organized by application area, country of origin and applied methodology. Most of the articles are from European authors. Brazil has most of the articles in South America and the second from Ibero-American countries. There are opportunities for studies in several relevant areas, such as agroindustry, mining, technological products and health.

Keywords:
Green Seal; Trends; Environmental Label; Ecological Labels; Environmental Certifications;

1| INTRODUCTION

The expansion of technical-productive capacities and perceptible acceleration of global demographic growth have made even more evident the fact that the natural resources and services derived from them are not unlimited. Its scarcity, depletion or degradation may be a prediction of the changing well-being of humanity and the future of the planet.

In 1940 emerges the idea of environmental labeling, aiming at environmental protection and human health. In 1978, the first seal or environmental label was issued by the German Environmental Agency, the Blue Angel (Blau Engel), declaring products from recycling and low toxicity, with the aim of encouraging producers and consumers to adopt sustainable practices (GULBRANDSEN, 2006).

Since then, new labels have started to come up all over the world, starting from the global concern with the environmental problems and competitiveness in the market, and that these, would provide technological changes and amendment within the model of economic development (GODARD, 1997).

Eco-labels have been implemented in several sectors of the economy such as: forestry, construction industry, business management, tourism and mainly (PIETRO-SANDOVAL, 2016).

The goal of this study was to analyze the scientific production of environmental labeling in the last decade, discussing its evolution and applicability in the Brazilian context.

2| METHODS

The research was delimited to articles published in periodicals in the last ten years (2006-2016) in the Scopus, Web of Science and SciELO databases. The key words: eco-labelling, ecolabel, Green Seal, Environmental Product Declaration and the respective Portuguese terms were used. The selection of articles was divided into two parts.

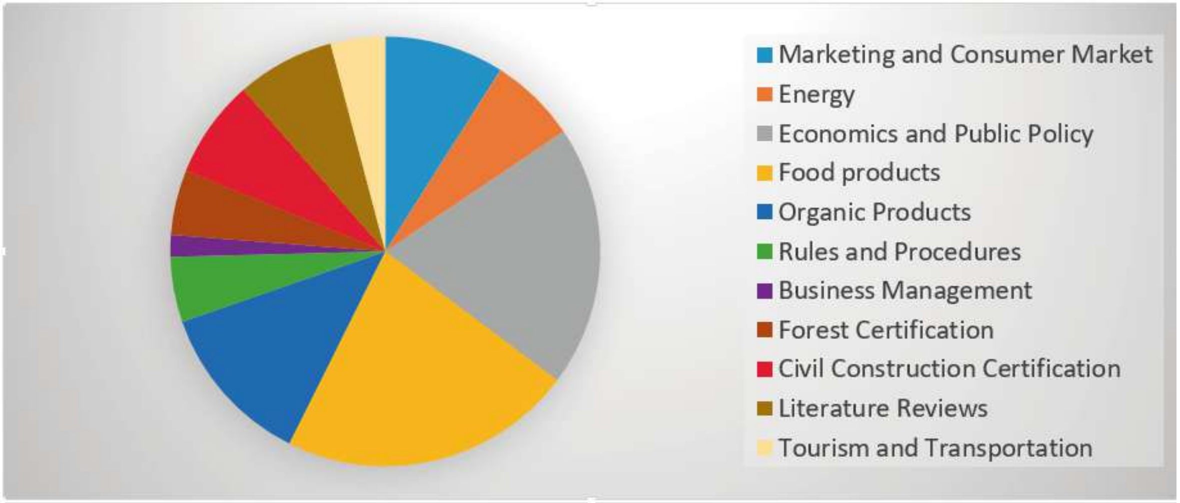
The first stage occurred in the analysis of the titles and abstracts of the articles found, to verify the relevance to the research topic. The articles present in more than one database were counted only one time. The second stage verified if the article was published in a journal with SJR≥0,5 on the basis of the classification available by Scimago Journal & Country Rank (SJR). This is a measure of the scientific influence of academic journals based in number of citations received by a journal and the importance or prestige of the journals from which come these citations (GONZÁLEZ-PEREIRA et al., 2010).

Once meeting these two criteria, the article was revised in order to identify the following aspects: field of application, country of origin, year of publication and methodology used, to be included in a classification and evaluation.

3| RESULTS AND DISCUSSION

Were returned 354 results in the Scopus database, 272 in the Web of Science and 55 in the SciELO, totaling 664 articles, once 17 articles were present in more than 1 database. Of these, 122 articles with SJR≥0.5 were selected, grouped into eleven thematic areas (Figure 1).

Figure 1 - *Main sectors, products and research areas of the Environmental Labeling application*



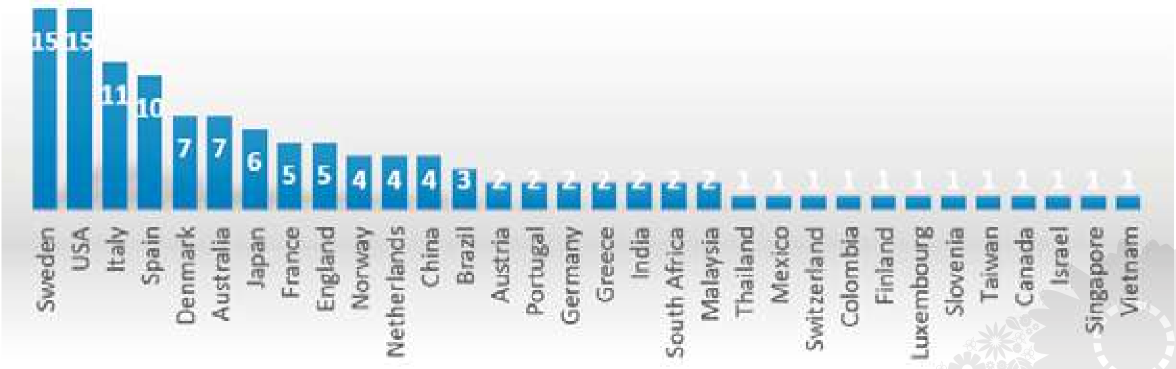
Source: *Elaborated by the authors.*

The studies associated with organic products, which discuss consumers' knowledge of environmental labels, with a view to raising awareness.

From the point of view of sectors, the application of labeling in Civil Construction stood out. Passer et al. (2015) highlights the evolution of certifications in civil construction in countries such as France, Switzerland, Germany and Belgium, reinforce the use of life cycle assessment (LCA) in improving the environmental performance of materials, projects and civil engineering.

Based on the selection criteria adopted by Sweden and the USA, with 12.3% each, they are the countries with the largest number of publications related to Environmental Labeling, followed by Italy and Spain with 9.0% and 8.2% respectively (Figure 2).

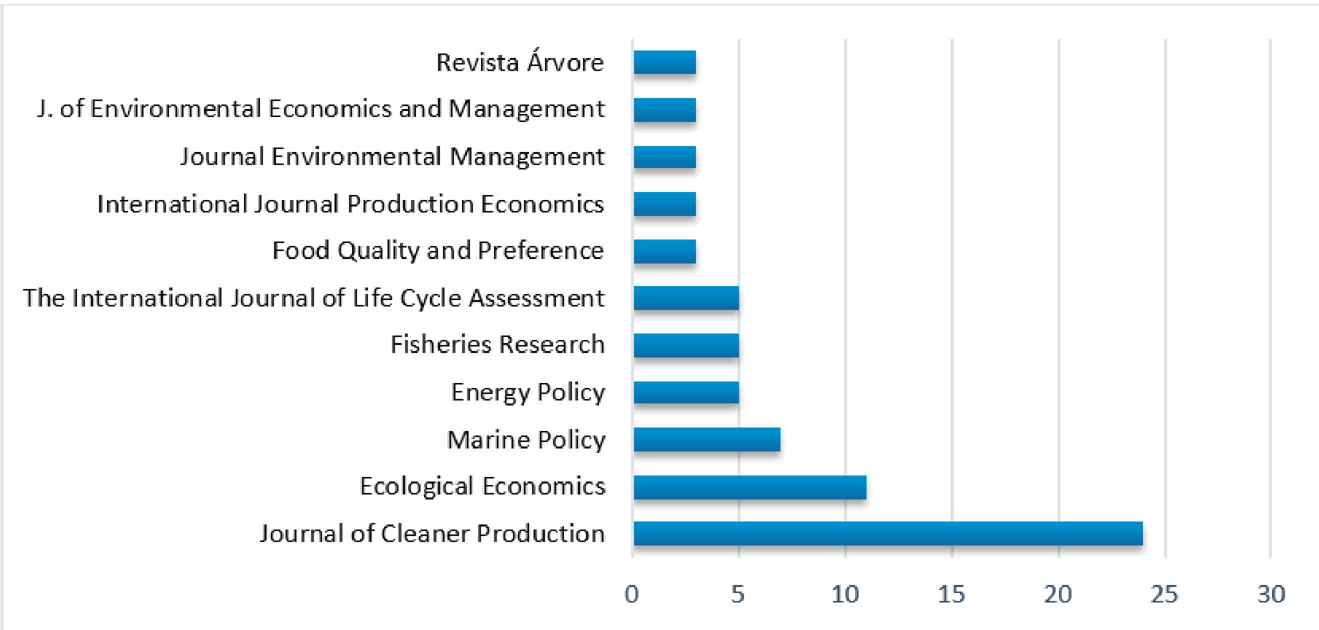
Figure 2 – *Publications by Country*



Source: *Elaborated by the authors.*

Europe was the continent with the highest number of publications in journals with scientific influence (58.2%), especially Sweden, Italy, Spain and Denmark. Followed by Asia (15.6%), highlighting Japan, China, India and Malaysia. In North America (13.9%) the USA stands out with almost 90% of the publications, mainly related to the management of greenhouse gas emissions. Oceania (5.7%) and South America (3.3%) concentrated their studies in three countries: Australia, Brazil and Colombia, respectively. The Ibero-American countries, when grouped, reached 13.9% of the articles, leveraged mainly by the contribution of Spain (58.8%) and Brazil (17.6%).
Pietro-Sandoval (2016) confirms that the European continent is a leader in quantity of publications, followed by North America and Asia, addressing topics such as food products, forestry certifications, construction and mainly food derived from fishing.
In an analysis of the most published journals on the subject, 60 journals from the different areas of knowledge that have published articles related to environmental labeling were identified.

Figure 3 - Scientific journals with 3 or more articles related to environmental labeling.



Source: *Elaborated by the authors.*

Almost 50% of published articles on environmental labeling are concentrated in 6 journals. Journal Cleaner Production concentrated almost 1/5 (19.7%), followed by the journal Ecological Economics (9.0%) and Marine Policy (5.7%). The journals The International Journal of Life Cycle Assessment, Energy Policy, Fisheries Research published 4.1% of articles. Only one Brazilian journal, the Revista Árvore, was included in the list of those who published the most.
It has also been found 20 articles related to environmental labeling, distributed in 7 national journals, with an impact factor below 0.5, demonstrating that the theme is still poorly treated in the country and is found in journals with less scientific impact. The journals Gestão & Produção (35%) and Ambiente & Sociedade (25%) concentrate 60% of the articles. The main focus of the national articles were in the areas of business management (environmental and organizational performance) and consumer market.

4| CONCLUSIONS

The evolution of discussions on environmental labeling has grown worldwide, including in Brazil, which has advanced in studies and applications in the area of certification, in companies and civil construction. The main themes found in the articles were certifications in fishery food products.
In Europe, the cradle of environmental labeling, different fields of application of labeling were identified, influencing the relationships and environmental performance of industries and consumers at the global level.
It was identified as an opportunity to carry out studies in the areas of: agribusiness, livestock, automotive industry and mining, transportation, technological products and health, considering its potential environmental and economic impact.

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PRODUCT ENVIRONMENTAL FOOTPRINT OF GREEN COFFEE PRODUCTION – STATUS QUO AND FURTHER DEVELOPMENT

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CONTEXT:

Quantitative and life cycle based assessments of the coffee supply chain proofed to be an effective means to measure and communicate environmental impacts. However, the lack of consistency in the modeling principles, data sources and impact indicators does typically not allow a comparison of environmental footprint studies.

Within the context of product and organizational environmental footprint (PEF/OEF) initiative of the European Union a product environmental footprint category rule (PEFCR) was developed for coffee with the aim to increase the consistency, comparability and quality of the environmental footprint studies of coffee. However, different views of participating companies on the benchmarking of different coffee production systems (use stage) lead to a stop of the project at the draft level.

The current draft coffee PEFCR also includes the green coffee production. The green coffee production is currently treated as a generic world average value, while also the calculation for site specific green coffee production is permitted if the data used is of sufficient quality.

Keywords:
PEF, green coffee, Latin America

OBJECTIVE:

Considering the key importance of green coffee production for Latin America as well as its imbrication in the world trade market, a proactive position in green coffee PEF assessment would strengthen the business resilience of the Latin American coffee sector. We propose to further develop the green coffee PEFCR by improving the current default data and calculation methodology.

METHODOLOGY:

We suggest to create an international working group with the task to refine the section of the draft PEFCR dealing with green coffee production, to improve the consideration of local specificities and to test it in different case studies.

We suggest to start from the current draft PEFCR on coffee that already suggested the system boundary of green coffee production, processing and supply within the full LCA of coffee (Figure 1).

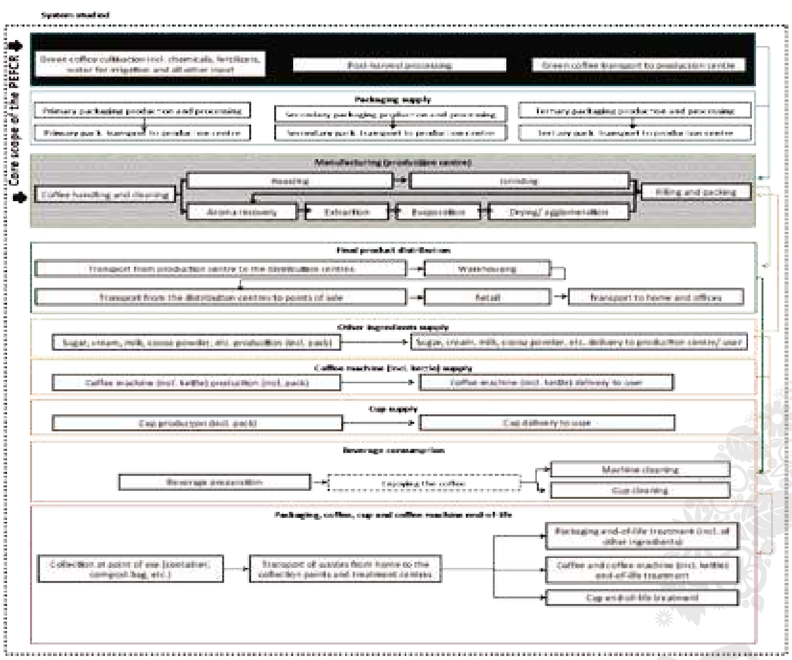


Figure 1: *Current system boundary suggested for LCA of coffee as per the draft PEFCR on coffee.*

This draft has also already suggested a list of default data to model the green coffee production, processing and supply (see Table 1 as examples). Such a list would typically be the type of data that this working group we would like to create would revise and improve.

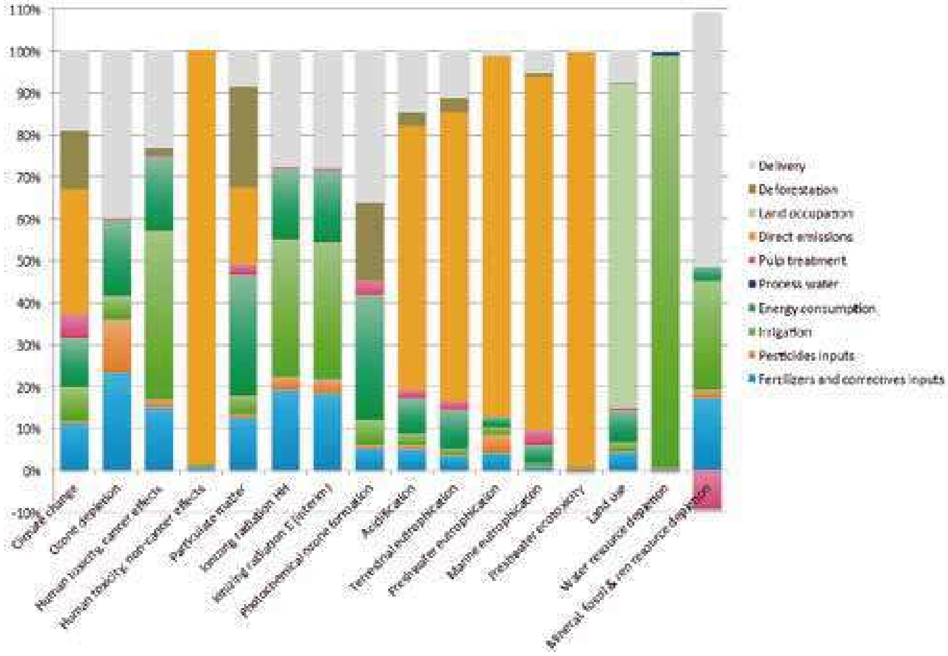
Table 1: *Current default data for green coffee modeling as per the draft PEFCR on coffee: Production, type of coffee, average yield, deforestation rates, transportation distances, irrigation rates and production volumes per country as well as for world average. For the irrigation rate, 40% of groundwater and 60% of surface water are considered.*

Country	Production volume in 2014		Type of coffee	Production volume in 2014 for Arabica		Production volume in 2014 for Robusta		Yield	Deforestation rate	Ship transport	Irrigation rate
-	t produced/ year[1]	Fraction of the total world production	-	t produced/ year	Fraction of the total world production	t produced/ year	Fraction of the total world production	(kg/ha-a)[2]	m^2 forest lost/ha-a, ENVIFOOD protocol approach [3]	km harbour to European harbour distance[4]	m^3/t green coffee (Pfister et al. 2011)
Brazil	2'550'720	34%	Mixed (70% arabica/30% robusta: FAOstat 2010)	1'785'504	40%	765'216	26%	1248	0	7'800	1104
Vietnam	900'000	12%	Robusta	0	0%	900'000	30%	2197	0	16'600	1088
Colombia	696'000	9%	Arabica	696'000	16%	0	0%	645	0	8'400	1420
Indonesia	411'000	6%	Mixed	237'076	5%	173'924	6%	523	192	16'000	2108
Ethiopia	390'000	5%	Arabica	390'000	9%	0	0%	693	218	8'400	1220
India	300'300	4%	Mixed (30% arabica/70% robusta: FAOstat 2010)	90'090	2%	210'210	7%	800	0	12'000	2204
Others	2'151'664 (difference with sum of available countries)	29%	Mixed	1'241'140	28%	910'524	31%	1200 (weighted average)	100 (average between min & max)	12'600 (weighted average	1300
World average	7'329'684 (sum of available countries)	-	Mixed (= total)					**1200 (weighted average)**	**51 (weighted average)**	12'600 (weighted average)	1104
	2'959'874 (derived from percentage)	-	Robusta (40% [5])					Assumed same as above as simplification			
	4'439'810 (derived from percentage)	-	Arabica (60%)								

The generic PEF results for green coffee (impacts for green coffee cultivation and delivery to producer) could be modeled and used as an updated as compared to the current one in the draft PEFCR on coffee (**Figure 2).**

1International Coffee Organization (http://www.ico.org/prices/po.htm), considering 60 kg green coffee/bag: we assume as a first proxy that world production shares equal EU import shares equal EU consumption shares. Website checked in April 2015.
2Based on "direct-land-use-change-assessment-tool-(version-2014-1-21-january-2014).xls" (available at http://blonkconsultants.nl/en/tools/land-use-change-tool.html)
3Based on "direct-land-use-change-assessment-tool-(version-2014-1-21-january-2014).xls" (available at http://blonkconsultants.nl/en/tools/land-use-change-tool.html)
4SeaRates.com
5Based on Panhuysen et al. (2014)

Figure 2: PEF results for green coffee (impacts for green coffee cultivation and delivery to producer), as modeled in the initial draft PEFCR on coffee.



CONCLUSION:

The aim is to have a broadly «accepted» updated PEFCR for green coffee as well as PEF compatible results for green coffee that could be used by international customers in their PEF of coffee.

--END--

LCA and rural development

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ACV COMPARATIVO DE LA PRODUCCIÓN DE AZÚCAR ESTANDAR Y REFINADO EN VERACRUZ, MÉXICO.

COMPARATIVE LCA OF RAW AND REFINED SUGAR PRODUCTION IN VERACRUZ, MEXICO.

ANÁLISE DO CICLO DE VIDA COMPARATIVO DA PRODUÇÃO DE AÇÚCAR CRISTAL E REFINADO EM VERACRUZ, MÉXICO

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RESUMEN:
La agroindustria de la caña de azúcar en Veracruz, México es descrita como un sistema binomial complejo, el cual debe garantizar su sostenibilidad como sistema productivo. El presente trabajo, tuvo como objetivo evaluar y comparar a través del Análisis de Ciclo de Vida (ACV), los impactos ambientales generados en la obtención de 2 diversas clases de sacarosa producidas en el estado de Veracruz por ser el principal productor de gramínea y sacarosa en la República Mexicana, relacionando rendimientos agroindustriales de 18 ingenios azucareros. El análisis toma en cuenta las siguientes etapas en el ciclo de vida de los 2 tipos de azúcar comparados: la obtención, siembra, cultivo y la cosecha; mismas que son insertadas dentro de un escenario productivo del tipo empresarial para su evaluación. Los 18 ingenios azucareros estudiados fueron agrupados acorde a la clase de sacarosa producida, obteniendo 2 grupos de análisis: productores de azúcar estándar y productores de azúcar refinada de acuerdo a sus consumos específicos y requerimientos energéticos en fábrica. Los resultados del presente estudio señalan que el azúcar refinado presenta mayores impactos ambientales que la estándar, debido a los requerimientos exigidos por el proceso de refinación y blanqueamiento del azúcar crudo. Lo anterior coadyuvará a la elaboración de políticas públicas al detectar impactos negativos al medio ambiente asociados con el manejo del cultivo, el uso eficiente del agua, la aplicación de insumos, así como los asociados con efluentes y emisiones a la atmosfera, con la finalidad de incorporar prácticas agrícolas y tecnologías sustentables dentro del sector de la agroindustria de la caña de azúcar.

Palabras clave:
ACV; Agroindustria; Sacarosa; Caña de Azúcar; Veracruz; Azúcar Estándar; Azúcar Refinada.

1| INTRODUCCIÓN

La producción agrícola de caña de azúcar transita por diversas operaciones unitarias: obtención, siembra, cultivo y cosecha, para así poder ser transformada en sacarosa a partir de distintos procesos unitarios, para finalmente comercializarla a través de sus múltiples cadenas de distribución. Los escenarios de mayor relevancia en la agroindustria de la caña de azúcar son los campos agrícolas cañeros y los ingenios azucareros, donde destaca la trascendencia de los métodos empleados, ya que actualmente se registra un proceso de modificación de insumos en la obtención del producto final debido a la adopción de nuevas tecnologías y prácticas de manejo para elevar su productividad y eficiencia de este binomio agroindustrial, además de añadir los procesos de comercialización, obteniendo como consecuencia el impacto en el uso de recursos naturales en la cual se sostiene dicha agroindustria.

Por ello, actualmente actores de la agroindustria de la caña de azúcar, académicos e investigadores junto con el gobierno de la República Mexicana, gestionan y amplían condiciones de producción, operación y eficiencia a factores sociales, ambientales y económicos con la finalidad de encarar los diversos retos y efectos ambientales de la agroindustria, precisando la necesidad de lograr un cambio hacia patrones de producción y consumos más sustentables, enmarcándolos en un ambiente rector de protección al medio ambiente. Por lo anterior, el gobierno mexicano, a través del Programa Especial y la Estrategia Nacional de Producción y Consumo Sustentable; (SEMARNAT, 2015), promueve la visión del cambio de paradigma hacia una economía más equitativa, responsable y verde, cimentada en el enfoque de ciclo de vida de bienes y servicios a fin de reducir las huellas de energía, hídrica, biodiversidad y materias primas.

La aplicación de ACV en el sector agroindustrial de la caña de azúcar en México coadyuvará en la identificación de impactos, vulnerabilidades y riesgos ambientales, así como en la identificación de áreas de mejora y oportunidad a lo largo de toda la cadena productiva debido a su carácter sistémico, el cual permite interpretar el desempeño ambiental de una unidad en forma integral, considerando los impactos ambientales de todos los elementos interactivos que estructuran el ciclo de vida de los productos (ISO, 2006). Análisis de Ciclo de Vida (ACV), es considerado como una de las herramientas más completas y eficaces para la gestión ambiental de las actividades productivas, ya que evalúa todo el ciclo de vida del producto, desde la cuna hasta la tumba; (Lopes, et.al; 2012, Samson, et.al; 2015).

Diversos estudios de ACV han sido desarrollados para casos específicos de la agroindustria, tal es el caso del estudio de Patcharaporn, et al., (2016), el cual evalúa impactos ambientales de diferentes métodos de cultivo y cosecha de la gramínea; por su parte Grillo et al., (2011); Luo et al., (2009); evalúan el proceso de obtención de etanol y bioenergía a partir de la caña de azúcar. Por su parte, Contreras et al., (2009); compara cuatro alternativas del uso de subproductos de la producción de caña de azúcar, Pérez, et al., (2012); evalúa y compara los impactos ambientales del ciclo de vida de diferentes tecnologías de cogeneración utilizadas en la industria azucarera cubana. En México, lo más cercano a la implementación de un ACV en la agroindustria de la caña de azúcar es lo publicado por García et al., (2016) relacionado con el cálculo de la huella de carbono para 4 ingenios azucareros en México con capacidades de molienda similares, pero de diferentes regiones geográficas, sin embargo no contempla las demás categorías de impacto que se implementan en ACV.

2| METODOLOGÍA

El desarrollo del presente ACV evalúa los impactos ambientales de 2 distintas clases de sacarosa: azúcar refinada y azúcar estándar, considerando las siguientes categorías de impacto: Cambio climático, Acidificación terrestre, Eutrofización de agua fresca, Toxicidad humana, Formación de foto oxidantes y Agotamiento de combustibles fósiles. En este trabajo no se presentan los resultados de impactos por cambio de uso de suelo debido a que se consideran rendimientos idénticos de campo de un sistema empresarial.

El estudio es limitado espacialmente al estado de Veracruz, México por ser el mayor productor de caña de azúcar (20,437,483 toneladas), así como de sacarosa 37.10% de la producción nacional mexicana, de igual forma se considera un límite temporal adaptado a una proyección estadística de zafra para el ciclo 2016-2017. La obtención de sacarosa es dada a partir de la producción y transformación de caña de azúcar en las 18 zonas de abastecimiento del estado de Veracruz, México (Tabla 1), que operaron las últimas 3 zafras y para cada uno de ellos se consideran los datos de las últimas 8 zafras.

Tabla 1. *Ingenios Azucareros y Zonas de Influencia del Estado de Veracruz, México considerados.*

Ingenio Azucarero:	Municipio:
La Gloria.	Úrsulo Galván.
El Modelo.	La Antigua.
Pánuco.	Pánuco.
Mahuixtlán.	Coatepec.
El Higo.	El Higo.
San Miguelito.	Córdoba.
El Potrero.	Atoyac.
Central Motzorongo.	Tezonápa.
San Nicolás.	Cuichápa.
Central Progreso.	Paso del Macho.
Tres Valles.	Tres Valles.
La Providencia.	Cuichápa.
San Pedro.	Lerdo de Tejada.
San José de Abajo.	Cuitláhuac.
El Carmen.	Ixtaczoquitlán.
Constancia.	Tezonápa.
Cuatotolápan.	Hueyápan de Ocampo.
San Cristóbal.	Carlos A. Carrillo.

El estudio fue referido a las actividades de agricultura realizadas para un sistema productivo caña de azúcar, del tipo empresarial, el cual es identificado y descrito por Mendonça, (2008); como un modelo industrial de producción basado en el aporte y suministro de maquinaria moderna e insumos por parte de las agroempresas, con el objetivo de obtener un gran control empresarial para la conversión rápida y en gran escala de la tierra, caracterizándose principalmente por la adopción de estrategias de mecanización, las cuales son adaptadas a este sistema productivo industrializándolo e integrándolo lo más posible.

Se calcularon y se asignaron rendimientos agroindustriales para este sistema productivo a partir de la ejecución de un clúster jerárquico, que como resultado agrupo 7 de los 18 ingenios en estudio, esto de acuerdo a una correlación: superficie industrializada-producción de azúcar. La unidad funcional, que sirvió como base para la comparación y análisis de ambas clases de sacarosa, se encuentra referida a una tonelada de azúcar producida. La Tabla 2 presenta los rendimientos utilizados en este sistema empresarial.

Tabla 2. *Rendimientos agroindustriales*

Unidad funcional:	**1 t de azúcar producida.**
Rendimiento en campo:	**8.92 t de caña de azúcar.**
Superficie industrializada:	**0.116 ha-1.**

La Tabla 3 denota las actividades asociadas a la producción global de los dos tipos de azúcar.

Tabla 3. *Actividades asociadas a la producción global de los dos tipos de azúcar*

Agricultura.	Industrialización.	Comercialización.
• Siembra. (Mecanización del suelo y Obtención de semilla.) • Cultivo. (Requerimiento nutrimental, Requerimiento hídrico y Control químico). • Cosecha.	• Molienda. • Fábrica de Azúcar. • Calderas-Cogeneración. • Clarificación de Jugo • Evaporación-Clarificación*	• Envasado. • Comercialización.

** En el caso del azúcar refinado, este proceso implica una refundición del azúcar crudo, una clarificación y evaporación extra y algunas veces una decoloración para el blanqueado del cristal.*

La generación del inventario de ciclo de vida consistió en la obtención de datos referentes a las superficies industrializadas, a la producción de caña y azúcar obtenida por unidad industrializada de cada uno de los 7 ingenios azucareros que conforman el sistema empresarial, posteriormente fueron calculados rendimientos agroindustriales, requerimientos de semilla, así como requerimientos nutrimentales y químicos necesarios para el desarrollo de la planta, el requerimiento hídrico en campo tuvo en cuenta tres tipos de variedades de caña de azúcar y fue considerado riego por gravedad, de igual forma fue considerada la maquinaria utilizada en la mecanización del suelo, fue considerada una cosecha en verde al 100%.

El consumo hídrico en la fábrica de azúcar, así como los consumos másicos y energéticos dentro de la fábrica de azúcar y los indicados con anterioridad fueron obtenidos a través de revisiones a las ultimas 8 publicaciones anuales de los manuales azucareros mexicanos editados por la Compañia Editora del Manual Azucarero,así como de informes del sistema INFOCAÑA del Comité Nacional de Desarrollo Sustentable de la Caña de Azúcar, (CONADESUCA, 2017); de igual forma fueron visitados establecimientos azucareros y consultados informes oficiales de corrida. El software SimaPro 8.1.1.16, fue utilizado para la realización del análisis del presente estudio, siguiendo las directrices normativas de referencia de la ISO 14040/44 (ISO, 2006). El cálculo de los impactos fue realizado a partir del método ReCiPe Midpoint (H) V1.12 / Europe Recipe H.

3| RESULTADOS

La Figura 1 presenta, en términos porcentuales, los impactos ambientales obtenidos para el azúcar refinada y azúcar estándar.

Figura 1. *Evaluación de Impacto de ciclo de vida para la producción de dos clases de sacarosa.*

Se puede observar que la producción de azúcar refinada insertada en un sistema empresarial presenta ligeramente mayores impactos en las categorías de impacto de cambio climático, acidificación terrestre, toxicidad humana, formación de foto oxidantes y agotamiento de combustibles fósiles en comparación con la producción de sacarosa estándar empresarial. En la categoría de Eutrofización, ambas producciones presentan los mismos impactos. La Tabla 4 muestra los resultados obtenidos en el análisis de impacto.

Tabla 4. *Resultados del análisis de impacto para las seis categorías evaluadas*

Categoría de impacto:	Unidad:	Azúcar Refinado Empresarial:	Azúcar Estándar Empresarial:
Cambio climático.	kg CO_2 eq	11729.935	11409.775
Acidificación terrestre.	kg SO_2 eq	71.154	69.451
Eutrofización de agua fresca.	kg P eq	14.205	14.171
Toxicidad humana.	kg 1,4-DB eq	5605.024	5521.568
Formación de foto oxidantes químicos.	kg NMVOC	45.297	44.026
Agotamiento de combustibles fósiles.	kg oil eq	3829.988	3718.546

El análisis de resultados muestra que el azúcar refinado presenta mayores impactos en todas las categorías, lo cual se debe al proceso de refinación del azúcar crudo, que en este caso implica una operación de sulfitación para añadir blancura al producto, a través de SO2 a la corriente de jugo del proceso. Por otra parte, el análisis de procesos unitarios, señala que tanto para azúcar estándar como para refinada, la mayor contribución a los impactos proviene del requerimiento nutrimental y control químico, debido al uso intensivo de plaguicidas y fertilizantes. El segundo proceso con mayores impactos ambientales se da en el proceso de molienda, debido al uso de fuentes energéticas no renovables tales como el combustóleo y el carbón en las pruebas de inicio de zafra.

4| CONCLUSIONES

El azúcar refinado genera impactos ambientales ligeramente superiores al azúcar estándar. El uso de plaguicidas y fertilizantes juega un papel preponderante en la generación de impactos ambientales por lo cual se sugiere el uso de fertilizantes naturales que ayuden a mitigar dichos impactos (vinazas, cachazas, composta y gallinazas). El uso de energía para sistemas de riego no presentó impactos, debido a que no se utiliza energía para el abastecimiento del recurso hídrico ya que se tiene en cuenta un sistema de riego por gravedad. De igual forma no se presentan impactos por quema de caña ya que se considera una cosecha en verde mediante cortadoras automatizadas. El uso de combustibles fósiles es determinante en la generación de impactos, por lo cual se recomienda el aprovechamiento de combustibles alternos (como ya ocurre en muchos ingenios).

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LCA OF MACAUBA (ACROCOMIA ACULEATA) OIL PRODUCTION IN THE NORTHEAST REGION OF BRAZIL

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ABSTRACT:

The economic potential of macauba palm (Acrocomia aculeata) has been recurrently emphasized, due to its high productivity and the broad possibilities of the use of its fruit. Specially in the Brazilian Northeast, where alternative crops for energy production can attenuate the hard conditions present in some areas. However, any alternative system aiming to benefit local population needs also to be environmentally sustainable. In order to assess the environmental profile of the crude oil production process from macauba fruits, a Life-Cycle Assessment of the system was performed. The functional unit was 1 kg of macauba crude oil in a cradle-to-gate approach, which it means from seed production to the gate of oil extraction unit. The impact categories considered in this study were Global Warming Potential (GWP), Abiotic Depletion Potential (ADP), Eutrophication Potential (EP), Acidification Potential (AP) and Human Toxicity Potential (HTP). The method used was CML 2001 (April 2013). The preliminary results indicate that, for the system considered, major impacts would come from the agricultural phase. Diesel and fertilizer production have significant influence on ADP. EP and AP are mostly affected by nitrogen fertilizers application and HTP due to fertilizer production. Due to its high yields and low mechanization, macauba's crude oil production system primarily captures more CO2 than it releases.

Keywords:
LCA, Macauba, vegetable oil.

1| INTRODUCTION

There is a demand for diversification of regional raw materials for biodiesel in Brazil. In addition, there is a need for cultivation of new energy crops, particularly in the poorest regions such as North and Northeast. The production and supply of biomass nearby the processing facility can result in gains in efficiency and possibly lower environmental impacts. However, to achieve the goal of social inclusion of the local population through an alternative system requires that the system be environmentally sustainable. In this scenario, the economic potential of macauba (Acrocomia aculeata) has been evaluated in the region, due to its high potential productivity and wide possibilities for the use of its fruits, which can generate oil, charcoal, food, cleaning products and other products. Macaúba is gaining attention in tropical regions for the production of sustainable biofuel feedstock, as it has a wide range of additional products and it has low ecological requirements to be planted (Lüdeke-Freunde et al, 2012). Despite these advantages, there are few studies on sustainability of macaúba managed plantations.
In order to assess the environmental profile of the process to produce oil from macauba, more specifically from the pulp/mesocarp of the fruit, a Life Cycle Assessment (LCA) of the system was performed, using the GaBi software and ISO 14040 standards.

2| METODOLOGY

Based on the Cycle Assessment Life (LCA) and following the ISO 14040 standard, the following steps were considered:
Scope of the process
The function of the technological system is to produce crude oil of macauba to serve as raw material for biodiesel production. The functional unit (F.U.) of the system is 1 kg of crude oil and macaúba reference flow coincides with the U.F. The system boundaries include the germinated seed production to the gate of oil extraction, ie, it is considered a cradle to gate approach.
Even though there is a potential for co-products production, the allocation was not considered for this still simplified assessment, having been assumed a monofunctional system, where the waste is not converted into co-products, which are utilized within the boundaries of the system itself.
The geographical coverage of the system is partial, where the main processes were modeled according to the regional reality of the region, and the auxiliary processes come from the database (DB) of the GaBi software, mostly representing European processes (German) and North Americans. Exceptions are the production of diesel and electricity, Brazilian processes within the base GaBi. All transport processes are global. The temporal coverage covers processes with data from 2012, these from DB GaBi and main processes with secondary data from 2004 and some 2015 primary collected through questionnaires and direct contact.

Technological coverage is also partial, and the main processes represent specific technologies of the system under evaluation. The auxiliary processes - from BD - represent European and American technologies that are not necessarily those used in similar cases in Brazil.

All relevant data were collected, being most of the input secondary data. The output data were calculated on the basis of inputs, by applying equations and models on the subject, available in the technical and scientific literature. No cut-off criteria were established.

The impact categories chosen for this study are the Global Warming Potential (GWP), the Abiotic Depletion Potential (ADP), the Eutrophication Potential (EP), the Acidification Potential (AP) and the Human Toxicity Potential (HTP). The evaluation method is the Dutch CML 2001 (April 2013).

3| RESULTS

Life Cycle Inventory Analysis

In the agricultural phase the following processes were considered: production of seedlings in the nursery, production of seedlings in the nursery, planting and maintenance of the crop. Primary data for this phase were collected through specific questionnaires sent to those responsible for each process of the system under analysis, as inputs for the mass and energy flows, and for the modeling. The missing data were completed by consulting the specific technical literature on macaúba cultivation. (the LCI table can be accessed as a complementary document, just write to authors). The oil extraction phase was modeled based upon specific manual on the oilseeds processing (Dorsa, 2004). Figure 1 shows the considered system flowchart.

The production of pre-germinated macauba seeds is held in a private company, which has a patent upon the germination process. So it was not possible to collect data related to this process, and no interference from this process was considered regarding the environmental profile of macauba oil.

In the pre-nursery stage, for the production of the seedlings, pre-germinated seeds are deposited in plastic polypropylene tubes. The seedlings remain in this stage for 60 days, where there is irrigation with ground water (0.01 L / seedling.day 3x) (Borcioni, 2012) and the application of superphosphate (SSP - 0.19 kg / seedlings) (Carvalho, 2011). For this process it was considered that the tubes are reused. There are also two applications of Methomyl pesticide at the rate of 7 L / palm, with 0.02% of active ingredient (ADAPAR, AGROFIT).

In the nursery, seedlings are transplanted to Low Density Polyethylene (LDPE) bags. This stage takes around 300 days (10 months) and applications of 0.016 kg of SSP, 0.012 kg of urea and 0.013 kg of K2O/ seedlings. Every two days the seedlings are irrigated with 0.1 L of water. There are also two applications of Methomyl pesticide at the rate of 7 L / seedling, with 0.02% of active ingredient (ADAPAR, AGROFIT).

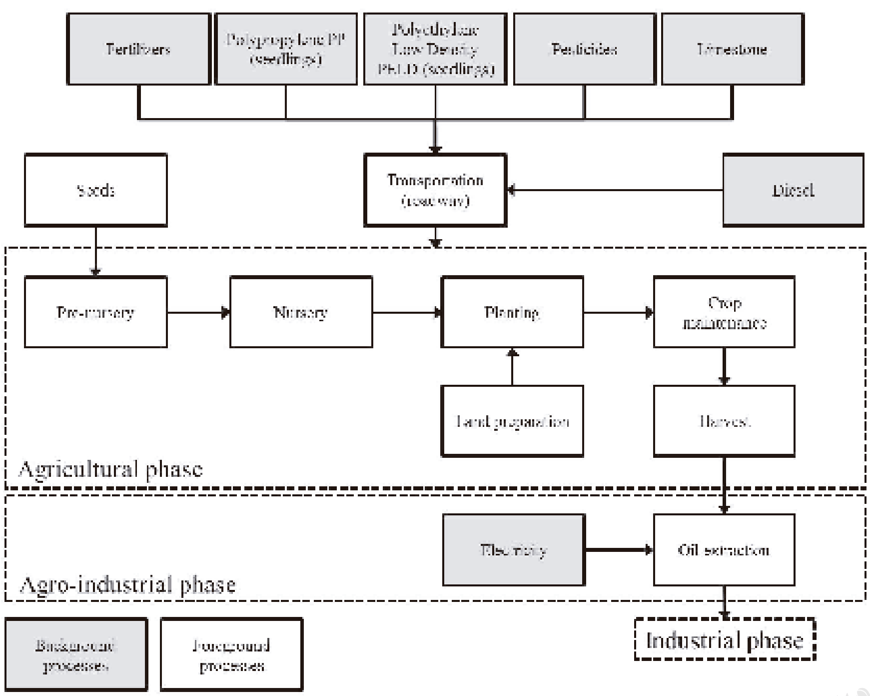

Figure 1: *Flowchart of macauba pulp oil production system (all processes are considered for LCI purposes).*

Since there is the application of nitrogen, the nitrogen emissions are quantified. For this purpose, the emission factors proposed by Malavolta (2006) are used. Then for each kilogram of nitrogen applied, an emission of 0.08 kg of N2, 0.013 kg of N2O, 0.16 kg NH3, 0.03 kg NO and 0.05 kg NO3. The remaining nitrogen unaccounted emissions is incorporated into plant biomass, since there is no specific information.

Regarding the land use, it was considered that the land was an agricultural area for over 20 years and by the time of macaúba crop establishment it was occupied by secondary vegetation. In this process, three consecutive sub-processes are considered. The first is the clearing of land by clearcutting of secondary vegetation, with the use of a small tractor that consumes approximately 6 kg of diesel / ha. The second is the uprooting roots with approximate consumption of 12 kg of diesel / ha. The latter process is plowing which consumes around 19 kg of diesel / ha. These diesel fuel consumption rate, and the consequent emission comes from GaBi database.

In the planting stage 351 seedlings / hectare are manually planted. The plastic bags go to a landfill. For each palm there is application of 0.2 kg of urea, 0.04 kg of SSP and 0.15 kg K2O (Cardoso, 2015). In this case, the same parameters for nitrogenous emissions reported for the nursery stage are applied.

The maintenance of the crop consists basically upon fertilizers application and weed control (Carvalho, 2011). In this model, the weed control is carried out manually nearby around the palm trees, and mechanical weeding over the plots. Fertilizers are applied monthly and the amounts and types of fertilizers vary according to the needs planting.

The production begins four years after planting (Carvalho, 2011). The harvest is done manually with the use of sickles to cut the bunches of macauba fruits. The average productivity of macaúba varies between 10 and 15 tons of fruit per hectare (Roscoe, 2007). For the system considered, by planting 351 palms / ha, considering on average, five bunches per palm, 250 fruit / bunch and 30 g / fruit, the productivity would result on 13.2 tons of fruits / ha. These values are converted to CO2 sequestered from the relationship between the dry weight (66%), carbon content (48%) and C conversion factor for CO2, 44/12 or 3.67 (Silva, 2008; Golden, 2011). Thus, such productivity would result on the sequestration of approximately 15 tons of CO2 equivalent.

Regarding the oil extraction from the fruits, different subprocesses are considered. The first is the bark removal, followed by the pulping, ie, the separation of pulp/mesocarp from the endocarp. The mesocarp is pressed mechanically to extract the oil. For the purpose of biodiesel production in this analysis, only the oil extract from the mesocarp is considered for, estimated in 27% of the fruit, even known that there is a potential to obtain larger amounts of oil, depends on the type of macauba and technology. Considering the previously reported productivity and oil extracted, the oil yield becomes 3.6 tons / ha. This process is accomplished through a mechanical press driven by electricity from the local network, with 12.5 horsepower and capacity of 100 kg / h (ECIRTEC).

Although not considered in this analysis, oil can be extracted from kernel as well, and the residual endocarp (up to 40%), can be converted to charcoal.

Life Cycle Impact Assessment

The method used for LCIA of macaúba oil was the CML 2001 - April 2013. The impact categories considered were: Global Warming Potential (GWP) potential Abiotic Depletion Potential (ADP), Eutrophication Potential (EP), Acidification Potential (AP) and Human Toxicity Potential (HTP). Table 1 shows the results of the environmental profile of macauba oil for the listed categories.

Table 1 – *Environmental profile of 1 kg of macaúba oil.*

FU	1 kg of macaúba oil	
Impact Category (CML 2001 – Apr. 2013)	Unit	Amount
GWP	kg CO_2 eq.	-3,91+00
ADP	MJ	4,13E+00
EP	Kg PO_4^- eq.	1,56E-03
AP	kg SO_2 eq.	6,99E-03
HTP	kg DCB eq.	4,39E-02

Normalization and weighting were not applied to the results obtained for this LCIA. The results for the impact categories are presented in absolute values according to the equivalence of each unit and refer to intermediary or midpoint impacts, i.e., express the quantity of emissions that have the potential to generate a final or endpoint impact. Thus, it is not possible to infer any direct harm to human health and to the living ecosystems. The exception is the ADP, which refer directly to the consumption of natural resources.

The GWP is negative because there is more absorption of CO2 due to the growth of palm trees, and consequently to the fruits production, than the emission of fossil fuels, derived mainly from the combustion of the engine of the trucks. The potential for CO2 uptake by palm trees was not accounted for, since at the end of the production cycle, they shall be cut off and return the fixed carbon to the atmosphere and soil.

The ADP is directly related to the consumption of mineral elements and the main contributors to this category are the superphosphate fertilizer production processes (SSP) with 41% and the production of diesel with 34%.

The EP is attributed to nitrogen emissions from the use of urea, mainly in the planting phase, when the supply of fertilizers is more significant, representing more than 85% of the emissions.

The AP follows the same dynamics of the EP, since the nitrogen emissions due to the use of urea generate approximately 75% of the equivalent emissions of SO2. Other processes that contribute are the generation of electricity, the tillage processes and the production of SSP, which together account for little over 20%.

Regarding the HTP, the majority of the emissions is related to the process of SSP production, approximately 70% of the total. The main potential agent of human toxicity are the Polycyclic Aromatic Hydrocarbons (PAH). Other processes that promote significant emissions are the generation of electricity (14%) and the production of diesel (10%).

4| CONCLUSIONS

The interpretation of the results, considering selected impact categories, for the scope previously defined, indicates that the environmental profile of macauba oil is characterized by the action of direct processes, mainly related to the agricultural phase of the system. The GWP has a very positive effect due to the high productivity of macauba crop. Therefore, it can be considered that the macauba oil production system consists of a mitigating global warming system.
In the case of ADP, the most representative processes (production of fertilizers and diesel) are outside the boundaries of the agricultural system, but are directly demanded. This could increase their influence on the environmental profile due to possible increase of mechanization, which consumes diesel.
The EP and AP denote the significance of nitrogenous fertilizers, represented by the urea, which is very volatile and inefficient, generating high levels of ammonia emissions. The two impact categories have a direct effect on the implementation of the region's agricultural system, which can be modified by selecting another nitrogen source.
The HTP presented a different dynamics, with the largest contributor originated from an auxiliary process (SSP production), which is outside of the boundaries of the system.
The results indicate that the more significant environmental impacts are concentrated in agricultural phase, which can be reduced through the management of the crop. On the other hand, due to the high yields and low mechanization, macauba's crude oil production system captures more CO2 than it releases, contributing positively to the reduction of global warming. To have a better understanding of the impacts of the system, it is important to evaluate social and economic impacts to the region as well.

Inventário de dados brutos – produção de óleo de polpa de macaúba.

** Em relação ao uso da terra, considerou-se que se trata área agrícola com mais de 20 anos e no período de plantio da macaúba a área encontrava-se ocupada por vegetação secundária.*
***Plantio de 351plantas/ha.*

Aspecto	Unidade	Quantidade	Fonte
Fase agrícola (entradas)			
Fase Pré-viveiro			
Água	L/muda.dia	0,03	Subterrânea
Superfosfato Simples	Kg/muda	0,19	
Pesticida (Metonil)	l/muda	7 (0,02% p.a)	
Fase viveiro			
Água	L/muda.dia	0,05	
Superfosfato Simples	Kg/muda	0,016	
Uréia	Kg/muda	0,012	
K2O	Kg/muda	0,013	
Pesticida (Metonil)	l/muda	7 (0,02% p.a)	
*Preparo do solo**			
Corte da vegetação secundária	Kg diesel/ha	6,0	
Retirada de raízes e arbustos	Kg diesel/ha	12,0	
Revolvimento do solo	Kg diesel/ha	19,0	
*Fase Plantio***			
Superfosfato Simples	Kg/muda	0,04	
Uréia	Kg/muda	0,20	
K2O	Kg/muda	0,15	
Total	**998**	**908**	

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DESEMPENHO AMBIENTAL DE CANA DE AÇÚCAR: SISTEMA DE PRODUÇÃO CONVENCIONAL VERSUS CONSERVACIONISTA

ENVIRONMENTAL PERFORMANCE OF SUGARCANE: CONVENTIONAL VERSUS CONSERVATIONIST PRODUCTION SYSTEM

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ABSTRACT:
This article compares the environmental performance of sugarcane produced by two different systems: conventional and no-tillage, the latter characterized by no soil disturb and crop succession. The study was based on the technical requirements of ISO 14040: 2016 and 14044: 2016. The inventories of the production systems used primary data collected from a traditional sugarcane plant. The emissions to environmental compartments were estimated and the background processes were obtained from the ecoinvent v.3 database. The RECIPE Midpoint (H) V1.12 / World RECIPE H method was utilized with the SimaPro® software, v. 8.3.0. Data showed that no-tillage system improved the environmental performance of sugarcane compared to conventional one. This practice brings benefits like the increase of stalk yield in the cane-plant period (about 12%), the elimination of tillage operation and the best use of the land by it adds soybean as an additional product. No-tillage system avoided the emission of about 5.0 t CO2eq ha-1 per 5-year cycle (a 25% reduction). Therefore, this LCA study endorses, in a quantified way, the environmental benefits of the adoption of conservationist practices, such as no-tillage in sugarcane.

Keywords:
Life Cycle Assessment; Environmental Impact Assessment; sugar-energy sector.

RESUMO:
Este artigo compara o desempenho ambiental da cana-de-açúcar produzida por dois sistemas de produção: convencional e plantio direto - este último caracterizado pelas práticas do plantio direto e da sucessão de culturas. O estudo baseou-se nos requisitos técnicos da ISO 14040:2016 e 14044:2016. Os inventários dos sistemas de produção utilizaram dados primários coletados de uma usina tradicional de cana-de-açúcar. As emissões para os compartimentos ambientais foram estimadas e os processos de segundo plano foram obtidos base de dados ecoinvent v.3. O método RECIPE Midpoint (H) V1.12 / World RECIPE H foi utilizado com o software SimaPro®, v. 8.3.0. Os dados mostraram que o sistema de plantio direto melhorou o desempenho ambiental da cana-de-açúcar em relação ao sistema convencional. Esta prática traz benefícios, como o aumento do rendimento de colmos na cana-planta (cerca de 12%), a eliminação da operação de preparo do solo, além de promover o melhor aproveitamento da terra, ao agregar a soja como produto adicional. O sistema de plantio direto evitou a emissão de cerca de 5,0 t CO2eq ha-1 por ciclo de 5 anos (uma redução de 25%). Portanto, este estudo de ciclo de vida confirma, de forma quantificada, os benefícios ambientais da adoção de práticas agrícolas conservacionistas, como a de plantio direto em cana-de-açúcar.

Palavras-chave:
Avaliação de Ciclo de Vida; Avaliação de Impacto Ambiental; Setor sucroenergético.

1| INTRODUÇÃO

A cana-de-açúcar é uma biomassa energética de importância mundial. No Brasil, há a preocupação de reduzir os impactos ambientais de sua produção, introduzindo-se práticas mais sustentáveis. A fase agrícola é sabidamente a maior geradora de impactos do ciclo de vida da cana-de-açúcar (Dias et al., 2016; Seabra et al., 2011), portanto alterações nas práticas agrícolas trazem resultados relevantes para o desempenho ambiental deste produto.

O sistema de plantio direto, caracterizado pelo menor revolvimento do solo, uso de cobertura vegetal e rotação de culturas (Derpsch et al., 2010), é considerado conservacionista e mais sustentável que o convencional. Como benefícios para a cana-de-açúcar, citam-se incrementos da matéria orgânica, da capacidade de retenção de água e da microbiota do solo (Segnini et al, 2013), além da redução de operações pesadas para o preparo do solo, o que diminui a emissão de poluentes derivados da combustão do diesel. A rotação com outras culturas, como leguminosas, ainda reduz emissões derivadas de fertilizantes nitrogenados (Matsuura et al., 2016).

Assim, esta pesquisa teve como objetivo comparar o desempenho ambiental da cana-de-açúcar produzida por dois sistemas diferentes: convencional e plantio direto.

2| METODOLOGIA

O desempenho ambiental da cana-de-açúcar foi avaliado pela abordagem da avaliação do ciclo de vida (ACV), seguindo os requisitos técnicos das normas ISO 14040:2016 e ISO 14044:2016. O escopo da pesquisa limitou-se a uma unidade de produção de cana-de-açúcar tradicional no estado de São Paulo. A unidade de referência adotada foi um hectare durante um ciclo de produção de cana-de-açúcar, incluindo-se a reforma. O fluxo de referência foi estabelecido com base na produtividade agrícola.

Avaliou-se o desempenho de um sistema convencional (SCONV), com pousio na reforma, e de um sistema de plantio direto (SPD), com soja na reforma. Ambos compreenderam os processos desde a extração de recursos naturais até a produção da cana-de-açúcar, incluindo a produção de soja e seus processos à montante, no SPD. O plantio e a colheita da cana foram totalmente mecanizados, sendo esta última operação realizada sem a queima da palha. Os transportes internos não foram considerados.

Os inventários dos sistemas de produção (SCONV e SPD) foram construídos a partir de dados primários coletados na referida usina, enquanto os inventários de operações agrícolas foram gerados por Cavalett et al. (2016). Também foram usados dados da literatura científica e da base de dados Ecoinvent v3.1 (Weidema et al., 2013). Para o SCONV, a produtividade média é referente a 1 ano de cana-planta (135 t ha-1) e 4 anos de cana-soca (96 t ha-1). Já para o SPD, a produtividade média é referente a 4 meses de soja (3,9 t ha-1 ano-1), 14 meses de cana-planta (151 t ha-1) e 4 anos de cana-soca (105 t ha-1). Para contabilizar a produção de mudas, optou-se por descontá-la da produção total de cana-de-açúcar, conforme Jungbluth et al. (2007).

No SPD, recursos naturais e insumos compartilhados para a produção de cana-de-açúcar e soja, assim como as emissões derivadas do seu uso, foram alocados segundo o critério de tempo de ocupação do solo, segundo Nemecek et al. (2008) e Matsuura et al. (2016). Assim, o fator de alocação para cana-de-açúcar foi de 0,75 e para a soja, 0,25.

As emissões foram calculadas de acordo com Nemecek e Schnetzer (2011) e Canals (2003), regionalizadas para a realidade brasileira. Não foram consideradas emissões de mudança de uso da terra, visto que o canavial em estudada estava estabelecido há mais de 20 anos.

Os impactos foram avaliados pelo método ReCiPe Midpoint (H) V1.12/World ReCiPe H (Goedkoop et al., 2012), com o software SimaPro®, v. 8.3.0.

3| RESULADOS E DISCUSSÃO

O desempenho ambiental diferiu entre os dois sistemas estudados em todas as categorias de impactos analisadas (Figura 1), com melhores resultados para o SPD, em relação ao SCONV, à exceção da eutrofização de água doce. Atribui-se esta superioridade ao menor número de operações agrícolas, pois não se realiza o preparo do solo, mas principalmente à inclusão da soja como produto adicional, ocupando a terra durante a reforma. Chagas et al. (2015) relataram resultados semelhantes, inclusive uma redução de cerca de 30% nas emissões de gases de efeito estufa (GEE).

Na categoria mudanças climáticas, a redução da emissão de GEE com o uso do SPD, em relação ao SCONV, é da ordem de 25 %, o que equivale a 5,0 t CO2eq ha-1 por ciclo. De um modo geral, as etapas de produção e uso de fertilizantes e as operações agrícolas impactaram as categorias Mudança Climática, Formação de Material Particulado, Toxicidade Humana e Ecotoxicidade de Água Doce.

Já a produção e uso de pesticidas afetaram as categorias Ecotoxicidade Terrestre e Aquática e Toxicidade Humana. No SPD, a etapa de produção de soja impactou principalmente as categorias Ecotoxicidade Terrestre e Aquática e Eutrofização de Água Doce – esta última influenciada pela emissão de fósforo para águas superficiais por erosão. Para esta estimativa, devido à falta de informação específica para o SPD, foi assumida a mesma perda de solo atribuída ao SCONV, o que corresponde a uma abordagem conservadora. De maneira geral, o plantio direto reduz a erosão, portanto a perda de solo carreando fósforo, e seu efeito sobre a eutrofização de água, podem ser mais baixos que o estimado neste trabalho Ainda assim, o SPD apresentou melhores resultados em relação ao SCONV.

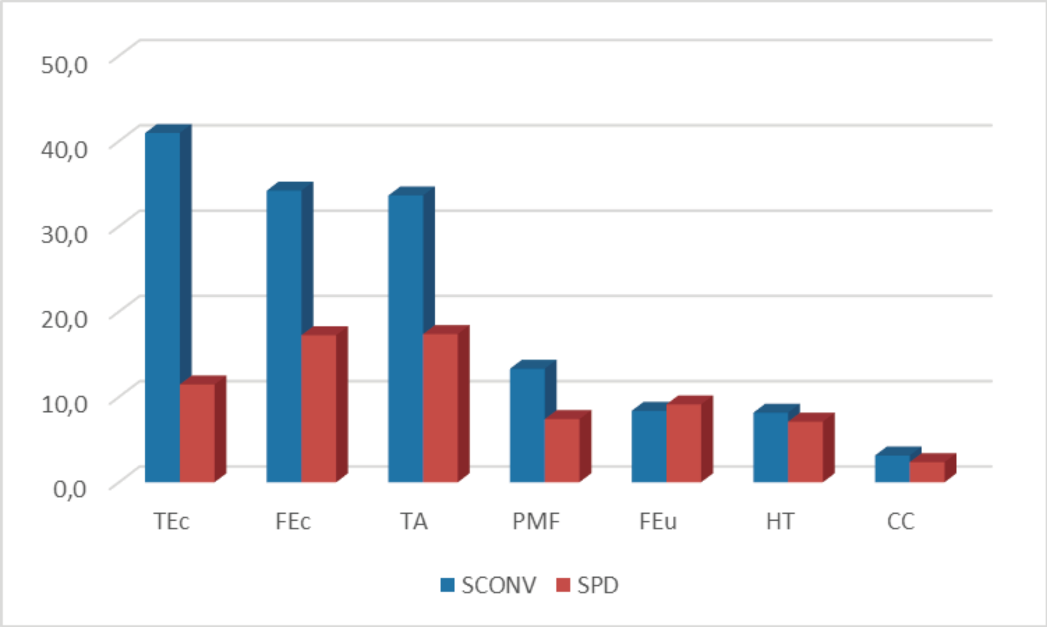

Figura 1. *Análise comparativa do desempenho ambiental (normalizado em relação às emissões globais do ano 2000.) da produção de cana-de-açúcar pelos sistemas convencional (SCONV) e plantio direto (SPD). (TEc Ecotoxicidade Terrestre; FEc Ecotoxicidade de Água Doce; TA Acidificação Terrestre; PMF Formação de Material Particulado; FEu Eutrofização de Água Doce; HT Toxicidade Humana; CC Mudança Climática).*

4| CONCLUSÕES

O estudo de avaliação de ciclo de vida confirma, de forma quantificada, os benefícios ambientais da adoção de práticas agrícolas conservacionistas, como a de plantio direto em cana-de-açúcar.

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ENVIRONMENTAL IMPACTS ASSESSMENT OF EGGS PRODUCTION IN BAHIA, BRAZIL

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ABSTRACT:

Purpose:
To identify the environmental impacts in the life cycle of 1 kg of eggs from Hisex White hens.

Methods:
The product system comprised: Feed Production, Transports (of chicks and grain) and Eggs Farm. Five impact categories of the CML-IA method were considered to perform a cradle-to-gate Life Cycle Assessment. The SimaPro© 8.0 was used as supporting tool. Primary data were obtained from an eggs farm placed at the southwest region of Bahia, Brazil, and secondary data from literature and databases (Ecoinvent and ELCD).

Results and Discussion: Grain Production was the most impacting in the categories Climate change - CC (35,50%), Eutrophication - ET (56,24%) and Land Use - LU (84,95%). The main contributors to impacts were the Horn Meal (19,5% in Acidification - AC and 14,2% in ET), Corn (9,79% in AC, 21,9% in ET and 5,03% in LU) and Soybean (20,1% in ET and 47,8% in LU). The transport of chicks was the most impacting in the categories CC (40,94%) and Depletion of abiotic resources - DA (48,70%). The vehicle usage resulted in potential impacts for CC category, due to CO2 emissions (39%), and DA category, due to diesel (42,2%) and natural gas (3,83%) consumption.

Conclusions:
The impacts in the Eggs Farm were not relevant when compared to those occurred upstream. Prospective scenarios could help the identification of alternatives for reducing the main elementary flows from the potential impacts identified.

Keywords:
LCA, Poultry, Eggs Farm, Environmental Management.

1| INTRODUCTION

There are few Life Cycle Assessment (LCA) studies regarding eggs production when compared to other agroindustrial activities. In the World Food LCA database, this activity has only 0.55% of available agroindustrial life cycle inventories (SCHENKER, 2016).
LCA studies of eggs production have focused primarily on global warming potential. Pelletier et al. (2013) analyzed the carbon footprint of eggs production in the Midwest of the USA; Vergé et al. (2009) estimated the GHG emissions of Canadian poultry industry, including eggs production; Cederberg et al. (2009) compared GHG emissions in meat, milk and egg production in Sweden.
In addition to GHG, Wiedemann and McGahan (2011) investigated the Cumulative Energy Demand (CED) and the Water Footprint of eggs in Australia; Pelletier et al. (2014) included the CED, Acidification and Eutrophication in the USA; and Ghasempour and Ahmadi (2016) studied ten impact categories, including Acidification and Eutrophication in Iran.
Pelletier (2017) studied the Acidification, Eutrophication and GHG Emissions, as well as Land, Water and Energy Uses in an environmental life cycle assessment of eggs production in Canada, considering different hen housing system types.
This study performed an environmental impacts assessment of eggs production in Brazil.

2| METHODOLOGY

An attributional LCA cradle to gate study was performed according to the standards ISO 14040 (2006) and ISO 14044 (2006), defining:

– Function and Functional Unit (FU): the production of 1 kg of eggs (FU) from Hisex White hens under conventional cage system. The product system (Figure 1) comprised: the stages of feed production (grains and horn meal), transport (chicks and grains), and eggs production (breeding, fattening, posture, classification and packaging). The software SIMAPRO® 8.0.5 was used to modelling the product system and as computational tool to analyze the life cycle inventory (LCI) and to perform the impact assessment (LCIA) at midpoint level. Five impact categories from the CML-IA method were considered: Climate Change (CC), Acidification (AC), Eutrophication (ET), Land Use (LU) and Depletion of Abiotic Resources (DA).

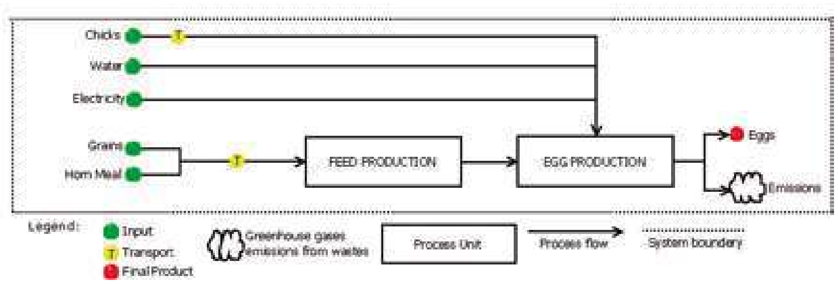

Figure 1 – *Product System*

Data collection for the LCI (Table 1) included site-specific primary data, which correspond to eggs production activities in a farm located in southwestern of Bahia state, Brazil. This farm represents about 20% of the state, with a herd around 50 thousand hens and production of 48 thousand eggs daily, approximately. Secondary data correspond to activities upstream of the farm (feed production and transport), obtained from Ecoinvent v.2 and ELCD databases; and emissions from chickens and manure (inside the farm), estimated using empirical and theoretical models (IPCC, 2006).

Table 1 - *Inventory of 1 kg of white Hisex White hen eggs in conventional cage system*

Unit Process	Process from SimaPRO	Amount	Unit
	Inputs		
Transport – chicks	Transport, lorry 3.5-16t, fleet average/RER S *	31.515 (E)	t.km
Transport – grain	Transport, lorry >28t, fleet average/CH S *	14.31(E)	t.km
Transport – other inputs	Transport, van <3.5t/CH S *	0.63 (E)	t.km
Electricity	Electricity. medium voltage, production BR, at grid/BR S *	0.2415 (V)	kWh
	Liquefied petroleum gas, at service station/CH S *	0.0255 (V)	kg
Water	Water, river *	9.339 (E)	L
Feed Production	Horn meal, at regional storehouse/CH S *	5.674 (V)	kg
	Corn, at farm/US S *	2.203 (V)	kg
	Soybeans, at farm/BR S *	1.034 (V)	kg
	Limestone, milled, packed, at plant/CH S *	0.165 (V)	kg
Buildings	Occupation, construction site	4.714E-7 (E)	ha.a
	Pine wood, timber, production mix, at saw mill, 40% water content DE S **	1.947E-4 (E)	ton
	Brick, at plant/RER S *	0.012 (E)	kg
	Fibre cement corrugated slab, at plant/CH S *	0.009 (E)	kg
	Outputs		
Emissions	Methane *	0.00115 (E)	kg
	Dinitrogen monoxide *	0.000163 (E)	kg
	Ammonia	0.008759 (E)	kg
Eggs		1 (V)	kg
	* Ecoinvent database; ** ELCD database		
	(E) Estimated; (V) Verified		

3| RESULTS AND DISCUSSION

The Feed Production was the most impacting in three categories (AC, ET and LU), followed by Transport of Chicks that was most impacting in CC and DA categories (Figure 2).
The main contributors in Feed Production were the horn meal (19.5% in AC and 14.2% in ET), the corn (9.79% in AC, 21.9% in ET and 5.03% in LU), and the soybean (20.1% in ET and 47.8% in LU).

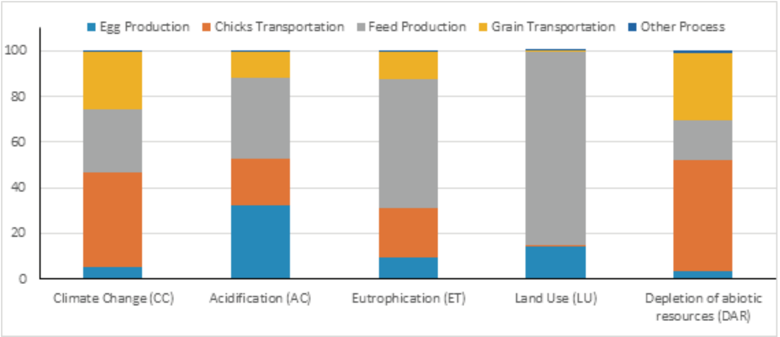

Figure 2 – *Impacts assessment of eggs production (CML-IA), in %.*

Considering the elementary flow level, the Transport of Chicks had the CO2 emissions (39%) from vehicle as the main contributor to CC category. The consumption of petroleum (42.2%) and natural gas (3.38%) contributed for DA category.
As in this work, Cederberg et al. (2009), Wiedemann and McGahan (2011), Pelletier et al. (2013), Ghasempour and Ahmadi (2016), and Pelletier (2017), also identified the grain production as the main contributor for CC category. This is mainly due to emissions associated with changes in land use, the use of fertilizers and mechanization. The Brazilian poultry feed production uses mainly the corn and the soybean, that are intensive and large-scale crops. The intensifying of agriculture and processing stage of these grains will result in higher environmental impacts like Eutrophication and Land Use due to the intensification and increase of production scale, the crop-growing areas, as well as the use of transportation.
For AC category, the main contributors were the horn meal (19.5%) and the corn (9.75%), and for ET were the corn (21.9%), the soybean (20.1%) and the horn meal (14.2%). The elementary flows for AC category are related to sulfur dioxide, ammonia and nitrogen oxide emissions. For ET are the losses due to the runoff of nitrogen and phosphate fertilizers, used in grains production.
Fertilizer production requires high consumption of fossil fuels and electricity. Thus, due to differences in the energetic matrix, is expected that the impacts associated to such production in Brazil can to be lower than in Europe or the USA. On the other hand, most fertilizers used in Brazil (70%) are still imported (Willers et al., 2017). In the LU category, feed production corresponded to 84.94% of the environmental load, with the soybean (47.8%) and maize (36.6%) as the main contributors. This confirms that the animal feed production is a significant contributor for the environmental load of the productive system.
According to Cederberg et al. (2009), Wiedemann and McGahan (2011), and Pelletier et al. (2013), chicken excreta are the main contributors to environmental impact in acidification and eutrophication categories in all systems studied. However, this study considers the animals' excreta composting which, according to Webster et al. (2006), provides better nitrogen retention, with lower volatilization of ammonia and other nitrogen compounds.
The Transport of Chicks (48.7%) and Transport of Grains (29,22%) were the unit process that most contributed for DA category. The main elementary flows were the petroleum and the natural gas. The chicks and the grains are transported by by road, for about 2500km and 750km, respectively. This scenario indicates to a high consumption of fossil fuel derivatives, mainly diesel.

4| CONCLUSIONS

Feed production and the transport of chicks were the main contributors for the negative impacts in the eggs' life cycle.
Impacts within eggs farm boundaries were insignificant for most categories, when compared to those upstream, except for the Acidification category.
Prospective scenarios should be modeled aiming at identifying alternatives to reduce environmental impacts due to main contributors.

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Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) (476725/4572012-7; 313293/2014-7) e Fundação de Amparo à Pesquisa do Estado da Bahia (Fapesb) (APP0056/2011; PAM0017/2014)

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ANÁLISIS DE COSTOS DE CICLO DE VIDA DE LA PRODUCCIÓN DE CAÑA DE AZÚCAR EN TUCUMÁN (ARGENTINA)

LIFE CYCLE COSTING OF SUGARCANE PRODUCTION IN TUCUMÁN (ARGENTINA)

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RESUMEN:

Introducción. La Argentina tiene una industria azucarera de larga tradición siendo la Provincia de Tucumán el centro neurálgico de esta actividad productora de azúcar y etanol combustible. Este trabajo tiene como antecedente un estudio reciente de Análisis de Ciclo de Vida (ACV) de la industria de la caña de azúcar en el que las labores de cultivo de la caña se clasifican en tres niveles tecnológicos: alto (NTA), medio (NTM) y bajo (NTB). Objetivos. Complementar el ACV con un análisis de costos de ciclo de vida (LCC) teniendo en cuenta los niveles tecnológicos antes mencionados. Método. Se utiliza el LCC, el cual, en el contexto de Pensamiento de Ciclo de Vida, es un procedimiento para determinar la suma de los costos asociados a un bien en su ciclo de vida (adquisición, instalación, operación, mantenimiento y disposición final). Resultados y conclusiones. Se muestra que no hay diferencias significativas entre niveles tecnológicos en cuanto a costos de producción de caña de azúcar, pero sí en el margen bruto. Se observa un valor creciente del margen bruto a medida que se incorpora tecnología al campo, y en este mismo sentido disminuye la magnitud de la mayoría de las categorías de impacto ambiental.

Palabras Clave:

Análisis de Ciclo de Vida; Análisis de Costos de Ciclo de Vida; Caña de azúcar; Azúcar; Bioetanol.

ABSTRACT:

Argentina has a long tradition sugarcane industry being the Province of Tucumán the center of this activity, which produces sugar and fuel ethanol. The present work has as antecedent a recent Life Cycle Analysis (LCA) of the sugarcane industry in which labors associated to the cane culture are classified according to three technology levels: high (NTA), medium (NTM) and low (NTB). Objectives. It is to go further and perform a Life Cycle Cost Analysis (LCC) of these technology levels. Methods. In the context of Life Cycle Thinking, LCC is a procedure for determining the sum of costs associated with a good (acquisition, installation, operation, maintenance and final disposal costs). Results and conclusions. It is shown that there are no significant differences between technology levels in sugarcane production costs. However, there is an increasing value of the gross margin as the incorporation of technology to the agriculture labors increases. In the same way, the value of most of the environmental impact categories decreases.

Keywords:

Life cycle assessment; Life cycle costing; Sugarcane; Sugar; Ethanol.

1| INTRODUCCIÓN

La Argentina tiene una importante industria de la caña de azúcar (azúcar y alcohol), concentrada en el noroeste del país, la cual es un pilar de la economía de la provincia de Tucumán: 65% de la producción argentina (EEAOC 2015). La estructura productiva engloba unos 5000 productores independientes con diferentes niveles tecnológicos (NT) (INDEC 2002). Si bien la abundancia de recursos naturales hace de la Argentina un excelente proveedor de derivados de la caña, los problemas asociados a la intensificación del cultivo (cambio de uso del suelo, competencia con alimentos, impacto del transporte y grandes volúmenes de efluentes) plantean importantes desafíos.
Existen numerosos estudios de Análisis de Ciclo de Vida (ACV) de com-bustibles a partir de caña -centrados en reducir el consumo de combustibles fósiles y las emisiones de gases de invernadero-, que no siempre incluyen un análisis económico. Por esto; un estudio que muestre diversas categorías de impacto junto a un índice económico es una necesidad urgente. Algunas contribuciones sobre ACV y caña de azúcar argentina son: Mele et al. (2011) y Amores et al. (2013). Luo et al. (2009), Galdos et al. (2013), García et al. (2011) y Jenjariyakosoln et al. (2014), entre muchos otros, realizaron ACVs de la actividad cañera en otros países, los cuales no reflejan el caso argentino. Además, no se conoce una caracterización económico-ambiental que discrimine los diferentes NT agrícolas en la producción de caña.
El presente trabajo se basa en un ACV reciente (Nishihara Hun et al., 2016) en el que los niveles asociados a la producción de caña se clasifican en: alto (NTA), medio (NTM) y bajo (NTB). El objetivo es hacer un Análisis de Costos de Ciclo de Vida (LCC) para estos niveles, considerando costos corrientes de adquisición, instalación, operación, mantenimiento y disposición (Scott M. et al., 2016). El LCC complementará al ACV dado que este último no refleja por sí solo los trade-offs entre el desempeño ambiental y económico.

2| METODOLOGÍA

El estudio de ACV se realizó según la serie ISO 14040 (2006) y el de costos según Ciroth et al. (2008). La definiciones (límites del sistema, modelo de impacto) y demás consideraciones para el estudio de ACV se detallan en Nishihara Hun et al. (2016). Los datos utilizados (ACV y LCC) corresponden a la campaña 2015 y se obtuvieron de entrevistas con técnicos de INTA-Famaillá y productores de Tucumán, eligiendo 1 ha como unidad funcional. La Tabla 1 muestra las principales características de los NT considerados.

Tabla 1. *Principales características de los tres NT considerados*

	Alto (NTA)	Medio (NTM)	Bajo (NTB)
Rendimiento caña (t/ha)	75	62	55
Rendimiento azúcar (kg/ha)	4811	3977	3528
Frecuencia de renovación del cañaveral (años)	5	6	7
Sistema de cosecha	80% mecanizada 20% semi-mec.	60% mecanizada 40% semi-mec.	20% mecanizada 60% semi-mec. 20% manual
Quema del residuo	escaso	total	total
Uso de agroquímicos	intensivo	moderado	escaso

Para el LCC se han calculado los costos de producción, los cuales se han dividido en Directos (CD) e Indirectos (CI) (Foulon, 1863). Los CD son los que sólo existen si se realiza la actividad: insumos y servicios consumidos en el ciclo productivo (ej.: semillas, labores, agroquímicos, cosecha y comercia-lización, etc.). Los CI son aquellos en que se incurre si la actividad es llevada a cabo o no (ej.: pago de servicios, gastos de administración, impuestos, etc.). No se tuvieron en cuenta las amortizaciones.
Para determinar la rentabilidad del sistema se han utilizado tres indicadores: Margen Bruto (MB), Margen Neto (MN) y Precio de Equilibrio (PE). El MB es el valor de la producción (PR) menos los gastos operativos totales generados por la actividad (CD): MB = PR – CD. El MN se calcula deduciendo del MB los CI: MN = MB – CI. El PE indica el precio al que debería venderse el producto para recuperar los costos sin obtener beneficio alguno (MN nulo).
Para el MB, los ingresos se estimaron considerando 64% de azúcar blanco (mercado interno), 5% de crudo, y 31% para exportación. Los precios promedio de azúcar de junio a diciembre de 2015 son: 3,76 $/kg azúcar blanco; 2,80 $/kg azúcar crudo y 1,82 $/kg azúcar para exportación. Los CI se estimaron como un 15% de los costos directos.

3| RESULTADOS Y DISCUSIÓN

La Figura 1 muestra el perfil ambiental (CML 2001) de la caña cosechada. En siete categorías de impacto, el NTA tiene menor impacto que NTM y NTB.

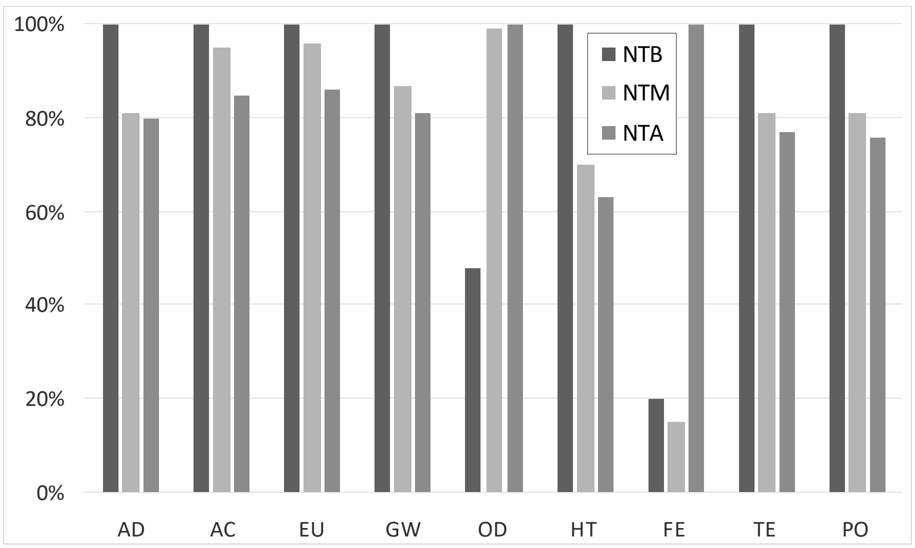

Figura 1. Perfil ambiental de la caña de azúcar para cada NT: NTA, NTM y NTB. AD: rec. abióticos, AC: acidif., EU: eutrofiz., GW: cal. global, OD: ozono estratosférico, HT: toxic. humana, FE: toxic. agua dulce, TE: toxic. terrestre, PO: oxidantes fotoquímicos.

Los resultados del LCC se presentan en las Tablas 2 a 4. Como ejemplo, las Tablas 2 y 3 presentan la estructura de costos y los ingresos por ventas, respectivamente, para el NTA. La Tabla 4 muestra los resultados finales de los indicadores económicos MB, MN y PE.

Respecto de los costos de producción, no se observan diferencias significativas entre los NT, debido, en parte, a que la estructura de costos (preparación de suelo, uso de agroquímicos, etc.) es similar en NTM y NTA. Analizando cada labor por separado (Figura 2), se observa que en la preparación de suelo, plantación y cultivo caña planta, hay un aumento del costo a medida que el productor dispone de mejor tecnología. Sin embargo, estas etapas no representan un porcentaje significativo en los costos totales (Figura 3). En el cultivo de caña soca y en la cosecha, el NTM presenta los mayores costos. En el primer caso, esto se explica por el uso más intensivo de agroquímicos respecto de NTB pero menor capacidad de renovación del cañaveral respecto de NTA. En el caso de la cosecha, el sistema semi-mecanizado tiene mayor costo y es el que predomina en el NTM.

Tabla 2. *Costos de producción para productores cañeros con NTA.*

Actividades	Cantidad	Precio unitario ($)	Total ($/ha)
Preparación de suelos			3820
Plantación			
Caña semilla	12 t	148	1776
Mano de obra	60 surcos	60	3600
Fertilizante base	120 kg	9	1080
Cultivo Caña Planta			
Tareas mecánicas			1260
Herbicidas pre-emergentes (*atrazina, acetoclor*)			376
Cultivo Caña Soca			
Tareas mecánicas			1620
Fertilización	3,5 kg/ha/surco	6 ($/kg)	1260
Herbicidas post-emergentes (*2,4-D, MSMA, ametrina, atrazina, metaloclor, paraquat*)			652
Cosecha y Flete			
Mecanizada			6999
Manual			
Semi-mecanizada			8814

Tabla 3. *Determinación del ingreso por ventas, NTA.*

Concepto	Participación (%)	Cantidad (kg)	$/kg	Total ($/ha)
Azúcar blanco	64	3079	3,76	11.576
Azúcar crudo	5	241	2,8	673
Exportación	31	1491	1,82	2714
Total	100	4811		14.964

Tabla 4. *Resumen indicadores económicos (unidad funcional = 1 ha).*

Concepto	NTB	NTM	NTA
Ingreso por ventas ($/ha)	10.974	12.370	14.964
Costos directos ($/ha)	12.101	12.685	12.574
Costos indirectos ($/ha)	1815	1903	1886
Margen Bruto ($/ha)	-1127	-314	2390
Margen Neto ($/ha)	-2942	-2217	504
Precio de equilibrio ($/kg)	3,9	3,7	3,0

Por otro lado, se observa que los productores que disponen de mejor tecnología obtienen un MB y un MN más elevado, y un PE más bajo.

3| CONCLUSIONES

De un estudio de ACV anterior surgió que los sectores más tecnificados generaban menos impactos ambientales. El presente trabajo complementó ese estudio con una evaluación de costos de producción para determinar si existía una tendencia similar. A su vez, este trabajo también resulta de utilidad para analizar los cuellos de botella tanto ambientales como económicos en cada NT. Se observa que las mayores ganancias del sector y los menores impactos ambientales corresponden a productores del NTA. Si bien los resultados sugieren que las mejoras tecnológicas son positivas, es preciso tener en cuenta que el concepto de sostenibilidad también comprende aspectos que de alguna manera podrían justificar la participación del sector de escasa tecnología.

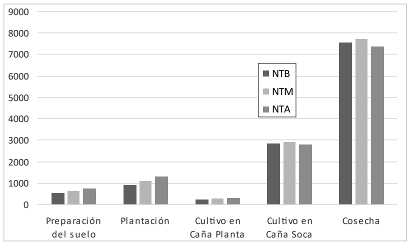

Figura 1. Comparación de costos [$/ha] por labor para cada NT.

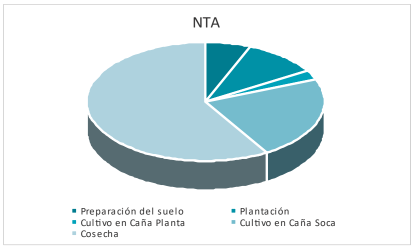

Figura 2. Contribución de cada labor a los costos en el NTA.

Acknowledgments

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ESTUDIO AMBIENTAL DEL CULTIVO DELSORGO AZUCARADO EN LA PROVINCIA DE TUCUMÁN (ARGENTINA) Y SU POTENCIAL USO PARA PRODUCCIÓN DE BIOETANOL

ENVIRONMENTAL STUDY OF THE SWEET SORGHUM CROP IN TUCUMÁN (ARGENTINA) AND THEIR POTENTIAL USE IN BIOETHANOL PRODUCTION

ESTUDO AMBIENTAL DO CULTIVO DE SORGO SACARINO EM TUCUMÁN (ARGENTINA) E SEU USO POTENCIAL PARA PRODUÇÃO DE BIOETANOL

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RESUMEN:
Objetivo: El objetivo del presente estudio fue estimar el perfil ambiental de la producción agrícola de sorgo azucarado en la provincia de Tucumán (Argentina) para su potencial uso como materia prima azucarada en la producción de bioetanol. Además, se plantearon los avances en la producción de bioetanol de sorgo para la generación de un inventario de ciclo de vida (ICV).
Metodología: El estudio se realizó empleando como herramienta el Análisis de Ciclo de Vida (ACV). El alcance del estudio contempla solamente la etapa agrícola de producción de sorgo. Para el inventario, se utilizaron principalmente datos aportados por experiencias realizadas en el campo, publicaciones especializadas y la base de datos Ecoinvent v3. Se trabajó con una herramienta informática de soporte SimaPro® v8.3.0.0, usando como método de evaluación de impacto el modelo ReCiPe Midpoint V1.12.
Resultados y discusión: Los resultados mostraron que la mayor contribución al impacto ambiental fue debida a la producción de diesel y herbicidas, principalmente.
Conclusiones: A partir de este análisis y la factibilidad de industrializar el sorgo azucarado para producción de bioetanol surge la necesidad de realizar estudios de ACV del bioetanol de sorgo, y evaluar así la sostenibilidad de los biocombustibles. Estas iniciativas de investigación servirán para que el sector productivo tucumano se pueda diversificar y concretar objetivos claros para obtener una mejor disponibilidad de energía renovable.

Palabras Clave:
cultivos energéticos; análisis de ciclo de vida; biocombustibles. Energy crops; life cycle assessment; biofuels.

ABSTRACT:
Purpose: The aim of this study was to estimate the environmental profile of sweet sorghum production in the province of Tucumán (Argentina) and its potential as a feedstock for ethanol production. In addition, advances in the production of sorghum bioethanol for the generation of a life cycle inventory (LCI) were made.
Methods: The study was performed using Life Cycle Analysis (LCA) as a tool. The scope of the study considered only the agricultural stage of sorghum production. For the inventory, data generated by field experiences and specialized publications were used, as well as the Ecoinvent v3 database. SimaPro® v8.3.0.0 was used as a support tool, using the ReCiPe Midpoint V1.12 model as an impact evaluation method.
Results and discussion: Results showed that the major contribution to the environmental impact was due to the production of diesel and herbicides.
Conclusions: Based on this analysis and the feasibility of industrializing sweet sorghum for bioethanol production, there is a need to carry out LCA studies of this product assessing the sustainability of biofuels. Research initiatives will serve local farmers and industry in order to diversify and achieve clear goals to obtain a better availability of renewable energy.

Keywords:
energy crops; life cycle assessment; biofuels. cultivos energéticos; análisis de ciclo de vida; biocombustibles.

1| INTRODUCCIÓN

El aumento de los precios del petróleo afecta a las economías del mundo exigiendo una disminución de la explotación de los hidrocarburos. Además, las políticas de mitigación de los gases de efecto invernadero (GEI), en las que contribuye potencialmente el transporte, genera el uso de los biocombustibles líquidos como fuente de energía renovable, a partir del aprovechamiento de la biomasa con fines energéticos (Pieragostini, 2015).
La Argentina buscó en la última década replantear su matriz energética priorizando el uso de la bioenergía, especialmente de los biocombustibles líquidos, lo que conlleva a promover el desarrollo rural y reducir las emisiones de GEI, dándole un valor agregado a las diferentes cadenas agroindustriales. (Chidiak et al, 2015).
Entre los biocombustibles líquidos que han adquirido importancia a nivel global, con una particular participación en el sector del transporte, se encuentra el bioetanol. Éste, es capaz de reducir las emisiones de GEI, mejorar la calidad del aire y competir en precio con las fuentes energéticas convencionales no renovables (Cárdenas, 2011).
Existen antecedentes que demuestran el elevado potencial de producción de biomasa en los cultivos energéticos tales como caña de azúcar (60-90 t/ha) y sorgo azucarado (50-80 t/ha), respecto de otras alternativas como son la remolacha azucarera (35-60 t/ha), maíz (7-12 t/ha) y trigo (5-7 t/ha). La producción de etanol por hectárea es mayor en el caso de la remolacha azucarera (6000 l/ha), seguida por caña de azúcar (5800 l/ha) y maíz (4000 l/ha). El nivel alcanzado por el sorgo azucarado (2500 l/ha) también resulta destacable. Otros indicadores fundamentales en la producción de biocombustibles son el balance energético (BE) y la emisión de gases de efecto invernadero evitadas. En este sentido, se destaca la caña de azúcar con un BE de 0,9 a 12 y una emisión evitada de 90%. Por su parte el, sorgo azucarado presenta un BE de 5 a 8 y una emisión evitada de 70%. El resto de los cultivos citados alcanza niveles menos favorables, llegando incluso a realizar aportes negativos, como es el caso de las emisiones de GEI del cultivo de maíz (30 a 40%) (Romero et al., 2012).
En Tucumán, la producción de bioetanol es a partir de la caña de azúcar en destilerías anexas a ingenios azucareros utilizando las mieles del proceso de fabricación de azúcar como materia prima. El bioetanol generado se mezcla en las proporciones establecidas por ley con gasolina para utilizarse en el sector transporte.
El sorgo azucarado (Sorghum bicolor (L.) Moench) es otro cultivo energético, de alta eficiencia fotosintética y productividad, viable de ser cultivado en Tucumán. Es un material apto para industrializarse en los ingenios azucareros del Noroeste Argentino (NOA), para usarse como cultivo de rotación de la soja y especialmente para cultivarse en áreas donde la caña de azúcar presenta limitaciones hídricas. A nivel industrial, este cultivo presenta grandes ventajas ambientales, económicas y técnicas puesto que incrementaría el abastecimiento de materia prima azucarada para la producción de bioetanol gracias a su elevado contenido en azúcares fermentescibles en el jugo de sus tallos, y de generación de energía eléctrica con fuentes renovables por su elevado aporte de biomasa durante la cosecha (Residuos agrícolas) y la industrialización (Bagazo) sin modificaciones en equipos y procesos normalmente utilizados por los ingenios azucareros para procesar la caña de azúcar. Estas ventajas ayudarían a las empresas sucroalcoholeras a disminuir sus costos fijos de producción y reducir el consumo de combustibles no renovables derivados del petróleo que actualmente constituyen el 90% de la matriz energética de la Argentina. (Romero et al, 2012).
Este potencial fue comprobado en una experiencia a nivel industrial realizada en el año 2016 por un ingenio azucarero de Tucumán quien procesó sorgo azucarado en sus instalaciones logrando obtener bioetanol por fermentación de jugo clarificado.
Por ello, el sorgo azucarado puede cumplir un papel importante complementando el aprovechamiento agro-energético de la caña de azúcar, cadena agroindustrial ya establecida en el NOA.
El objetivo del presente estudio fue estimar el perfil ambiental de la producción agrícola de sorgo dulce en la provincia de Tucumán para su potencial uso como materia prima azucarada en la producción de bioetanol, empleando como herramienta el Análisis de Ciclo de Vida (LCA). Además, a partir de las experiencias realizadas en un ingenio azucarero se obtuvieron datos preliminares para la generación de un inventario de ciclo de vida (ICV) de la producción de bioetanol de sorgo.
Dicho estudio se enmarca dentro del “Proyecto Biosorgo: producción comercial de bioetanol y bioelectricidad a partir de sorgo azucarado, cultivo energético complementario de la caña de azúcar”, de la Estación Experimental Agroindustrial Obispo Colombres (EEAOC).
Con el fin de cumplir con criterios de sustentabilidad (Farrell et al. 2006), los productores de bioetanol argentinos se enfrentan al reto de analizar más detenidamente el comportamiento ambiental de sus productos.

2| METODOLOGÍA

El estudio se realizó teniendo en cuenta la metodología propuesta por la norma ISO 14040 de Análisis de ciclo de vida.
Fase 1. Definición del objetivo y alcance del estudio.
Se definió como objetivo del estudio estimar el perfil ambiental del cultivo de sorgo azucarado en la provincia de Tucumán. Para el análisis, se seleccionó un productor de la localidad de Graneros en el sudeste de la provincia de Tucumán. El alcance del estudio consideró sólo la etapa agrícola de producción de sorgo, definiéndose la unidad funcional en 1 kg de sorgo. El sistema de manejo agronómico planteado comprende las labores de siembra directa, aplicación de herbicidas pre y post emergentes, así como el control de plagas correspondiente (insecticidas). Se consideró para la cosecha, una cosechadora mecánica integral de caña de azúcar y el equipamiento necesario para el apoyo de estas tareas. Se tuvo en cuenta el consumo de combustible para dichas tareas, un ciclo del cultivo estival de 120 días y un rendimiento de biomasa estimado en 34,5 t /ha (tallo molible).
Fase 2. Análisis de inventario de ciclo de vida.
En la fase de inventario se priorizaron los datos primarios aportados por las experiencias realizadas en el campo durante el año 2015. La información se completó con datos secundarios de diversas fuentes (entrevistas con expertos y publicaciones especializadas) y bases de datos internacionales como Ecoinvent v3 (Swiss Centre for Life Cycle Inventories, 2015). También se realizaron balances de materia y energía para estimar ciertos valores como las emisiones GEI en la combustión de combustibles fósiles.
Fase 3. Evaluación de impacto del ciclo de vida
Se trabajó con una herramienta informática de soporte SimaPro® v8.3.0.0 (PRéConsultants, 2015), usando como método de evaluación de impacto el modelo ReCiPe Midpoint V1.12 (Goedkoop et al., 2008).
Fase 4. Interpretación
Como parte de esta etapa, se analizaron los resultados obtenidos en las fases anteriores.

3| RESULTADOS

La Figura 1 muestra cómo se compone el impacto ambiental asociado a la producción de 1 kg de sorgo azucarado en la provincia de Tucumán. En abscisas se muestran catorce de las categorías de impacto de la metodología ReCiPe Midpoint V1.12 y en ordenadas, la contribución de los procesos intervinientes, en cada categoría, expresada en porcentaje. Los colores representan a los diferentes procesos que intervienen directamente en la producción de sorgo azucarado.

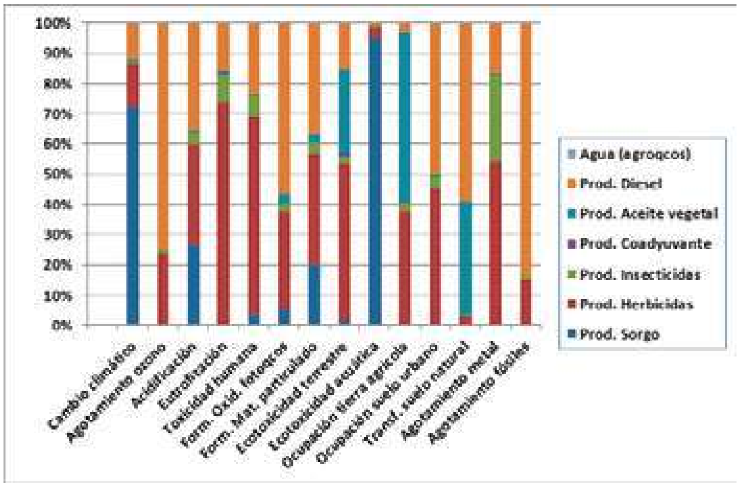

Figura 1. *Perfil ambiental del sorgo azucarado en Tucumán, estimado para 1 kg de sorgo (caracterización).*

Puede observarse que en todas las categorías de impacto predomina la contribución del proceso de producción de combustible fósil (diésel) y producción de herbicidas, principalmente.
En las categorías “agotamiento de ozono” y “agotamiento de fósiles” la producción de diesel (naranja) contribuye en un 75% y 83.6% respectivamente, mientras que la producción de herbicidas (rojo) aporta un 23.5% y 15.3% a las categorías mencionadas.
El impacto propio de la producción de sorgo (azul) es evidente en la categoría “cambio climático” y “ecotoxicidad acuática”. En el primer caso, se debe al uso de diesel en las tareas de campo, tales como siembra y cosecha. Tambien contribuyen al cambio climático la producción del combustible fósil y algunos agroquímicos. En la categoría “ecotoxicidad acuática” el impacto es consecuencia de la aplicación de herbicidas e insecticidas.
El impacto de la producción de insecticidas es evidente en la categoría “agotamiento de metal”

En cuanto a “eutrofización” y “toxicidad humana”, la producción de herbicidas contribuye en un 74% y 65.6% respectivamente.
Sin embargo, los resultados mostraron en la etapa de normalización (por razones de espacio se omite el gráfico) que el mayor impacto resulta en la categoría “ecotoxicidad acuática” debido a la producción de agroquímicos y en menor medida a la producción del combustible fósil. La producción de sorgo no presenta una gran contribución en la categoría cambio climático.

4| CONCLUSIONES

Los resultados expuestos en este estudio permitirán realizar ajustes en el manejo agronómico del cultivo de sorgo azucarado con fines bioenergéticos.
El perfil ambiental estimado permitirá optimizar el uso de agroquímicos como así también generar cambios en la apreciación y la elección de los mismos, buscando no sólo un efecto sanitario sino también el menor impacto ambiental posible. También, favorecerá análisis orientados a reducir el número y la duración de labores mecanizadas y mejorar la eficiencia en el uso de la maquinaria.

Dada la factibilidad de industrializar el sorgo azucarado para producción de bioetanol, surge la necesidad de realizar estudios de análisis de ciclo de vida del bioetanol de sorgo, desde la extracción de materia prima (producción agrícola de sorgo) hasta la fabricación del bioetanol (enfoque “de la cuna a la puerta”). De esta manera se continuará evaluando la sustentabilidad de los biocombustibles.
Las experiencias realizadas en un ingenio azucarero proporcionaron los primeros datos para la confección preliminar de un inventario de ciclo de vida y la planificación de mediciones de emisiones en una próxima molienda.
Estas iniciativas de investigación servirán al sector productivo tucumano para diversificarse y concretar objetivos claros para obtener una mejor disponibilidad de energía renovable.

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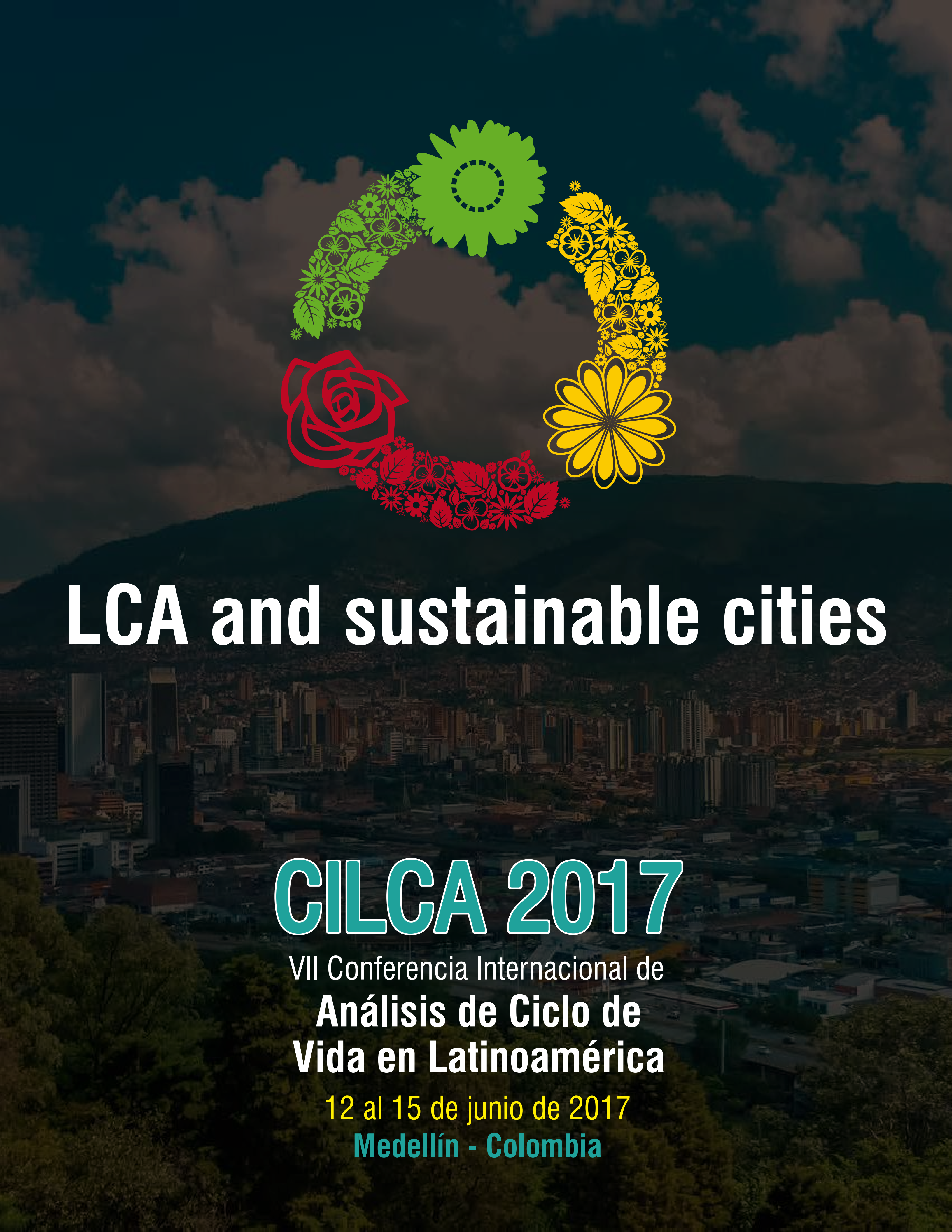

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ALTERNATE DESIGNS OF SCHOOL BUILDINGS IN SINGAPORE AND THEIR LIFE CYCLE ENVIRONMENTAL BENEFITS

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ABSTRACT:

It is common for school buildings in Singapore to undergo major renovations or even demolitions after less than 30 years. Reasons for such renovations or demolitions, which typically generate large amounts of construction and demolition wastes, include need for additional infrastructure, changes in educational curricula, increase in student and staff populations. The objective of this study is to identify patterns in the renovations or demolitions of 12 school buildings and propose a coherent set of design guidelines that creates alternate designs for these schools that can reduce the need or extent of future renovations and demolitions. For each of these alternate design, we estimated the potential net amount of construction and demolition wastes that could be saved and, by using life cycle impact assessment methodology, estimated the net decrease in life cycle impacts (namely, global warming potential and acidification potential) and resource requirements (namely, energy and water). Based on these findings, broad policy recommendations for improving future building designs were proposed.

Keywords:

Life cycle assessment, adaptive building design, construction and demolition wastes

1| INTRODUCCIÓN

To improve the overall quality of education for primary school students in Singapore, the Ministry of Education, under the Primary Education Review and Implementation program, recommended that all schools be transferred into a single session model. Long term, a total of 18 new schools will be built and enhancement of 80 existing schools was planned in the future. These constructions and renovations aimed to provide more flexibility in curricular time and teachers the ability to provide holistic education through a wider range of academic and non-academic activities.

However, these renovations have resulted in large amounts of construction and demolition (C&D) wastes. The aim of this study is to, firstly, understand patterns in the ways 12 selected old school buildings were renovated. Next, environmental impacts and resource consumptions of these patterns of renovations were quantified, before design guidelines were proposed to improve the adaptability of future school building designs. Finally, the expected reductions in environmental impacts and resource consumptions of these adaptable designs were estimated.

2| METHODOLOGY

This study is divided into two parts.

In the first part, 12 school buildings were studied; they had undergone renovations and for each of these buildings, the nature of their adaptability was evaluated in terms of four key factors – internal adaptability, extension adaptability, use adaptability, and planning adaptability.

Internal adaptability refers to the ability of the existing interior layout of the building to adapt to future changes of space (for example, segregation of interior space). Extension adaptability refers to the ability to have physical elements, such as an extra floor, be added to an existing structure to allow the building to adapt to new requirement and perform additional functions. Use adaptability refers to the ability of the modified space to be used for alternate uses without any renovations in the future. Planning adaptability is enhanced if supporting structures of the building can adapt to future uses easily by means of using "transformable materials or structures" (for example, by the use of lightweight materials).

For any renovation or demolition performed on each of these buildings, the amount of resources required – namely, cost, time and effort – were estimated and scored; this is termed "resource score". For example, any work that requires installation of structural elements, including demolition of existing blocks, is rated as "high" in cost, effort and time; each of these are given a score of "5" on a scale of 1-5. Any cosmetic modification, including paint work, is rated as "low" and scored "1". In short, every piece of construction job performed on a certain school building was evaluated according to:

I) Improvement in the various types of adaptability, and
II) Resource score.

The higher the improvement in adaptability and lower the resource score, the more desirable the renovation is.

The environmental impacts of the renovation projects and alternate designs are calculated using life cycle assessment (LCA). LCA is a methodology for assessing the inputs into, and outputs from, the various life cycle stages of a product or service; these flows can then be converted into various environmental impacts. LCA is a common methodology used for building materials. For example, Bjorklund et al. (1996) conducted a comparison of different structural materials using an LCA approach. The life cycle energy consumption and greenhouse gas (GHG) emissions for wood, steel, and concrete structural commercial building frames were also compared by Canadian Wood (1997) and Cole (1999). There were also studies that incorporated life cycle costs into the comparison; these include those by Guggemos and Horvath (2005) and Weight (2003).

In this study, as far as possible, the life cycle inventory (LCI) of the building materials in these buildings were calculated from local sources; whenever local data was unavailable, LCIs were obtained from generic databases such as Ecoinvent or GaBi.

3| RESULTS AND DISCUSSION

Analyses revealed that after renovations, most of these buildings improved their extension and use adaptability. However, about 50% of these renovated buildings do not have internal and planning adaptability.

Figure 1 shows the percentages of high, medium and low resource scores for each of the 12 school buildings. It was found that all but one school (school 10) has a majority of high resource scores. In other words, even after incurring large amounts of resources for renovations, only 50% of these buildings improve their internal and planning adaptability. Although school 10 performs the best based on resource scores, its use adaptability is low.

Notwithstanding this weakness, the original design of school 10 offers a few key guidelines for improving future design of school buildings, so that resource consumptions during renovation can be reduced and overall adaptability can be enhanced; they are:

I) Allocate additional buffer spaces, such as recreational spaces, around existing buildings that can be used for extension in the future. This implies that such recreational spaces must be reconfigurable to synchronize with future extension of built up space.

II) Ensure connections among different parts of the building. These connections should be expanded and even improved after the renovation.

III) Utilize interior partitions (especially drywalls) or prefabricated demountable panels to enable internal space to be modified according to changing needs.

IV) Ensure a degree of redundancy in the mechanical system, including additional air inlets and outlets.

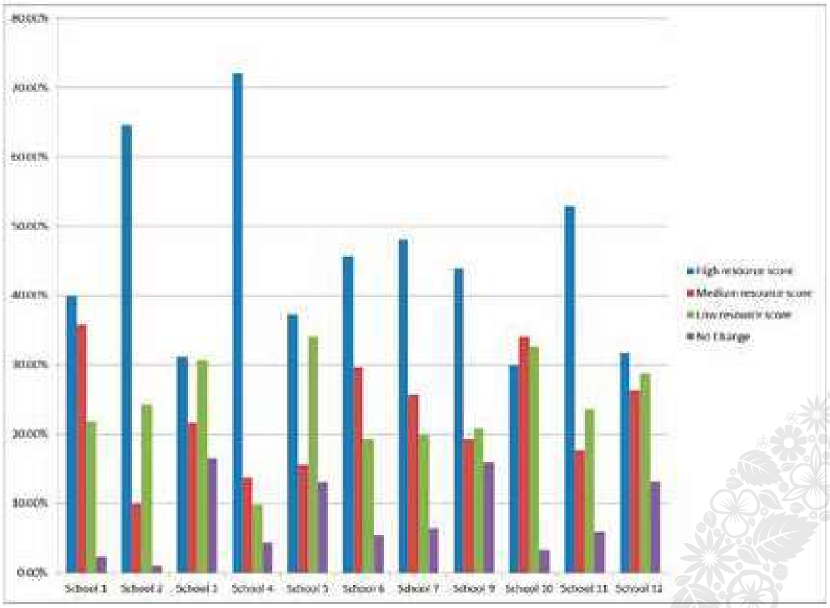

Figure 1. *Percentages of high, medium and low resource scores for the renovation works performed for the 12 school buildings.*

LCA results indicate that, on average, the renovations in the 12 buildings incurred 380 metric tonnes of building materials per building, most of which was reinforced concrete. This resulted in an additional 53.8 metric tonnes of CO2 equivalent, 4.42 metric tonnes of SO2-eq, 584.3 GJ of energy and 34.2 metric tonnes of water.

If all buildings were designed and constructed using the abovementioned four-point guideline, there is a possibility of the average environmental impact to be reduced by 10%.

4| CONCLUSIONS

Detailed evaluations of 12 school buildings in Singapore revealed opportunities for improving the design of future schools, so that adaptive reuse is possible and resource consumption during the renovations of these buildings can be reduced. The general design guidelines based on the study of school 10 can be applied to future school buildings, and there is a potential to reduce the environmental impacts and resource consumptions by 10%.

These results show that it is important for future policies to encourage the implementation of the four-point guideline in school designs, by incorporating this guideline in future version of the Green Mark Scheme, which is the local green building standard and assessment system.

The next step of the project is to consider the recyclability of the C&D wastes generated from these renovation projects and how by using these wastes in future projects, the life cycle impacts and resource consumptions can be further reduced.

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ANÁLISIS AMBIENTAL DE UNA VIVIENDA CON ÉNFASIS EN APROVECHAMIENTO DE RECURSOS LOCALES (GUADUA) Y GESTIÓN DE RECURSOS HÍDRICOS NO CONVENCIONALES.

ENVIRONMENTAL ANALYSIS OF A HOUSE WITH EMPHASIS IN THE USE OF LOCAL RESOURCES (GUADUA) AND MANAGEMENT OF NON CONVENTIONAL WATER RESOURCES.

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RESUMEN:
Esta ponencia expone la evaluación sobre los posibles impactos ambientales que pueden evitarse a partir de una vivienda social con énfasis en el uso de recursos locales como la guadua en su fase de construcción y el aprovechamiento de recursos excedentarios como el agua de lluvia y aguas grises en la fase de uso. Como unidad de análisis, se seleccionó una vivienda social real en la ciudad de Pereira; construida por un programa de vivienda institucional hace 15 años. Como resultados, se ha encontrado que el uso de los materiales locales en la fase de construcción de la vivienda, combinado con el uso de recursos hídricos no convencionales (agua de lluvia, aguas grises) para uso doméstico no potable, puede contribuir a un menor potencial de impacto ambiental; derivado de la disminución del potencial total de las emisiones de gases de efecto invernadero comparado con una vivienda social convencional. Como herramientas metodológicas, se aplica el análisis de Ciclo de Vida del aprovechamiento de los recursos locales para la construcción y los hídricos no convencionales en la vivienda; la evaluación ambiental de su aprovechamiento potencial, la aproximación al análisis de los impactos derivados de esto y su representación a escala barrial.

Palabras clave:
Recursos excedentarios; Guadua; agua de lluvia; aguas grises; sistemas urbanos; vivienda

ABSTRACT:
This paper presents the evaluation of the potential environmental impacts that can be avoided from in a social housing with an emphasis on using local resources such as bamboo in it´s construction phase and the use of surplus resources as rainwater and greywater in the use phase. As the unit of analysis, a real social housing was selected in the city of Pereira; built by a program of institutional housing 15 years ago. As a result it was found that the use of local materials in the construction phase of housing, combined with the use of non-conventional water resources (rainwater, gray water) for undrinkable domestic use, may contribute to a lower potential environmental impact; associated with a significant decrease in total potential of Co2 emissions compared to a conventional social housing. As methodological tools, the life-cycle assessment applies - ACV the use of local resources for construction and non-conventional water resources at housing; environmental assessment of it´s potential use, the approach to the analysis of the impacts of this and their representation at the neighborhood scale.

Keywords:
Resources surplus, bambú, rainwater, gray water, urban systems, housing.

1| INTRODUCCIÓN:

El objeto de estudio de esta investigación, la vivienda urbana, centra su interés en el consumo sostenible y aprovechamiento de recursos naturales locales, como lo son la guadua para la construcción, y de suministro de agua no convencional que para el caso involucra alternativas como el agua de lluvia y las aguas grises, con un énfasis en sus efectos a escala barrial.

El estado del arte más relevante para esta investigación, parte de la estimación realizada por Morales-Pinzón et al (2012a) sobre el Potencial de aprovechamiento de los recursos de agua de lluvia, a partir de aspectos urbanos y sociales en Colombia. El autor plantea otros aportes al estado del arte en este tema, a partir de la modelización de coste económico y el análisis ambiental de las aguas pluviales, (Morales-Pinzón et al., 2014a); así como otros estudios como la Modelización financiera y ambiental de las Implicaciones de la dureza del agua para la utilización de agua de lluvia recolectada en lavadoras (Morales-Pinzón et al., 2014b); y, desde un enfoque más amplio, la consideración del uso de materiales locales como la guadua, que sumados a el uso de fuentes alternativas de agua no convencional (agua de lluvia, aguas grises) para uso doméstico (Morales-Pinzón et al., 2014c). Por otra parte, Escamilla y Habert (2014), han realizado la evaluación del ciclo de vida de cinco materiales de construcción a base de Bambú, con el propósito de generar un enfoque general para la evaluación exitosa del impacto ambiental de materiales no convencionales.

2| METODOLOGÍA

La metodología utilizada para el desarrollo de la evaluación ambiental, fue el Análisis del Ciclo de Vida, el cual se encarga de abordar y analizar los aspectos ambientales y los impactos potenciales a lo largo del ciclo de vida de un producto o de una actividad productiva (Sanes, 2012). Conforme a las fases que comprenden el desarrollo metodológico del ACV (Norma ISO 14040), el objetivo y alcance parte de una unidad funcional de construcción y uso de 1m2 de vivienda con un ciclo de vida de 50 años y habitada por 4 personas; donde los límites del sistema plantean una evaluación del impacto ambiental de la vivienda sobre el ciclo de vida simplificado de las fases de construcción, uso y fin de su vida útil. El potencial de uso de agua de lluvia y aguas grises, así como de materiales de construcción se estimó utilizando el software Plugrisost (Morales-Pinzón et al., 2012a). El análisis de los impactos ambientales potenciales, fue modelado a partir de datos reales de la vivienda seleccionada, y se complementó con un modelo de simulación para la fase de uso del agua no convencional, siguiendo los parámetros generales que se adoptaron en el inventario. Los inventarios analizados se realizaron en un tipo de vivienda social, urbana en la ciudad de Pereira, unifamiliar de 45 m2 y un solo nivel. Los datos de agua de lluvia y aguas grises fueron procesados mediante el software Plugrisost, así como las cantidades de materiales y energía utilizados (Morales-Pinzón et al., 2012a). La vida útil del sistema se definió en 50 años de acuerdo con la propuesta original de Roebuck et al. (2011). La precipitación se obtuvo de los registros históricos de los años 2008-2014 reportados por la Red Hidroclimatológica del Departamento de Risaralda (UTP, 2014). Como entradas, fueron seleccionados tanque de hormigón, tubos de polipropileno y una bomba de acero inoxidable. El Análisis de Ciclo de Vida (ACV), para los materiales de construcción de la vivienda convencional y la vivienda más sostenible se realizaron con la ayuda del software SimaPro. Como un método de análisis de los impactos potenciales se utilizó la línea de base v2.04 LMC. La categoría de impacto evaluada a escala barrial fue el ***Potencial de Calentamiento Global*** (GWP, en kg CO2 eq.). Con el propósito de definir una escala barrial para el análisis de los parámetros considerados, se realizó un análisis de conglomerados o clúster a partir de las variables e información desarrollada por Orozco y Guzmán (2014) para los proyectos de vivienda social en la ciudad de Pereira. Se consideraron tres clústeres que configuran tres tamaños promedio de barrio para una ciudad intermedia como Pereira, siendo el clúster 1 conformado por 62 barrios y un promedio de 131.7 viviendas, el numero 2 por 9 barrios y un promedio de 1137 viviendas, y el numero 3 por 20 barrios y un promedio de 512.1 viviendas.

3| RESULTADOS Y DISCUSIÓN

A partir de los estudios citados en los apartes anteriores de este documento, se configura un conjunto de datos relacionados con el potencial de impacto ambiental de la vivienda unifamiliar, que escalados a nivel barrial podrían ser considerados como una aproximación al impacto potencial de los modelos de ocupación territorial de la ciudad de Pereira. Dicho resultado representa una aproximación limitada por la heterogeneidad que se puede presentar en la tipología de vivienda existente, y los factores ambientales. Sin embargo, considerando estos límites, constituye una estimación del efecto potencial a escala barrial. Los parámetros desde los cuales se realiza la proyección se presentan en la Tabla 1.

Categoría de análisis	Parámetro	Unidades	Valor
Demanda doméstica de agua [1]	Demanda doméstica de agua - vivienda unifamiliar	m^3/año vivienda	183,6
Demanda de agua lluvia y gris [2]	Demanda satisfecha agua gris (Vivienda unifamiliar con capacidad de almacenamiento de 0,5m3)		37
	Demanda satisfecha agua lluvia (vivienda unifamiliar con capacidad de almacenamiento de 1m3)		40,5
Potencial de emisiones de gases de efecto invernadero por consumo de agua de fuentes no convencionales y agua de red.	Potencial de calentamiento global (GWP) agua red Pereira	kg CO_2 eq. / m^3 de agua de red	0.2
	Potencial de calentamiento global (GWP) agua lluvia. sistema vivienda unifamiliar tipo casa	kg de CO_2 eq. / m^3 de agua de lluvia utilizada	0,121
	Potencial de calentamiento global (GWP) agua gris - sistema vivienda unifamiliar tipo casa	kg CO_2 eq. / m^3 de agua gris usada en el sistema	0,119
	Potencial de calentamiento global (GWP) todos los sistemas (promedio) en vivienda unifamiliar	kg CO_2 eq. / m^3	0.1205
Impacto potencial evitado	Potencial de calentamiento global (GWP) evitado agua lluvia. sistema vivienda unifamiliar tipo casa	kg de CO_2 eq. / m^3 de agua de lluvia utilizada	0,079
	Potencial de calentamiento global (GWP) evitado agua gris sistema vivienda unifamiliar tipo casa	kg CO_2 eq. / m^3 de agua gris usada en el sistema	0,081
Potencial de Calentamiento Global (GWP) vivienda según materiales de construcción y recursos hídricos utilizados	Potencial de calentamiento global (GWP) de una vivienda convencional	kg CO_2 eq. /m^2 de área construida	1080
	Potencial de calentamiento global (GWP) de una vivienda con materiales locales y recursos hídricos no convencionales		881,3
	Etapa construcción. potencial de calentamiento global (GWP) de una vivienda con materiales locales y recursos hídricos no convencionales		261,7
	Etapa uso. potencial de calentamiento global (GWP) de una vivienda con materiales locales y recursos hídricos no convencionales		555,23
	Etapa final vida útil. potencial de calentamiento global (GWP) de una vivienda con materiales locales y recursos hídricos no convencionales		64,4
	Potencial de calentamiento global (GWP) evitado por uso de bambú		233,5
	Potencial de calentamiento global (GWP) evitado por uso de bambú y recursos hídricos no convencionales		198,7

Fuente: Resultados de los análisis a escala vivienda citados en este estudio y estimaciones planteadas por Morales-Pinzón et al. (2015).
(1). Demanda doméstica satisfecha de agua lluvia y gris estimada con capacidades de almacenamiento de 0,5 m3 para viviendas unifamiliares, según lo planteado por Morales-Pinzón et al. 2014.
(2). Demandas domesticas planteadas originalmente en L/día por Morales-Pinzón et al. 2014.

Tabla 1. *Categorías de análisis y parámetros considerados para la estimación a escala barrial del potencial de impacto ambiental.*

Tomando como unidades de análisis los clúster o conglomerados definidos en la metodología, y sus tamaños, se proyectaron los resultados obtenidos de escala vivienda a escala barrial, contando con tres aproximaciones acordes a las características de cada clúster. brindando una aproximación a la magnitud del impacto ambiental de los proyectos habitacionales a escala barrial. Es así como la implementación de un aprovechamiento de agua lluvia y de agua gris con sistemas individuales por vivienda, a escala barrial, y sin incorporar sistemas de bombeo para la distribución del agua, representa una reducción del 39,6% en el potencial de calentamiento global para proyectos habitacionales donde la tipología predominante es la vivienda unifamiliar. Este análisis, permite aproximar la magnitud del impacto a nivel urbano, donde el potencial de calentamiento global de un barrio como el conglomerado 2, si solo aprovecha el agua de red, representa 41,7 toneladas de CO2 equivalentes en los 50 años del ciclo de vida de la vivienda. Al combinar el uso de materiales locales (Guadua) en la construcción de la vivienda social del tipo unifamiliar, con el uso de los recursos hídricos no convencionales evaluados en este estudio, se encuentra una posible reducción a escala barrial del 18% en el potencial de calentamiento global generado, representando cerca de 10.161 toneladas de CO2 eq./50 años, en un proyecto similar al del conglomerado 2 (ver Figura 1).

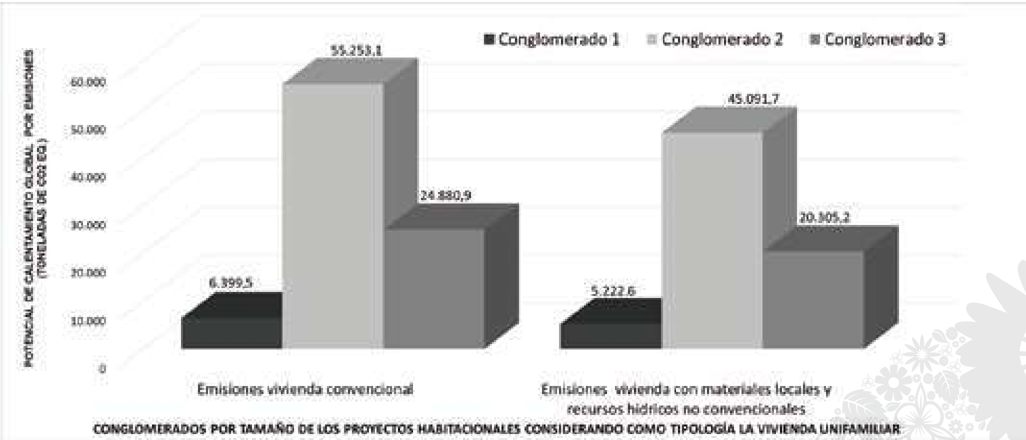

Figura 1. *Potenciales impactos ambientales por emisión de gases efecto invernadero de los proyectos habitacionales a escala barrial constituidos por viviendas unifamiliares considerando el uso de materiales locales de construcción y el aprovechamiento de recursos hídricos no convencionales.*

Por otro lado, si solo se considera el material de construcción en la vivienda unifamiliar, la utilización de materiales locales como la Guadua a escala barrial, representa una reducción de hasta un 5.94% en el potencial de calentamiento global generado frente a un barrio constituido por viviendas construidas con materiales convencionales; reducción que aumentaría hasta un 6.6% si se utilizan recursos hídricos no convencionales.

4| CONCLUSIONES

La estimación del potencial urbano en la reducción de los impactos identificados, a través de la evaluación a escala barrial para los tres conglomerados habitacionales considerados, proporciona una idea sobre la importancia de la implementación de las alternativas planteadas, su pertinencia como estrategias para la sostenibilidad urbana, y su rol en la adaptación y mitigación territorial al cambio climático.

A escala barrial, la implementación de un aprovechamiento generalizado de agua lluvia y agua gris representa una reducción del 39% en el potencial de calentamiento global para proyectos habitacionales donde la tipología predominante es la vivienda unifamiliar con consumo de agua de red sin bombeo.

La Guadua a escala barrial, representa una reducción de hasta un 5,9% en el potencial de calentamiento global generado frente a un barrio de viviendas construidas con materiales convencionales.

Al combinar el uso de materiales locales con el uso de los recursos hídricos no convencionales, se encuentra una posible reducción a escala barrial del 18% en el potencial de calentamiento global generado.

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VERTICAL FARMING REDUCES ENVIRONMENTAL IMPACTS OF FOOD IN CITIES. CASE STUDY OF COMMON BEAN CROP

LA AGRICULTURA VERTICAL REDUCE LOS IMPACTOS AMBIENTALES DE LOS ALIMENTOS EN CIUDADES. EL CASO DEL CULTIVO DE LA JUDÍA VERDE

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ABSTRACT:

Food consumption has become a major driver of a city's total environmental limitation factors where food supply seems to be a key element for the management of the environmental impacts. Further research is required to assess alternative ways of producing food reducing the environmental impacts and increase energy efficiency. Regarding this problem, vertical farming consists of producing food (e.g. vegetables) in a building of a city or urban area. Vertical farming crops can include hydroponic irrigation systems, which deliver the required amount of nutrient solution (water and fertilizers) to feed the plants. Integrated rooftop greenhouses (i-RTGs) are a type of vertical farming that take advantage of synergies between building and greenhouse. The i-RTG under study is located on ICTA-ICP building (UAB, Spain) and integrates residual heat energy, rainwater and CO2 flows in the metabolism of the building. In this i-RTG, bean, tomato and lettuce crops have been cultivated.
For the environmental assessment of this study, bean have been chosen as the crop and LCA, according to ISO 14040 (ISO 2006), as the methodology. The aim of this study is to environmentally analyze the necessary inputs and outputs for the production of 1 kg of bean in an integrated rooftop hydroponic system (Functional Unit). Results, which show the benefits of the local production of food, highlight the operational part of the project as more impacting than the infrastructure.

Keywords:

Life Cycle Assessment, Rooftop Greenhouse, Vertical Farming, Industrial Ecology, i-RTG-building symbiosis.

Purpose:

The aim of this study is to analyze the environmental impacts of common bean production in an i-RTG in the west Mediterranean area using hydroponic irrigation methods and applying LCA methodology.

1| METHODS

Study system. Infrastructures and installations

The rooftop greenhouse system under study is located on the ICTA-ICP building (41°23'40.03"N, 2° 9'50.76"E), located in the Universitat Autònoma de Barcelona (UAB) Campus, 15 km away from Barcelona, in the west Mediterranean. The building, with 4 floors (with two more that are underground) and approximately 7500 m2 is highly efficient in water and energy terms; a temperature between 16 and 30ºC is reached inside the building thanks to a bioclimatic outer skin, comparable to a greenhouse. The skin is just a part of an automated system that opens and closes this skin, reaching 62% less energy consumption than what is needed to run a conventional building of similar dimensions (Nadal et al., 2017).

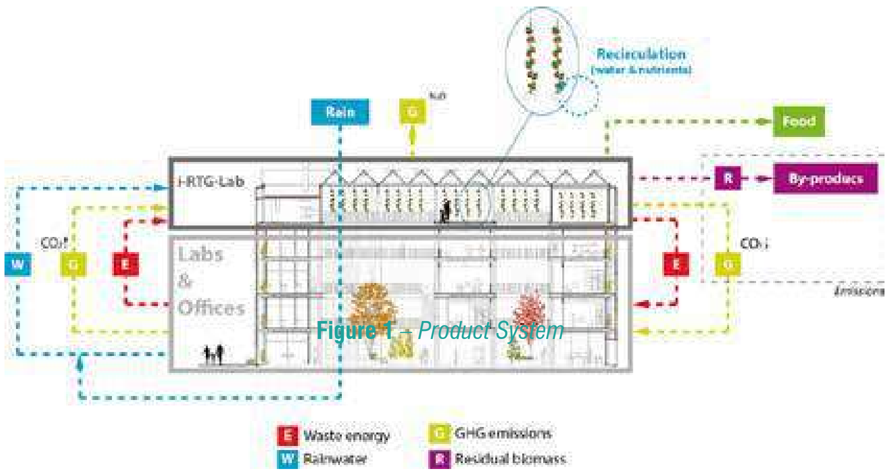

Figure 1 – *i-RTG – ICTA-building interconnected system*

In the rooftop, located in the 4th floor, the so-called Fertilecity project is developed, which aims to study the viability of integrated rooftop greenhouses in the Mediterranean area. Urban Agriculture Lab 1 (LAU 1) is used in this project to quantify a linear flow of nutrients and water. The surface of this zone is 122.8 m2, with 68.7% of this area (84.34 m2) dedicated to crops, with 171 plants. Within this area, 57 perlite sacks are distributed in 12 lines. A steel structure and polycarbonate sheets are the main i-RTG materials. Crops are cultivated with a hydroponic method (soilless), irrigating depending on the dynamic conditions of the crop and rainwater availability (tap water is also used when needed). Other parameters like temperature, radiation, humidity or water fluxes, are also periodically monitored.

Crop

Common bean (Phaseolus vulgaris), with a low-bush, have been used as the analysis crop for this project. This choice is based on data extracted from previous studies done with tomato crops from the Fertilecity project, which have highlighted a problem related with radiation received from the crop in the present i-RTG during winter months. This fact is due to the over-dimensioned rooftop structure and service elements to fulfil with architectural and safety requirements. The crop was developed during autumn 2016, starting on September 13th. The harvest was carried on from October 20th to November 8th, when the crop life ended and all plants were uprooted (57 days after plantation).

Environmental Tools

Life Cycle Assessment (LCA) was the methodology used for the environmental assessment, according to ISO 14040 (ISO 2006). Software used for LCA was Simapro 8 and 1 kilogram of edible beans was defined as Functional Unit of the system.

2| RESULTS AND DISCUSSION

In this section, LCI and LCIA are included, combined with other data. In Table 1, it is observed that, in what were considered standard conditions plants, the production was 31,16 kg, 0,50 per m2.

Table 1 - *Accumulated bean production in numbers and weight*

Units	kg	Number	$kg \cdot m^{-2}$
Commercial (C)	27.33	2751	0.44
Edible (C + Non-C)	31.16	3393	0.50

Considering production data, the life cycle inventory was made to determine the impact of producing 1 kg of common bean in a hydroponics i-RTG. Data included in the inventory is described in Table 2. LCI has been divided into two main categories: infrastructure of the i-RTG (with a large lifespan) and the operational stage of the project, related with the bean crop.

Table 2 – *Data included in the Life Cycle Inventory*

Category	Sub-category	Description
Operation	Fertilizers	K, Mg, Ca, NO_2, NO_3, PO_4, SO_4
	Water	Tap water, rainwater
	Pesticides	5 different types
	Substrate	Perlite, HDPE
	Energy	By bombs
	Transport	Of perlite and nursery plants
i-RTG Infrastructure	Structure	Fixed infrastructure
	Fungible and other materials	Rain harvesting system (RW-HS) + Auxiliary equipment

Results in Fig. 2 show that the impacts in most of the categories were caused by fertilizers, fungible equipment and substrate. However, fertilizers' impact could be reduced through more detailed monitoring of system parameters. RTG's structure impact can also be diminished by optimising dimensions and materials used. Categories like pesticides or energy used by the system were categorized as low-impacting. On the other side, substrate was found to be the maximum impact category in Climate Change or Fossil Depletion. This may be due to the bean short cycle, which gives operational part of the project the most impacting one.

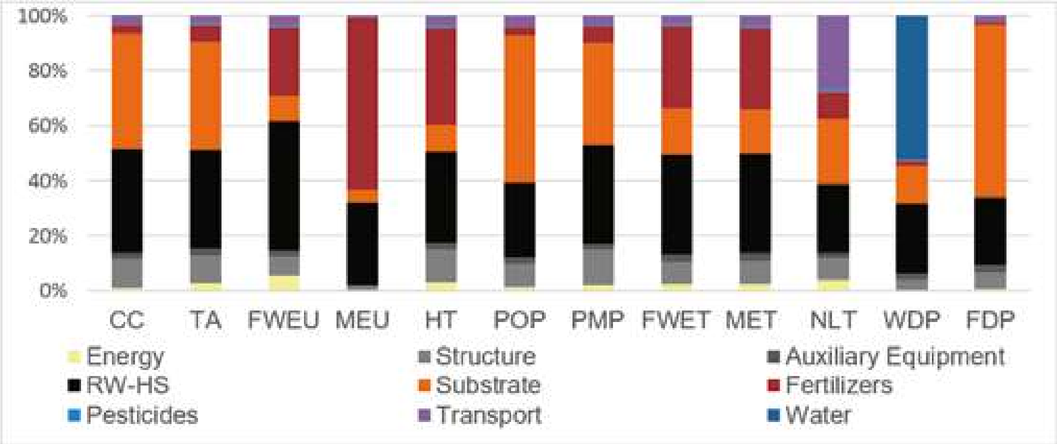

Figure 2 – *Impact Assessment of the i-RTG bean crop. Grey and black colours refer to i-RTG Infrastructure part of the inventory*

3| CONCLUSIONS

The operational part of the inventory is more impacting than the infrastructure. This fact is chiefly on account of the substrate, which is the most impacting category in 5 LCA impact categories. Some operational categories with high impact, such as fertilizers, could be reduced by more detailed monitoring of the rainwater harvesting system, water and nutrient flows and substrate retention. Further research is also needed regarding i-RTGs structure, to better adequate dimensions and materials needed, while fulfilling safety and architectural requirements. Food transport emissions would decrease because of vertical farming (production close to consumption; Specht et al., 2014). Other relevant aspects of vertical farming to be highlighted are the generation of new agricultural spaces and green areas in cities (Pons et al., 2015). Additional avoided impacts come from residual heat recirculation or use of rainwater (when available represented a 55% of tap water saved). Focusing on the product, moving greenhouses closer to cities would establish the option for buying on-demand, ultra-fresh and locally grown food (Despommier 2013), due to the proximity between production areas and consumers.

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ENERGY SELF – SUFFICIENCY AND REDUCTION OF GREENHOUSE GAS EMISSIONS IN URBAN ENVIRONMENTS: A CASE STUDY FOR THREE CITIES IN PERU

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ABSTRACT:
Cities in Latin America and the Caribbean (LAC region) generate approximately 70% of national gross domestic product (GDP). However, urban environments in this area present a high emission of greenhouse gases (GHGs) due to the need to import fossil fuel-based energy. Therefore, it is imperative for societies, namely in cities, to begin a process to decarbonize their activities. Therefore, the main objective of this study was to determine the potential of energy self-sufficiency and GHG mitigation in three representative medium-sized cities in Peru (one for each geographical region) through the revalorization of underutilized rooftop areas in these urban environments with good conditions to capture incoming solar radiation. More specifically, photovoltaic solar panels were the technology explored to be implemented in these rooftop areas, considering the high solar radiation available in most Peruvian cities. The methodology applied included the characterization of the cities selected. Hence, data of incident solar energy, temperature and energy consumption were collected. A scenario of application has been defined and analyzed through the Life Cycle Assessment (LCA) to determine the reduction of the environmental impacts as compared to the current context of using electricity from the national or regional grids. ArcGis10.3 was the software to quantify the total usable area in the cities. In addition, a series of correction factors, including tilt, orientation or roof profiles. Energy, urban planning and demographic data were retrieved from several Peruvian institutions, including local municipalities. More specifically, the electricity mix of each region was computed individually based on data from year 2014. Results, which were computed with the IPCC 2013 assessment method and with the SimaPro8.2 software, showed that the three cities analyzed could benefit from substantial reductions in terms of GHG emissions linked with their demand for electricity in the residential, commercial and public lighting sectors. For instance, annual reductions in GHG emissions ranged from 583 t CO2eq in the city of Ayacucho to over 500,000 t CO2eq in Pucallpa considering current city limits. In fact, reductions from 15% to 94% were identified in the cities analyzed, with the highest values in the Amazon basin, since the current electricity grid is reliant on the use of fossil fuels in over 99%. Considering that Peru has recently signed the Treaty of Paris, results suggest that implementing policies to install photovoltaic solar panels in urban environments in the Amazon basin would be the most efficient way to reduce GHG emissions as compared to other regions of the country.

Keywords:
industrial ecology; LCA; Life Cycle Assessment, photovoltaic solar panels; smart cities; urban metabolism.

1| INTRODUCTION

Cities concentrate a high percentage of the world's population and economic activity. According to the Inter-American Development Bank (IDB), reaching sustainable urban growth is still an important challenge and implies the development of innovative decisions that do not compromise the welfare of future generations (IDB, 2011). Processes that are carried out in cities need energy, water and food, which come from external sources that generate great amount of GHG emissions, as well as other environmental impacts (Kennedy et al., 2009). In this context, urban metabolism was defined by Kennedy and colleagues (2007) as "the sum total of the technical and socio-economic processes that occur in cities, resulting in growth, production of energy, and elimination of waste". Similarly, in a more recent study, Kennedy and colleagues (2014) defined urban metabolism as "a scientific phenomenon comprising individual processes that occur in all cities at different spatial and temporal scales". The importance of urban metabolism resides in the fact that it allows building inventories at a macro-scale for different urban sizes, since these macro flows are usually not well aggregated or available. Thereafter, urban metabolism allows quantifying the material and energy flows that enter or exit urban environments (Delgado et al., 2012). These flows can then be combined with other methodologies, including spatial methods (e.g., GIS), environmental methods (i.e., Life Cycle Assessment – LCA, Water Footprint, etc.) or management and economic methods.
A study carried out by Gouldson and colleagues (2014) in five cities worldwide, including Lima in Peru, suggested that investing in low-carbon policies such as a local renewable energy or efficient public transport significantly reduces energy consumption and GHG emissions in a range of 10 to 24% in a period of 10 years. Moreover, if these policies could be replicated in others cities, it is estimated that it an 18% reduction in GHG emissions linked to use of energy could be attained in urban environments (Gouldson et al., 2014). The importance of this study is linked that it has been the only published study in which there is an attempt to apply urban metabolism to a Peruvian city, in this case, the capital Lima.

However, in a world in which climate-related and environmental problems are emerging, these hazards have become a challenge for cities, especially in developing and emerging nations in which investments in early warning systems or preventive infrastructure is scarce, and urban expansion can be rapid and informal. Therefore, redesigning models of urban metabolism is consistent with decisions that do not compromise the well-being of current and future generations. In fact, the sustainable development of cities in Peru, a country that is highly vulnerable to natural disasters, represents a great challenge for the territorial-urban policy at its different levels (Leff et al., 2002). For instance, the change in model would require the convergence in the urban environment of internalizing environmental costs, resolving social inequities and addressing financial constraints (Winchester, 2006). In other words, efforts must be place to gradually abandon a model of dependency that Peruvian cities have adopted through time, without considering the potential that resides in the geographical area of the city (Leff, 2002). This issue is of particular importance in terms of energy flows, since the Peruvian national grid depends mainly on two energy sources: i) a hydropower sector that is becoming increasingly fragile due to changing patterns in terms of precipitation and a critical melting rate of glacial ice in the Peruvian nevados (Baraer et al., 2012); and, b) a thermoelectric system that is based on burning fossil fuels, mainly national natural gas, with the evident impact in terms of GHG emissions. Moreover, considering that Peru will have to guarantee water supply for irrigation and human consumption in the hyper-arid but heavily populated coastal area, and that it has recently signed the Treaty of Paris to reduce GHG emissions by 31% in 2030, it is imperative that urban environments in the country shift to cleaner and less vulnerable energy sources.

The main objective of this study was to calculate the self-sufficiency energy potential of cities in Peru, as well as the associated reduction in GHG emissions. Three cities, each one of them located in a different geographical region of Peru, were selected: i) Ica, along the Peruvian coast, where most of the Peruvian population is located, 250 km South of Lima, which has a hiper-arid climate; ii) Ayacucho, in the southern highlands, with moderate precipitation and a relatively high number of annual hours of sun; and, iii) Pucallpa, in the Amazon basin under typical rainforest conditions. Urban environments were considered due to the high rate of urban population in Peru, 77% in 2015 (INEI, 2016). These cities were analyzed through the implementation of solar modules in commonly underutilized urban areas, the rooftops of buildings, in order to adapt this infrastructure to local architectural characteristics and with the aim of identifying to what extent they could become self-reliant on energy. Thereafter, the environmental impact was quantified with the use of the LCA methodology, which allowed comparing the production of these modules with the current scenario in which all the electricity is obtained from the national grid. The study is intended to be of utility for policy-makers at a local, regional and national level, since it may provide novel ideas in which Peruvian cities should develop. Moreover, the small but thriving renewable energy corporate sector in Peru may also benefit from this type of discussions.

2| METHODOLOGY

Peru is the most diverse country in the world in terms of climates across its geography. However, these tend to be grouped into three main natural areas or bioregions: the hyper-arid Peruvian Pacific coast, the highland in the Andes and the Amazon basin. Therefore, the selection of urban environments to study their energy potential was based on choosing a representative city in each of these natural areas. In this context, medium size cities were considered in which local authorities willingly provided energy-relevant data to conduct the analysis. Hence, the coastal city selected was Ica (14°04´S; 75°44´W), a growing medium sized city with important agricultural production. For the highlands, the chosen city was Ayacucho (13°09´S; 74°13´W). Finally, in the Amazon basin the city of Pucallpa was selected (8°23 S; 74°33 W). A series of socio-economic characteristics for the three cities can be observed in Table 1.

Table 1. *Main socioeconomic data for the cities of Ica, Ayacucho and Pucallpa.*

	Unit	Ica	Ayacucho	Pucallpa
Municipal area[a]	km^2	1197	141	11,135
Total population[b]	hab	244,390	183,896	211,651
GDP per capita[c]	USD	8967	6761	6737
Poverty[d]	%	8.6	43.8	17.9
Socioeconomic level[a,e]	--	C	C	C

a Data obtained from the Peruvian Central Bank (BCRP, 2016); b Data obtained from the Peruvian Statistics Institute (INEI, 2012); c Data obtained from the Peruvian Statistics Institute (INEI, 2015); d Data obtained from the International Development Bank (IDB, 2012); e Socioeconomic levels in Peru are ranked from A to E, being A the group with highest purchase power and group E the lowest one.

Data required to model the desired energy self-sufficiency potential in the three cities included a range of demographic and climate indicators. In the first place, demographic data obtained for the case studies included population density, total population and the size of the municipalities that are included in the boundaries of the cities (INEI, 2015). Secondly, electricity consumption was retrieved from the local electric companies (Electro Dunas, Electrocentro and Electro Ucayali, personal communication, July 2016). As shown in Figure 1, these values, which are referred to the period 2010-2016, were transformed into an average annual per capita consumption. It should be noted that total electricity consumption included residential, commercial and public lighting uses, but excludes industrial use of electricity.

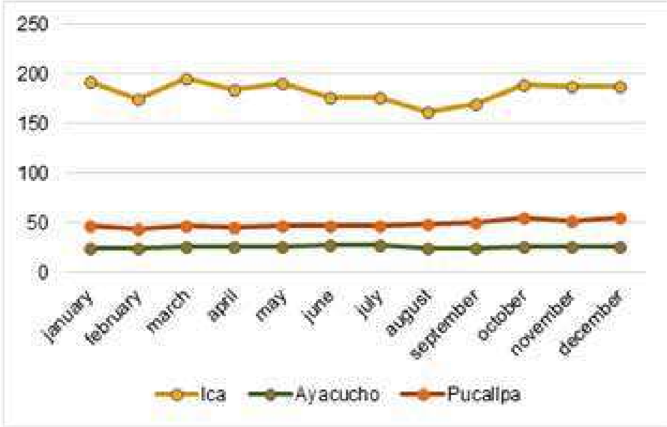
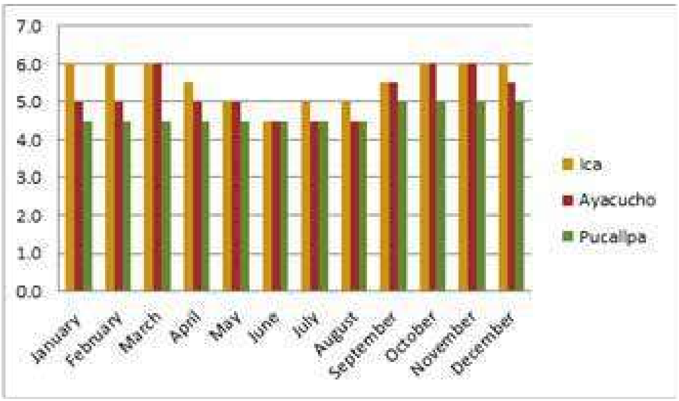


Figure 1. *Monthly electricity consumption per capita in the analyzed cities reported in kWh per capita in the period 2010-16.*

Regarding climate data, incident solar energy was computed in order to identify how much energy can be produced per unit area of surface in a given geographical region. This indicator is critical in terms of understanding the importance of solar energy in a specific location. Figure 2 shows the incident solar energy per month in each of the three cities selected based on data provided by the Peruvian Meteorological Institute (SENAMHI) and the Ministry of Energy for the period 2010-2014 (SENAMHI, 2015). Finally, temperature data, including average values, as well as maximum and minimum temperatures, were obtained from SENAMHI in order to identify the efficiency of solar modules (SENAMHI, personal communication, May 2016).



Once these data were aggregated, the required residential energy was calculated in kWh/m2 to identify the amount of solar panels that need to be placed in the rooftops. Therefore, ArcGis v10.3 was used to calculate the rooftop area available in each city. To do so, a representative area of approximately 130 ha was selected in each case study. The section of city was chosen on the basis of two main criteria. On the one hand, areas with predominantly residential neighborhoods were identified. On the other hand, districts of the city with similar socioeconomic levels to the average of the city were used in the assessment. Once the rooftop areas were computed for the selected polygon using ArcGis, this information was extrapolated to the entire size of the city. The preliminary rooftop area, which coincides with the built up area, was 753.23 ha in the case of Ica, 585.47 for Ayacucho and 3869 ha in Pucallpa. Thereafter, a ratio was generated between the total population of the cities and the rooftop areas, which was later translated into electricity consumption per unit area (i.e., kWh/m2). The final step in order to compute required residential energy was to use a correction factor of 0.75 in order to account for energy losses in the solar panel systems installed.

Rooftop profiles depend on a series of factors, including the disposition of the panels, as shown in Table 2. The size of the individual panel assumed in this study was a conventional 1m x 1.5m piece. Considering that the efficiency of the panels ranged from 15% to 18% based on the temperatures registered in these towns, the optimal energy provided per panel was computed. However, these panels cannot occupy the entire available space, for a variety of reasons. In the first place, since a certain distance between panels must be respected, a 0.60 factor was considered for the city of Ayacucho, whereas for Ica and Pucallpa this factor was 0.72. The differing factors between cities depend on the shape of the roofs, as shown in Figure 3. Secondly, a factor of 0.7 was assumed due to the lack of cleaning of these units, that impedes an optimal utilization of incoming energy (Esperanza Cárdenas, Acciona Energía – Spain, personal communication, January 2017). A third issue of interest is the orientation of the panels. Although traditionally these were orientated towards the North in the southern hemisphere, recent studies suggest that the ideal orientation should be East or West (Hartner et al., 2015; Singh et al., 2015). Therefore, either of the latter was assumed in the current study. Finally, a fourth factor that should be taken into account is the tilt of the panels, which depends mainly on latitude. In the case of predominant flat rooftops (i.e., the city of Ica), optimum tilt was assumed to guarantee optimal efficiency (factor of 1), whereas in Ayacucho and Pucallpa a factor of 0.80 was considered, based on the assumption that the panels have the same tilt as that of the roofs.

Table 2. *Correction factors considered to calculate the disposition and efficiency of the photovoltaic solar panels.*

Description	Factor	Observations
Rooftop profile	0.60 - 0.72	Data provided by Acciona Energía (2017).
Cleaning	0.7	Data provided by Acciona Energía (2017).
Interference	Depends on the representative area in each city.	ArcGis v10.3 and Google Earth.
Orientation	Flat rooftop: 1.00.Inclined rooftop: Depends on the representative area for each city.	ArcGis v10.3, Google Earth (Singh et al., 2015; Hartner et al., 2015)
Tilt	Flat rooftop: 1.00 Inclined rooftop: 0.80	ArcGis v10.3, Google Earth (Hartner et al., 2015)
Shading	Depends on a representative area for each city.	ArcGis v10.3, Google Earth (Hong et al., 2015)

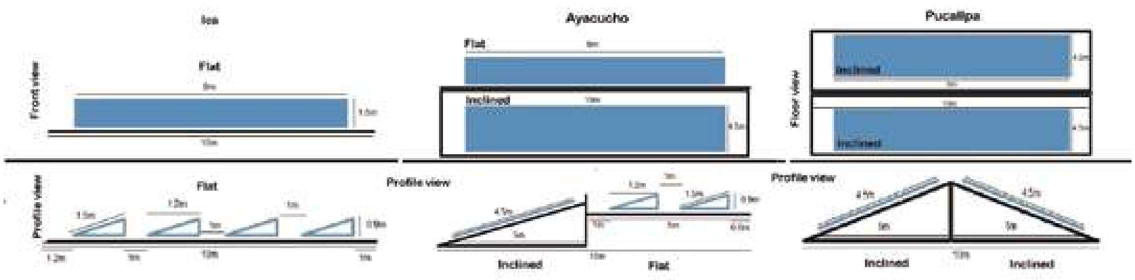


Figure 3. *Predominant rooftop profiles in each of the cities assessed.*

When the placement of the panels is scaled to the 130 ha sample area in each city, two additional correction factors must be taken into consideration: interference and shading. For the former, Google Earth was used in combination with ArcGis to perform a series of iterations to identify unavailable rooftop areas. This iteration allowed calculating the real available rooftop in the representative area of each city, which was the extrapolated to the entire city. Hence, a total of 53,123 m2 were identified for Ica, 79,242 m2 for Ayacucho and 56,232 m2 for Pucallpa considering current city limits. For the latter, a final correction has to be performed based on the fact that the uneven distribution of building heights in a city's skyline creates shading that must be accounted for. Hence, in a similar way as the iteration used for interference, rooftops that are prone to permanent shading were excluded from the area of interest, lowering the final available rooftop areas to 34,158 m2 in Ica, 45,643 m2 in Ayacucho and 40,318 m2 in Pucallpa. Topographic relief linked to the surrounding orography does not generate additional shading in the cities included in the case study, but may be an issue to be considered in other cities.

In parallel, the electricity mix of Peruvian regions was obtained from the Ministry of Energy and Mining (MINEM, 2010, 2011, 2012, 2013, 2014), with the aim of modelling the GHG emissions linked to current electricity production. A previous study by Vázquez-Rowe et al. (2015) had delved into the environmental impacts caused by electricity production in Peru in the period 1989-2013. However, in the current study it was decided to model the electricity mix of each Peruvian region individually, to account for regional variability. Hence, electricity production data were retrieved for the period 2010-2014. Thereafter, the GHG emissions linked to the current production of electricity of the regions of Ica, Ayacucho and Ucayali (i.e., the region where Pucallpa is located) were computed using LCA. In the case of Ucayali and Ica energy production was dominated by thermoelectric power plants, 99% and 91%, respectively, in year 2014, whereas in Ayacucho 79% of the production was linked to hydropower generation in that same year. The functional unit chosen to calculate the GHG emissions of these three systems was 1 kWh of electricity produced in each of these regions for the average mix in the period 2010-2014. Ecoinvent® was used as the database that supported the background data for the mathematical computation (ecoinvent®, 2017). The assessment method used to compute the environmental impact results was IPCC 2013 – 100 years (IPPC, 2013), which includes updated characterization factors for important GHGs, such as methane (CH_4) and dinitrogen monoxide (N_2O). Finally, the software used to compute the results was SimaPro 8.2.0 (PRè-Consultants, 2017). Modelling for the photovoltaic scenario was performed by using 3 kWp, multi-Si photovoltaic installations, which include infrastructure. In accordance with the current electricity mix, the selected functional unit was 1 kWh of electricity produced and available for consumption. Thereafter, the selected functional units for the current and the projected scenarios are homogenized to kWh/m2, in which the unit area corresponds to the total built up area of each town.

3| RESULTS AND DISCUSSION

Results for each city demonstrate that the photovoltaic solar energy that can be obtained from underutilized rooftop areas in the analyzed cities would allow attaining full coverage of current electricity demand in all three cities. Moreover, given that the self-sufficiency factor is above 1 throughout the entire year, a substantial fraction of the electricity would be lost unless the surplus production is: i) sold to the electricity grid; ii) used for industrial activities within the city limits; or, iii) used to face expected increases in electricity demand in urban dwellings in the future.

Figure 4 shows the specific results obtained for the city of Ica. Throughout the entire year the production of energy is substantially higher than the current required energy, ranging from a factor of 2.64 in June to a factor of 3.71 in January. When translated into GHG emissions, reductions ranging from 79.7% to 80.3% can be attained per month, since the GHG emissions per square meter in the current scenario have a minimum of 599.4 g CO_2eq in the month of August, as compared to a peak of 144.8 g CO_2eq in the month of March when using photovoltaic panels. When extrapolating to their entire city, these savings would imply a reduction of 48,850 t CO_2eq per year. This reduction alone is higher than the reductions that the Peruvian government has suggested in its Intended Nationally Determined Contributions (INDCs) in the frame of the Treaty of Paris regarding distribution of energy with photovoltaic panels by 2030 (15,000 t CO_2eq).

In the case of the city of Ayacucho, energy production obtained with the photovoltaic scenario would also be substantially higher than the required energy, with a self-sufficiency factor ranging from 2.48 in June to 3.79 in October. In contrast, the reduction in GHG emissions is much lower per square meter than in the case of Ica, since only reductions ranging from 15.9% to 19.5% were attained. The reason behind this is the fact that the regional electricity mix in Ayacucho is linked mainly to the production of hydroelectricity (79%), whereas the use of thermal power plants represents less than 25% of the total electricity generation. This implies that climate change environmental impacts linked to electricity use in Ayacucho are already low, and the implementation of solar panels in this city would not derive in such a significant reduction in GHG emissions.

Finally, in the case of Pucallpa the self-sufficiency ratio was the lowest of the three cities, ranging from 1.92 in October to 2.14 in June. Despite this lower ratio, the autonomy of the city to cover its residential, commercial and public lighting electricity requirements would be fulfilled. Interestingly, Pucallpa has the highest impacts in terms of climate change regarding its energy grid, since it relies 99% on thermoelectric power stations. In fact, this is an issue that does not only affect Pucallpa and its region (Ucayali), but also the other two Peruvian regions that are located entirely in the Amazon basin: Loreto and Madre de Dios. Therefore, the reduction in GHG emissions that can be attained in the city of Pucallpa by installing photovoltaic solar panels was roughly 94% throughout all the year. In fact, if this scenario were to be implemented, the reduction in GHG emissions for the entire city could be as high as 546,044 t CO_2eq per year, tenfold the savings that could be attained on an annual basis in Ica.

Based on these results, it appears plausible to establish investments to gradually reduce the dependence of medium-sized Peruvian cities from the national or regional electricity grid, increasing energy security. The installation of photovoltaic solar panels demonstrates to be a reasonable strategy to revitalize underutilized rooftop areas in urban environments. However, the environmental impact results suggest that in a context in which Peru has to transition towards a low carbon economy by 2030 cities in the Amazon basin would benefit the most from the use of urban photovoltaic solar panels, since GHG reductions to produce electricity can reach 90-95%, while minimizing reliance on non-renewable energy.

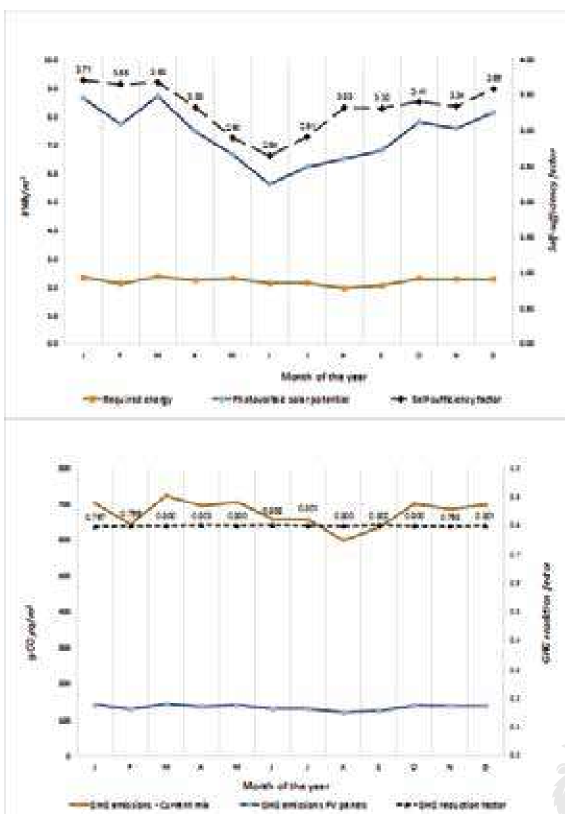


Figure 4. *Energy self-sufficiency potential in the city of Ica and GHG emission mitigation through the use of underutilized rooftop area for photovoltaic energy production.*

Figure 5. *Energy self-sufficiency potential in the city of Ayacucho and GHG emission mitigation through the use of underutilized rooftop area for photovoltaic energy production.*

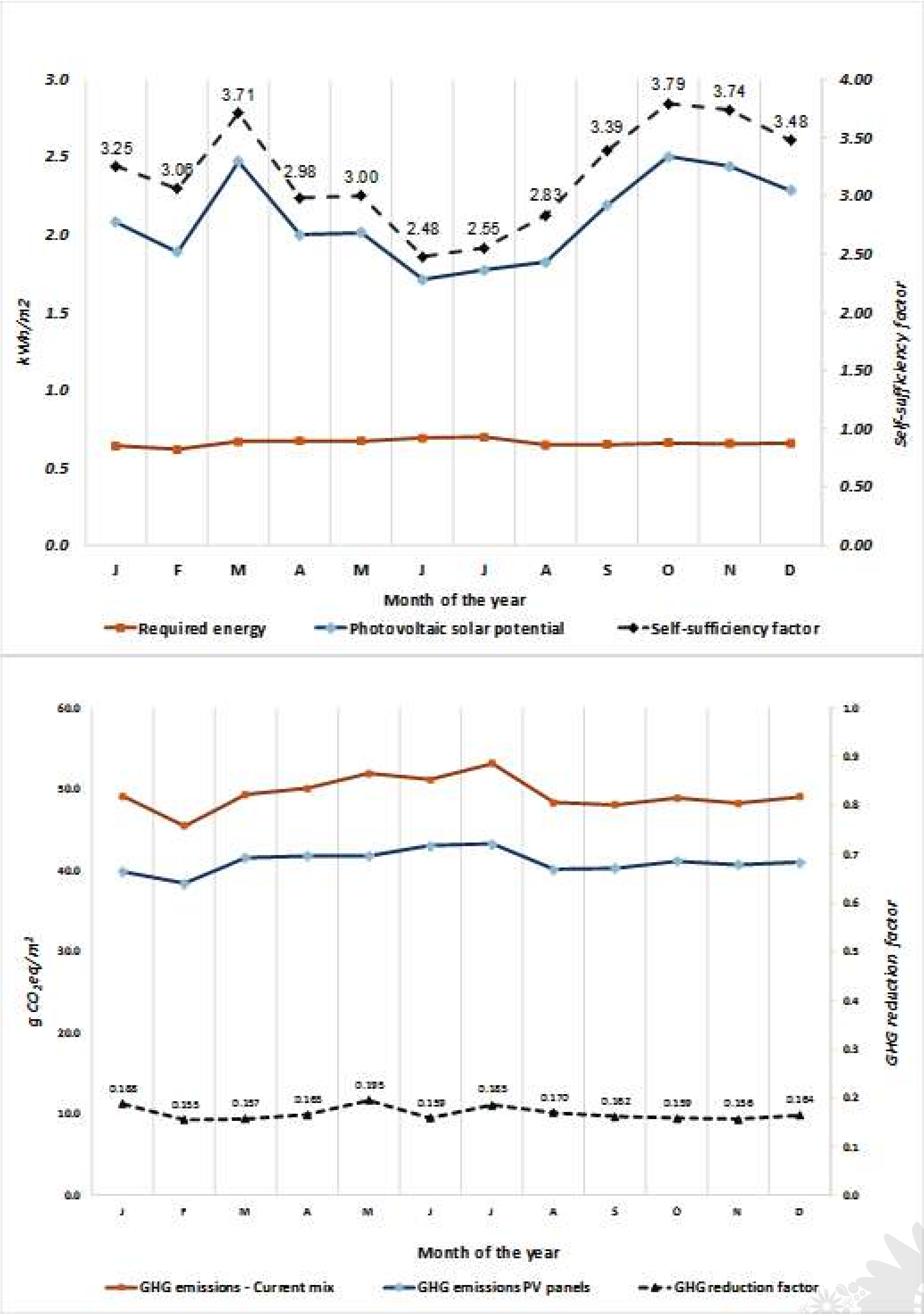
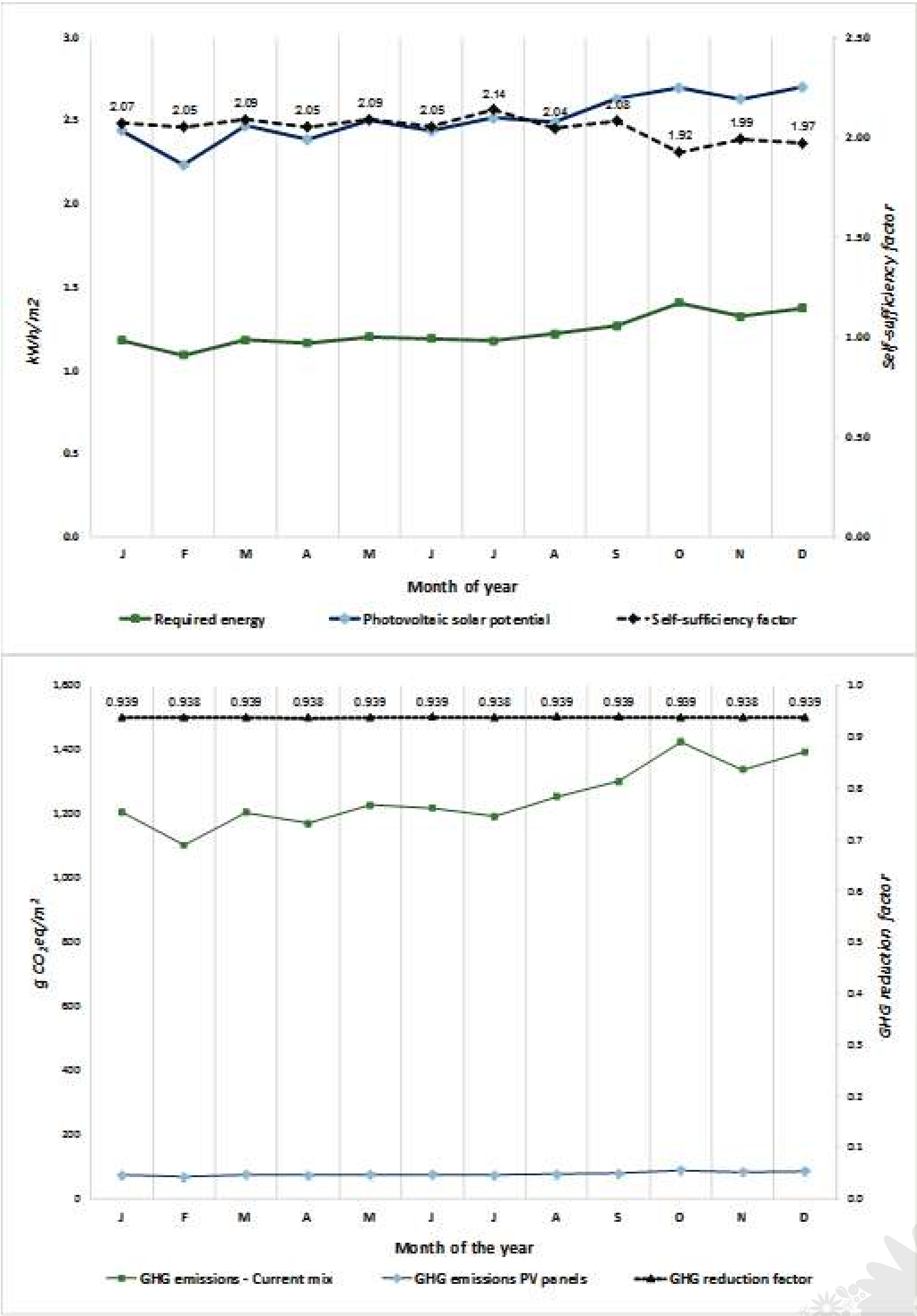


Figure 6. *Energy self-sufficiency potential in the city of Pucallpa and GHG emission mitigation through the use of underutilized rooftop area for photovoltaic energy production.*



4| CONCLUSIONS

It is concluded that Peruvian medium-sized cities have characteristics that would allow them to be self-sufficient in energy for residential, commercial and public lighting purposes if investments in photovoltaic solar energy are performed in underutilized areas of urban rooftops. Future plans regarding urban development in Peruvian, and by extension, other Latin American cities must contemplate the implementation of solar photovoltaic energy (i.e., solar modules) in the rooftops of buildings. Beyond the benefits linked to attaining energy independence and security, our study demonstrates that substantial reductions in GHG emissions can be attained through this perspective as compared to the current situation. In other words, an emission of over 600 kton CO2eq could be avoided on annual basis with the implementation of this strategy in the three cities. Current research is focusing on identifying the trade-offs in order environmental impacts, such as the depletion of resources, particulate matter formation and photochemical oxidant formation. Moreover, the combination of rainwater harvesting infrastructure with the proposed installation of photovoltaic panels will be analyzed to tackle water and energy security under the rooftop area recovery that has been proposed in the current study. Future research should also focus on analyzing which cities in Latin America would benefit the most from this type of studies, considering those with highest population or urban expansion growth rates, those that are more reliant on fossil fuels or those in which centralized electricity grid systems appear inefficient in terms of vulnerability to natural disasters.

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MARCO DE TRABAJO PARA ACELERAR LA ADOPCIÓN DE LOS ODS EN REGIONES

FRAMEWORK TO ACCELERATE THE ADOPTION OF SDG IN REGIONS

MARCO DE TRABALHO PARA ACELERAR A ADOPÇÃO DOS ODS AS REGIÕES

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RESUMEN:

Los Objetivos de Desarrollo Sostenible (ODS) son una agenda que trabaja para obtener una sociedad más sustentable, en todo el mundo. La incorporación de los 230+ indicadores ODS (ODS-i) en los países de América Latina y el Caribe presenta un desafío importante para los gobiernos locales. Para facilitar la implementación de esta Agenda y aprovechar el trabajo en indicadores ya existentes, hemos desarrollado un marco de trabajo para comparar conjuntos de indicadores de una manera fácil y rápida.

El marco de trabajo consiste en dos pasos claves: priorización de los indicadores más relevantes de acuerdo al objetivo de cada conjunto de indicadores y clasificación, donde los pares de indicadores se califican con "calificaciones de similitud", desde el 1 (tangencialmente relacionados) al 5 (idénticos).

Usando el framework, logramos clasficiar 11,500 pares de indicadores de ODS-i e ILAC (una iniciativa regional) en un total de 20 horas de trabajo de un recurso humano especializado. LA priorización redujo la lista de ODS-i desde 230 a 122 indicadores. La clasficiación logró reducir ese número a un total de 87 ODS-i que podían ser relacionados a indicadores ILAC. Encontramos: 15 ODS-i con similitud alta, 47 ODS-i relacionados y 25 ODS-i con similitud tangencial a los indicadores ILAC. De esa forma, logramos identificar un total de 186 pares de indicadores relacionados, de un total de 11,500 pares posible (1,6%).

Este marco de trabajo puede ahorrar recursos valiosos de los gobiernos y grupos de investigación que trabajan en este tema en toda la región.

Palabras clave:

indicadores; marco de trabajo; comparación; ODS; ILAC.

Palabras chave:

indicadores; marco de trabalho, comparação; ODS; ILAC

ABSTRACT:

The Sustainable Development Goals (SDG) are an Agenda that works towards a more sustainable society, worldwide. The incorporation of the 230+ Sustainable Development Goals indicators (SDG-i) in Latin American and Caribbean countries poses a challenging effort to our regional governments. To ease the implementation of this Agenda and leveraging the sustainable development indicators already in use, we have developed a framework to compare sets of indicators in an easy and quick manner.

The framework consists of two main steps: prioritization of most relevant indicators according to the goal pursued with each set and classification, where pairs of indicators are given "similarity scores", from 1 (tangentially related) to 5 (identical).

Using the framework, we managed to classify 11,500 pairs of indicators from SDG and ILAC (a regional initiative) in a total of 20 hours of specialized human resource. Prioritization reduced the SDG-i list from 230 to 122 indicators. Step 2, classification, further reduced the list to a total of 87 SDG-i that could be related to ILAC indicators. We found 15 high similarity SDG-i, 47 related SDG-i, and 25 poorly related SDG-i. Therefore, from the initial 11,500 possible pairs, we came down to 186 similar pairs (1,6% of possible pairs).

This framework could save valuable resources from governments and research groups all over the region.

Keywords:

indicators; framework; comparison, SDG, ILAC.

1| INTRODUCCIÓN (revisión y objetivos de la literatura)

Los indicadores de desempeño son números usados para medir progreso de metas organizacionales. Adoptar nuevas estrategias requiere cambios en las metas, lo que demanda la creación de nuevos conjuntos de indicadores. Este puede ser un proceso fatigoso, caro y lento para las organizaciones, ya que deben generar e implementar nuevos procesos para medir indicadores diferentes, ralentizando la correcta implementación de las nuevas estrategias.

Este trabajo presenta un marco de trabajo para comparar conjuntos de indicadores de forma rápida y consistente, de forma que los indicadores que la organización ya posee implementados se puedan usar para medir las nuevas metas.

Un ejemplo de esto es la adopción de los Objetivos de Desarrollo Sostenible (ODS) (y sus 230 indicadores) por los países de Latinoamérica y el Caribe. La meta 17 de los Objetivos indica que se debe aprovechar el trabajo hecho en iniciativas previas (ONU, 2016). En la región, una iniciativa previa es ILAC, que tiene 50 indicadores. Analizamos la relación entre los indicadores de ODS e ILAC para encontrar similitudes que pudieran ayudar a los países a aprovechar sus indicadores actuales para lograr supervisar los ODS.

2| METODOLOGÍA

Nuestro marco de trabajo tiene 2 pasos. El paso 1 es la priorización, donde pares de indicadores que no tienen relación entre las dos iniciativas se evalúan con 0. La priorización es una tarea rápida y debería ser sencilla para un experto familiarizado con ambas iniciativas. El paso de 2 es la clasificación, donde los pares de indicadores restantes se evalúan con una “escala de similitud” del 1 (relacionado tangencialmente) al 5 (idénticos).

Puntaje	Descripción del puntaje	Ejemplo
5	Idénticos/casi idénticos	**ODS 6.2.1** “Porcentaje de la población usando servicios de saneamiento seguros” e **ILAC 2.4.1.2** “Proporción de la población con acceso a servicios de saneamiento mejorados”
4	Idénticos - requiere un dato extra	**ODS 11.6.1** “Porcentaje de los residuos sólidos urbanos que son recolectados regularmente y tienen disposición final adecuada, con respecto al total de los residuos generados en la ciudad” e **ILAC 3.5.2.1** “Residuos sólidos urbanos depuestos adecuadamente” (toneladas)
3	Coincidencia parcial/relacionado	**ODS 6.8.1** “Porcentaje de unidades administrativas locales con procedimientos y políticas operacionales para la participación de las comunidades locales en la gestión del agua y saneamiento” e **ILAC 2.2.1.1** “Proporción de cuencas que tienen comités de manejo”
2	En tema. Sirve como base	**ODS 3.3.1** “Número de nuevas infecciones de HIV por 1,000 personas no infectadas (por edad, género y poblaciones clave)” e **ILAC 4.1.1.1** “Prevalencia del VIH /SIDA entre la población de 15 a 49 años”
1	Tangencialmente relacionado, potencialmente útil	**ODS 6.3.2** “Porcentaje de los cuerpos de agua receptores con calidad de agua que no represente un riesgo para el medio ambiente o la salud humana” e **ILAC 1.2.1.1** “Proporción de áreas terrestres y marinas protegidas”
0	Sin relación	**ODS 2.4.2** “Porcentaje de los hogares agrícolas que usan sistemas de irrigación comparado con todos los hogares agrícolas”.

Tabla 1. *Puntajes de sistema semicuantitativo para evaluación de pares de indicadores.*

Se puede establecer la similitud entre indicadores leyendo su nombre, descripción u hoja metodológica (metadatos). Es un paso más lento que la priorización, pero aún es rápido y repetible.
Los 6 puntajes que se puede dar a cada par de indicadores (del 0 al 5), pueden dividirse en tres niveles, para facilidad en la interpretación. Cada nivel tiene dos posibles puntajes:
Nivel 1: Pares de indicadores que se pueden relacionar fácilmente. Son idénticos o casi idénticos (puntajes 4 y 5).
Nivel 2: Pares que tienen algunas cosas en común (puntajes 2 y 3).
Nivel 3: Pares que tienen baja o nula relación (puntajes 0 y 1).
El hecho de que haya dos puntajes por nivel permite algo de forgiveness (principio del diseño que permite que el usuario se recupere de sus errores) en la evaluación, sin afectar las conclusiones que se extraen del método.
Este marco de trabajo ha sido conceptualizado como una primera herramienta en la adaptación de nuevos indicadores y no como un sistema infalible para encontrar pares similares.

3| RESULTADOS Y DISCUSIÓN

Usando el marco de trabajo, logramos clasificar 11.500 pares de indicadores ILAC y ODS en un total de 20 h de recurso humano especializado.
De los 230 indicadores ODS con los que comenzamos, luego de la priorización quedaron sólo 122 indicadores con potencial similitud a indicadores ILAC.
El paso 2, clasificación, redujo aún más la lista, para finalizar con un total de 87 indicadores ODS que tienen relación a alguno de los indicadores de ILAC. De esos 87, 15 estaban en el nivel 1 (idénticos o casi idénticos), 47 en el nivel 2 (relacionados) y 25 en el nivel 3 (sin relación o tangencialmente relacionados).
En resumen, de 11.500 pares posibles, redujimos la lista a 186 pares similares (1,6% de los posibles), en 20 horas.
Esta lista corta sirvió para priorizar el trabajo con delegados nacionales, enfocándonos en aquellos indicadores ODS que pueden ser incorporados más rápidamente a los países de la región. También es útil para evitar la duplicación de esfuerzos entre oficinas gubernamentales, estableciendo relaciones claras entre indicadores preexistentes y aquellos que deben ser implementados. Como es común, estos dos procesos normalmente están supervisados por equipos diferentes, facilitando la duplicación de trabajos y la pérdida de eficiencia de los gobiernos.
Hemos trabajado en este proyecto durante un año y ha habido menos de 10 cambios en la clasificación de los indicadores, mostrando la consistencia del marco de trabajo.

4| CONCLUSIONES

Este marco de trabajo ha permitido la identificación eficiente y consistente de pares de indicadores de iniciativas diferentes, manteniendo la rigurosidad del proceso de análisis. Confiamos que este proceso puede ser valioso para cualquier organización que esté cambiando de estrategia y desee aprovechar trabajo previo para esfuerzos futuros.

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Resource Management

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Medellín - Colombia

CONTRIBUIÇÃO PARA O PLANEJAMENTO DA OFERTA FUTURA DE GÁS NATURAL NO BRASIL

CONTRIBUTION TO THE PLANNING OF FUTURE SUPPLY OF NATURAL GAS IN BRAZIL

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RESUMO:
Este estudo verificou impactos ambientais associados ao sistema que atende a demanda brasileira de gás natural (GN). Uma ACV atribucional foi aplicada com enfoque do 'berço-ao-portão da unidade de refino' para medir os efeitos adversos da produção de 41,4 MJ de energia na forma de gás (FR) em termos de Demanda Primária de Energia (PED) e Mudanças Climáticas (CC). A análise revelou desempenhos de 109 MJ/FR e 6.56 kgCO2eq/FR devidos, em sua maioria a perdas de metano (CH4) fóssil. Uma verificação complementar em que se analisou os efeitos ambientais de três alternativas de adequação do mesmo arranjo permitiu concluir que substituições de GN do Brasil (GNBR) por homólogo da Bolívia (GNBO) reduz efeitos de PED e CC. Uma ampliação de oferta para atender a consumos futuros das regiões Nordeste e Centro-oeste do país seria positiva caso o suprimento de GN ocorresse desde reservas do Espírito Santo.

Palavras-chaves:
gás natural; desempenho ambiental; planejamento energético.

ABSTRACT:
This study verified the environmental impacts of the system used to meet Brazilian demand for natural gas. Attributional LCA has been applied from 'cradle-to-gate of refining unit' approach to measure the adverse effects of the production of 41.4 MJ of energy as gas (RF) as Primary Energy Demand (PED) and Climate Change (CC). The analysis revealed performances of 109 MJ/RF and 6.56 kgCO2eq/RF mainly due to losses of fossil methane (CH4). Another investigation examined the effects provided by three alternative adequacy of that arrangement concluding that substitutions of Brazilian NG (GNBR) an alternative provided by Bolivia (GNBO) reduces impacts of PED and CC. An increase in supply to meet future consumption in the Brazilian Northeast and Mid-east regions would be positive if GN supplying came from Espírito Santo reserves.

Keywords:
natural gas; Environmental performance; energy planning

1| INTRODUÇÃO

O segmento gasífero brasileiro se desenvolveu a partir da descoberta de petróleo em poços associados existentes na Bacia de Campos, litoral do Rio de Janeiro. Essa condição explica o fato de a maior parte do gás produzido no país ser originário de campos offshore. O Brasil é também o principal importador de gás na América do Sul. Cerca de 39% da oferta interna do produto de 2013 foi suprida com gás importado, em sua quase totalidade da Bolívia (MUÑOZ et al, 2014). A demanda nacional gás natural (GN) atingiu em dezembro de 2016 cerca de 112 milhões m3/dia (MMm3/d), valor que supera em 11% o patamar registrado no mesmo período de 2015. Uma malha com 9410 km de gasodutos procede a distribuição daquele volume; no entanto, algumas zonas do país permanecem ainda desconectadas do sistema (CNI, 2016). Assim como ocorre com outras ações antrópicas, as atividades de exploração e produção de GN trazem efeitos adversos sobre o ambiente. Aparte da depleção do recurso em si, tais ações resultam em perdas atmosféricas e hídricas, além de importantes alterações ao meio físico. Figuram como precursores de impacto nesse caso emissões de metano (CH_4), óxidos de nitrogênio e enxofre (NO_x e SO_x), monóxido de carbono (CO), e de hidrocarbonetos de baixo peso molecular (C_xH_y) (MIRANDA et al, 2010). Esse quadro justifica uma análise do desempenho ambiental dos processamento e distribuição do GN consumido no Brasil para não apenas de identificar oportunidades potenciais de melhoria de performance, mas também, orientar ações de desenvolvimento no setor. Este estudo procurou suprir, ainda que em parte, essa lacuna ao verificar o comportamento do sistema em termos de Demanda Primária de Energia (PED) e Mudanças Climáticas (CC) (i) para sua condição atual de operação, e (ii) quando lhe forem adicionadas rotas complementares para suprimento de GN no Brasil. Para tanto, aplicou-se ACV atribucional com enfoque do 'berço-ao-portão da unidade de produção'.

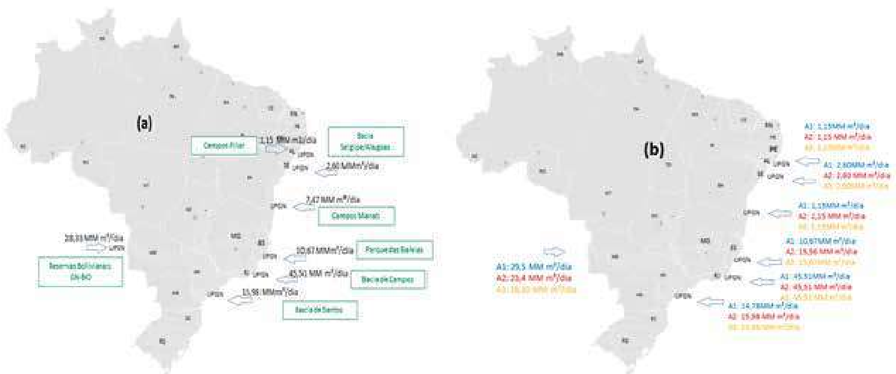
2| METODOLOGIA

Para atender aos propósitos acima indicados, o estudo foi estruturado segundo cinco etapas executivas: (i) modelagem da extração, transporte a unidade de refino, e do beneficiamento em si do GN de acordo com as condições praticadas no Brasil; (ii) avaliação de impactos de PED e CC para o sistema; (iii) seleção e modelagem de rotas futuras da oferta de GN; (iv) quantificação do desempenho do sistema para aquela condição; e (v) proposta de recomendações a partir dos resultados obtidos.

3| MODELAGEM DO CICLO DE VIDA

Este estudo seguiu as bases conceituais descritas pela norma ABNT NBR 14044 (ABNT, 2009). O sistema de produto (Fig.1a) inclui as etapas de extração de GN dos reservatórios, transporte até os terminais e unidades de refino (UPGNs), e as transformações que nelas ocorrem para produção de 41,4MJ de energia, ou 1.0 m3 GN (fluxo de referência FR do estudo) em condições de comercialização. O gás boliviano (GNBO) procede dos campos de Sabalo, San Alberto e Margarita e atende demandas existentes no Mato Grosso, Mato Grosso do Sul, São Paulo, e na região Sul do país.

Figura 1: *Esquema simplificado das fontes de proviemento de GN no Brasil: (a) situação atual; (b) situação futura*



Já a produção interna GNBR (61% da oferta útil do país no mesmo período) ocorre nos litorais do Rio de Janeiro, São Paulo, Espirito Santo, Bahia e Sergipe, além de campos onshore situados em Alagoas. Tais localidades perfazem a cobertura geográfica do modelo. Dados secundários de cobertura temporal, restrita a 2016, retratam consumos e emissões do sistema. Os processos multifuncionais foram tratadas via Surplus Method (Heijungs & Suh, 2002).
A Avaliação de Impacto de PED ocorreu via método Cumulative Energy Demand (CED), v 1.09. Já os impactos de CC foram verificados por ReCiPe, Midpoint (H), v 1.12 o qual baseia sua estimativas nas orientações do Intergovernmental Panel on Climate Change (IPCC, 2006).

4| RESULTADOS E DISCUSSÃO

4.1. Diagnóstico: situação atual do sistema

O desempenho do sistema para PED foi de 109 MJ/FR, na quase totalidade sob a forma do consumo de Fontes Fósseis Não-Renováveis (NRF) (Tab 1). O GNBR respondeu por 84% desse montante, devido a consumos de GN em operações de reinjeção, que ocorrem sobretudo em poços associados em atividade nos litorais do Rio de Janeiro e São Paulo. O aporte do GNBO reside em sua maior parte em perdas ocorridas nos campos de Sabalo, do qual emana 44% de toda produção boliviana adquirida pelo Brasil.
A tendência de distribuição se mantem para CC. Nesse caso GNBR acumula 88% dos 6.56 kg CO2 eq/FR. No tocante aos precursores de impacto 99%+ das participações nas duas categorias de impacto resultam de emissões para o ar de CH4 fóssil.
Durante a extração do gás as perdas aéreas de CH4 no Rio de Janeiro e em São Paulo atingem respectivamente 118 e 42.5 g/FR.

Tabela 1. Desempenho ambiental da distribuição de GN no Brasil

Contribuição (/ 41,4 MJ)	PED (MJ)	CC (kg CO_2 eq)
GN_{BR}	92	5.78
GN_{BO}	17	0.78
Total	109	6.56

4.2. Cenários futuros de adequação da oferta de GN

Três das alternativas ora em fase de projeto, comissionamento ou construção no país foram selecionadas para verificação de desempenho ambiental (Fig.1b). Todas elas deverão ser incorporadas ao sistema brasileiro de GN até 2020 (EPE, 2014). A alternativa A1 substitui o suprimento do Distrito Federal (1.20 MMm3/d), que no arranjo atual procede de São Paulo (GNSPBR), por GNBO. Já na alternativa A2 o GNBO deixa de atender a região Sul do Brasil (que consome 4.89 MMm³/d), dando lugar ao gás extraído no Espirito Santo (GNESBR).

Tabela 2. *Modificações introduzidas por alternativas de adequação do sistema nacional de GN*

Alternativa	Destino	Fornecimento Atual	Fornecimento Futuro	Volume (MMm^3/d)
A1	DF	GN^{SP}_{BR}	GN_{BO}	1.20
A2	Região Sul	GN_{BO}	GN^{ES}_{BR}	4.89
A3	Regiões NE e CO	–	GN^{ES}_{BR}	5.00

Por fim, A3 verifica o efeito de aumento de demanda nas regiões Nordeste (NE) e Centro-Oeste (CO) em 5.0 MMm³/d, também via GNESBR. O volume equivale a 6.87% de acréscimo na demanda atual de GN do país. Todas as adequações avaliadas são factíveis quanto a disponibilidade dos reservatórios, e existência de malha de distribuição de GN, muito embora esta análise se estenda, também do 'berço-ao-portão da UPGN'. A Tabela 2 sintetiza os ajustes introduzidos a partir de cada alternativa.

4.3. Impactos das Adequações futuras

A implementação de A1 resultou em redução de 1.47% no impacto de PED com relação ao comportamento atual do sistema. As principais contribuições seguem ocorrendo na forma de NRF (∼100%), e GNBO elevou em 6.25% sua participação no montante total de demanda primária de energia. Os ganhos associados a A1 se devem à redução de consumos com reijeção e exploração, inexistente no GNBO, mas que representam 31% das perdas da extração do GNBR. Quanto a CC houve também uma redução (1.83%), justificada por GNBO conter mais CH4 (91%v/v) do que GNBR (89%v/v).
Com A2 o desempenho do sistema quanto a PED se eleva em 6.62%, atingindo 116 MJ/FR. Compondo ambos os resultados de PED de A1 e A2 conclui-se que GNBR predispõe pior aproveitamento do recurso fóssil gás natural do que GNBO. O impacto em termos de CC ratificou a tendência ascendente de PED e ao atingir 7.02 kg CO2 eq/FR. As emissões de CH4 que ocorrem durante a extração do gás na costa do Rio de Janeiro permanecem como principais precursores de impacto para a categoria.
Na ampliação ensaiada em A3 a PED do sistema atinge 112 MJ/FR, aumento de 2.56% com relação à condição atual. A variação foi impulsionada por consumos em GNRJBR e GNESBR respectivamente de 46.1 e 20.9 MJ/FR. Dentro da mesma tônica, CC atingiu 6.71 kg CO2 eq/FR (elevação de 2.27%), também em virtude de emissões de CH4 fóssil originárias de perdas e vazamentos.
Ressalte-se que os incrementos derivados de aportes registrados para qualquer dos impactos superaram a elevação de oferta gerada (6.87%) com a ampliação do sistema. Tal resultado pode ser considerado como auspicioso em favor das adequações avaliadas.

5| CONCLUSÕES E RECOMENDAÇÕES

A análise de desempenho ambiental do suprimento de 41,4 MJ de energia como GN no Brasil resulta em impactos derivados de consumos (109 MJ como PED) e emissões (6.56 kg CO 2eq), que se devem a perdas de CH4 fóssil via reinjeção. A verificação de ações de potencial adequação do mesmo arranjo revelou que a substituição de GNBR por GNBO tende a reduzir efeitos globais do sistema tanto em termos de PED, como de CC. Uma possível proposta de aumento de oferta para atender a consumos futuros das regiões Nordeste e Centro-Oeste do país seria positiva em termos ambientais caso o provimento de gás ocorresse a partir de GNESBR.O próximo passo da pesquisa compreende investigar outros ajustes do sistema, juntando a análise impactos da distribuição do GN até o uso final.

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ACV SOCIAL, UM CAMINHO PARA A RESPONSABILIDADE SOCIAL CORPORATIVA

SOCIAL LCA, AWAY FOR CORPORATE SOCIAL RESPONSIBILITY

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ABSTRACT:

The aim of this paper is to identify how SLCA – Social Life Cycle Assessment can support decision process leading to more beneficial social conditions throughout the product life cycles, as an important tool to make CSR a real contribution to strategic business management. CRS theory was revised and the connecting points with LCA methodology were investigated to identify how these methods can be seen as a pathway to identify hotspots social impacts in business, helping to low the risks of a project. The result is that the LCA techniques, to environmental or social assessments, bring an objective approach that is based in a systemic evaluation of impacts of products and services, helping organizations to make decisions with all the information available. In this way, SLCA is presented as a good technique to address the multiple stakeholder interests in sustainable development by expose social, environmental and economic issues to the decision process.

Keywords:
CSR - Corporate Social Responsibility; SLCA – Social Life Cycle Assessment; Sustainable Development; Decision Process.

RESUMO:

Esse artigo tem como objetivo identificar como a metodologia da ACV-S pode contribuir para um processo de tomada de decisão empresarial que considere os impactos positivos e negativos identificados no ciclo de vida de um produto, atuando assim como uma ferramenta de responsabilidade social corporativa (RSC) que contribua para a sustentabilidade dos negócios. A partir de uma revisão da literatura sistematizada por Archie B. Carroll em 1999 sobre evolução dos conceitos de responsabilidade social e as contribuições mais recentes que culminaram com a publicação da norma ISO 26000 sobre RSC e a análise da metodologia de ACV-S proposta pela UNEP/SETAC em 2011, foi observado como essas linhas de pensamento podem contribuir para uma atuação empresarial mais sustentável. As técnicas de ACV, seja para avaliação social ou ambiental, se apresentam como uma abordagem objetiva para a RSC que se baseia na avaliação sistêmica dos impactos de produtos e serviços. Essas técnicas podem auxiliar as organizações a tomar decisões com o máximo de informações disponíveis se apresentando como uma boa ferramenta para conciliar os interesses de diferentes públicos para o desenvolvimento sustentável.

Palavras chave:
RSC – Responsabilidade Social Corporativa; ACV-S – Avaliação Social do Ciclo de Vida; Desenvolvimento Sustentável; Processo de Decisão.

1| INTRODUÇÃO

As empresas são cobradas a se responsabilizar para além do produto que colocam no mercado, estendendo a toda cadeia, desde sua concepção até o descarte final. Todavia, a dimensão social do desenvolvimento sustentável não tem obtido tanta atenção de pesquisadores e gestores quanto seria necessário (Hellweg e Canal, 2014). Há deficiência nos métodos científicos e nas práticas organizacionais para avaliar o desempenho social associados à implantação de projetos, processos de produção, logística e demais processos de uma cadeia produtiva. Sob o olhar das organizações, o desafio é fazer com que essa atuação responsável alcance não só os objetivos sociais, mas principalmente os objetivos organizacionais.
Esse artigo tem como objetivo identificar como a metodologia da ACV-S pode contribuir para um processo de tomada de decisão empresarial que considere os impactos positivos e negativos identificados no ciclo de vida de um produto, atuando assim como uma ferramenta de responsabilidade social corporativa (RSC) que contribua para a sustentabilidade dos negócios.

2| METODOLOGIA

A evolução histórica do conceito de responsabilidade social foi obtida a partir da revisão sistemática publicada por Carroll (1999). Essa evolução foi complementada com o conceito atual apresentado pela norma ISO 26.000 (2010). A abordagem do conceito de responsabilidade social a partir do ponto de vista da metodologia de Avaliação Social do Ciclo de Vida (ACV-S) foi levantada a partir da análise dos documentos de referência em ACV-S publicados pela UNEP/SETAC: Guidelines for Social Life Cycle Assessment of Products (2009) e The Methodological Sheets for Sub-categories in Social Life Cycle Assessment (2013). Após esse levantamento, realizou-se uma análise comparativa dos conceitos.

3| RESULTADOS E DISCUSSÃO

Longe de ser um consenso o conceito de responsabilidade social corporativa trata da dimensão humana das relações organizacionais. As raízes da RSC como conhecemos hoje tem um dos primeiros registros literários no livro "Responsabilidade Social dos Homens de Negócio", de Howard Bowen de 1953 (Carroll, 1999). Podemos considerar que o documento mais recente e amplamente reconhecido é a ISO 26000 (2010), que abrange as questões mais discutidas na RSC nos últimos anos. O quadro 1, mostra como os conceitos de RSC evoluíram.

Conceitos de RSC
• Tomada de decisões a partir de valores da sociedade (Bowen, 1953). • Estratégia empresarial (Johnson, 1971). • Os interesses sociais e da própria empresa em uma perspectiva de longo prazo (Stein, 1970). • Ideia de "bom vizinho" que esforça em não incomodar e assume responsabilidade em melhorar o coletivo (Eilbert & Parket, 1973). • Parâmetros de RSC são mutáveis no tempo e no espaço (Seith, 1975). • Adaptabilidade do termo RSC que significa alguma coisa, mas nem sempre a mesma coisa para todo mundo (Votaw, 1973). • Engloba aspectos legais, éticos e conserva uma relação causal sobre os impactos das atividades da empresa (Votaw, 1973). • Ideia de permanente mudança como um alvo em movimento (Churchill, 1974). • Conceito de impactos causados totalmente ou em parte, pela empresa (Fitch, 1976). • Responsabilidades discricionária, arbitrária ou voluntária que está no campo da decisão da empresa Identificação de temas sociais que tem a ver com o negócio na empresa (Carroll, 1979). • Responsabilidade Social colocada no processo de decisão constrói um comportamento responsável (Jones, 1980). • As atividades econômicas que afetam o meio ambiente de maneira a ameaçar as pessoas (Brundtland, 1987). • RSC a partir de três princípios: legalidade, responsabilidade pública e critério gerenciais que envolvem a questão moral dos tomadores de decisão (Wood,1991). • Responsabilidade de uma organização pelos impactos de suas decisões e atividades na sociedade e no meio ambiente, por meio de um comportamento ético e transparente que contribua para o desenvolvimento sustentável, inclusive a saúde e bem-estar da sociedade; levando em consideração as expectativas das partes interessadas, que esteja em conformidade com a legislação aplicável e seja consistente com as normas internacionais de comportamento e esteja integrada em toda a organização e seja praticada em suas relações dentro de sua esfera de influência (ISO 26000, 2013)

Quadro 1: *Evolução dos conceitos de RSC.*
Fonte: *Elaborado pelos autores à partir de Carroll (1999).*

A UNEP/SETAC em seu guia (2009) assume que responsabilidade social se refere a responsabilidade que as empresas assumem com o objetivo de contribuir para o desenvolvimento sustentável. Outras definições da metodologia da UNEP sobre os aspectos sociais de uma avaliação de ciclo de vida (ACV) foram reunidos no quadro 2.

Conceitos de ACV-S
• Identifica oportunidades de melhoria de aspectos sociais (baseado em ISO 14040, 2006). • Técnica de avaliação de potenciais impactos sociais positivos e negativos através do ciclo de vida de um produto ou serviço (UNEP, 2009). • Analisa de forma abrangente através do ciclo de vida desde a matéria-prima até o descarte (UNEP, 2009). • Setor privado pode orientar a produção e gestão para a responsabilidade social (UNEP, 2009). • Compromisso das empresas com o desenvolvimento sustentável (UNEP, 2009). • Impactos sociais como consequência das pressões, positivas ou negativas, sobre os públicos envolvidos (UNEP, 2009). • Impactos são causados por decisões específicas e deliberadas ou como efeitos colaterais de decisões econômicas (UNEP, 2009). • A não geração de impactos negativos, pode ser considerado um impacto positivo sob a ótica social, diferente das avaliações ambientais (Jørgensen et al, 2008). • Impactos positivos na sociedade adicionam valor a avaliação de uma empresa (Ekener-Petersen, 2013). • Considera que a performance além do exigido pode ser considerado um impacto positivo (Petti et al., 2016). • Avaliação a atuação das empresas tendo como base parâmetros internacionais ou através de relações de causa e efeito (Parent et al., 2010).

Quadro 2: *Conceitos de ACV-S.*
Fonte: *Elaborado pelos autores.*

Podemos perceber alguns pontos de convergência em Eilbert & Parket (1973) que descrevem que a melhor forma de entender a RSC é pensando em um "bom vizinho" que se esforça em não incomodar os vizinhos (1973, apud Carroll, 1999), ou como a ACV-S chamaria de impactos negativos, e que ao mesmo tempo assume responsabilidades de fazer o ambiente coletivo um pouco melhor, o que podemos considerar como impactos positivos em uma perspectiva de ACV-S. Eles resumiram essa ideia pensando a RSC como "o comprometimento dos negócios em geral com um papel ativo na solução de problemas sociais, tais como discriminação racial, poluição, transporte e planejamento urbano. " Essa ideia é inovadora nos discursos de RSC nos anos 70, mas é exatamente o que é proposto de maneira objetiva no campo da ACV-S no guia metodológico da UNEP (2013).

Outro ponto está ligado ao pensamento de Sethi (1975 apud Carroll,1999), que leva a discussão para o campo dos valores, normas sociais e expectativas de performance, considerando que esses parâmetros que são mutáveis no tempo e no espaço. O guia metodológico da UNEP (2013) reconhece adaptabilidade e pontua sobre os documentos que foram utilizados como parâmetros valorizando a universalidade das instituições que os formularam, tais como as Nações Unidas, a Organização Internacional do Trabalho ou a Anistia Internacional.

Nesta mesma linha de pensamento Votaw (1973) já havia escrito sobre a adaptabilidade dos temas de RSC (1973 apud Carroll, 1999). Nesta mesma linha a UNEP (2013) apresenta um escopo básico, mas expressa que cada estudo deve considerar e justificar a escolha de uma subcategoria ou a exclusão de outra.

Carroll (1979) apresenta seu modelo de performance social que divide a RSC em quatro categorias. A responsabilidade econômica das empresas, é reconhecida como a função fundamental das empresas na sociedade ao "produzir bens e serviços que a sociedade quer e vendê-los com lucro". Em segundo, a responsabilidade legal, onde se considera todos os aspectos legais aplicáveis ao negócio. A primeira é considerada funcional e a segunda, mandatória. Nas demais a adesão das empresas se torna opcional e moldada pela sociedade, considerando a época e a localidade onde a empresa está atuando. As duas últimas etapas propostas por Carroll (1979) estão alinhadas com os parâmetros propostos pela UNEP (2009), A responsabilidade ética é a terceira, definida como "o comportamento ou atividades adicionais que não são necessariamente codificadas na lei, mas são igualmente esperadas das empresas pelos membros da sociedade. A quarta é descrita como discricionária, arbitrária ou voluntária, pois está unicamente no campo de decisão das empresas a sua atuação neste campo.

A discussão ganha novos contornos quando em 1987, o Relatório Brundtland – "Our Common Future" define conceito de desenvolvimento sustentável mostrando que o desenvolvimento econômico pode afetar o meio ambiente de uma maneira tão definitiva que passa a ameaçar também as pessoas. Esse conceito amplia os olhares da RSC para uma necessidade global de cuidado conjunto, já que o meio ambiente é um só independente das fronteiras físicas e legais. Além disso contribui para uma visão muito difundida hoje, que associa fortemente a questão social, ambiental e econômica, o que hoje conhecemos pelo conceito de triple botton line. Assim, o interesse crescente na inclusão dos aspectos sociais nas avaliações o ciclo de vida de produtos cresceu na medida em que o debate sobre a sustentabilidade ampliou as iniciativas de métodos que avaliem os impactos ambientais, sociais e econômicos (JØRGENSEN et al., 2008).

Wood (1991) propõe um entendimento da RSC a partir de três princípios. Legalidade, que a autora considera como institucional, que permite a atuação das empresas através do consentimento social, seja ele legal ou econômico. A responsabilidade pública, em nível organizacional, onde as empresas são individualmente responsabilizadas por seus impactos sociais e ambientais. E por fim os critérios gerenciais, onde a questão moral dos tomadores de decisão tem papel importante se considerarmos que as empresas são compostas por pessoas que fazem escolhas de acordo com seus critérios morais (1991, apud Carroll, 1999). Essa proposta é bastante didática e relativamente simples se considerar uma grande empresa, localizada em um país com uma legislação clara, com uma boa noção de pertencimento comunitário e com padrões morais amplamente aceitos.

Melo (2001) analisa que o processo de globalização é responsável pela emergência de um fenômeno relacionado ao aumento do poder dos grupos privados transnacionais e multinacionais gerando um processo de realocação de atividades produtivas, com concentração de renda, de poder econômico e, ao mesmo tempo, grande exclusão social. Os pilares da ética, cumprimento da lei e mitigação de impactos, discutidos nas teorias de RSC, neste contexto tomam proporções muito diferentes da realidade industrial americana e europeia onde foram pensados. Na tentativa de criar parâmetros globais para dar conta desta globalização produtiva diversos organismos internacionais se engajaram na busca de pactos, normas e modelos para promoção das mudanças sociais necessárias.

As técnicas de ACV podem ser utilizadas para ampliar a visão dos gestores às diversas realidades socioambientais por ter o potencial de abranger todo o ciclo de vida de um produto, mesmo que disperso geograficamente. A ACV-S como uma derivação da ACV ambiental tem um grande potencial de unir as questões socioambientais dentro de uma mesma metodologia que consegue visualizar as duas questões dentro de um mesmo processo e ampliar a possibilidade de escolhas sustentável não só para os consumidores como disponibilizar para os gestores em escopo de informações mais completas sobre os impactos da atuação da empresa para os gestores utilizarem no processo de tomada de decisão. O impacto social foi considerado por alguns autores como sinônimo de performance, efeito e consequência (IOFRIDA et al., 2016). Se considerarmos a perspectiva comportamental, a UNEP aponta que os impactos sociais são causados por decisões específicas e deliberadas, como por exemplo a proibição de algum direito ou a permissão de alguma ilegalidade, ou podem ser causados como efeitos colaterais de decisões socioeconômicas (UNEP, 2009). As técnicas de ACV, seja para avaliação social ou ambiental, se apresentam como uma abordagem objetiva para a RSC que se baseia na avaliação sistêmica dos impactos de produtos e serviços. Essas técnicas podem auxiliar as organizações a tomar decisões com o máximo de informações disponíveis.

4 | CONCLUSÕES

Vemos que para diversos autores (Votaw, 1973, Carroll, 1979, Wood, 1991) a RSC trabalha com os aspectos legais, alcançam o campo da ética e chegam até a reconhecer uma relação causal sobre o que a empresa é responsável devido aos seus impactos. A ACV-S pode contribuir para a identificação objetiva dos impactos de uma organização, utilizando o conceito de ciclo de vida para fundamentar o escopo de atuação da empresa. Considerando que já existia reconhecimento sobre o potencial da ACV-S com um método que auxiliava na tomada de decisão, mas ainda havia dúvidas sobre quais decisões os resultados da avaliação estavam auxiliando (JØRGENSEN, 2013). É possível concluir que a ACV-S pode contribuir para que as empresas tomem decisões produtivas que gerem menor impacto social e que orientem seus esforços de RSC para áreas geográficas, públicos ou temas diretamente ligados aos impactos que ela gera. Desta maneira a ACV-S se apresenta como uma técnica relevante para atender aos interesses de diversos públicos no desenvolvimento sustentável por expor as questões sociais, ambientais e econômicas no processo de decisão.

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AVANCES DE INVESTIGACIÓN: ANÁLISIS DE CICLO DE VIDA SOCIAL EN LA PRODUCCIÓN DE FORRAJES PARA EL SISTEMA DE PRODUCCIÓN DE LECHE EN PEQUEÑA ESCALA DE LA REGIÓN NORTE DEL ESTADO DE MÉXICO.

ADVANCES IN RESEARCH: ANALYSIS OF SOCIAL LIFE CYCLE IN THE PRODUCTION OF FODDER FOR THE SYSTEM OF MILK PRODUCTION ON A SMALL SCALE IN THE NORTHERN REGION OF THE STATE OF MEXICO.

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RESUMEN:

El documento pretende llevar a cabo un S-LCA utilizado como grupo de estudio a productores lecheros de pequeña escala ubicados en la parte de Norte del Estado de México. Región caracterizada por su producción y transformación de leche desde 1970. Se parte de que el LCA en la producción de leche ha tenido interés en los aspectos ambientales, por lo que existen diversas publicaciones con resultados interesantes, pero es necesario abrir las evaluaciones para incluir aspectos sociales y económicos con la intención de llegar a ESLCA (evaluación de la sustentabilidad del LCA). En este sentido, se tratara de explicar y analizar los desafíos enfrentados durante la aplicación de la evaluación del ciclo de vida social (S-LCA) siguiendo la metodología definida por el PNUMA/SETAC. Hasta el momento no se tiene avances debidos a la falta de recursos para el trabajo de campo y adquisición del software SimaPro 8.

Palabras clave:
Social-ACV., producción de leche., forrajes, nitrógeno y campesinos.

Keywords:
CSR - Corporate Social Responsibility; SLCA – Social Life Cycle Assessment; Sustainable Development; Decision Process.

ABSTRACT:

The document is intended to carry out a S-LCA used as study group to small-scale dairy producers located in the northern part of the State of Mexico. Region characterized by it is production and processing of milk from 1970. It is assumed that the ACLS on the production of milk has had an interest in the environmental aspects, so there are different publications with interesting results, but it is necessary to open the assessments to include social and economic aspects with the intention of arriving at ESLCA (evaluation of the sustainability of the LCA). In this sense, it will try to explain and analyze the challenges faced during the implementation of the life cycle assessment (S-LCA) following the methodology defined by the UNEP/SETAC. So far there is no progress due to the lack of resources for the field work and the acquisition of the software SimaPro 8.

Keywords:
Social-LCA, milk production, fodder, nitrogen and peasants

DESARROLLO DEL TEMA:

Una de las fortalezas del ACV radica en la habilidad de proporcionar una evaluación ambiental clara sobre procesos productivos. El enfoque también proporciona un marco para identificar estrategias efectivas para reducir el impacto ambiental. Teniendo la ventaja de ser un método que permite tomar decisiones sobre productos o técnicas y poder contrastar la viabilidad y conocer el impacto directo que se genera en la ruta de producción.
Las metodologías para la evaluación del ciclo de vida (ACV) se ha desarrollado durante las últimas tres décadas, como consecuencia de que los consumidores exigen productos con menor impacto al medio ambiente, lo anterior ha traído consigo que las empresas se vean obligadas a estudiar sus procesos de producción, así mismo, generar modelos y marcos de análisis que aporte información para la toma de decisiones. Una constante en el desarrollo de marcos de análisis ha sido generar no solo estudios de impacto ambiental sino, incorporar aspectos sociales en los estudios. En este sentido, Baitz, et., al. 2013, plantea que los ACV deben generar conocimientos necesarios para que se haga las preguntas correctas, identificando los conocimientos y modelos relacionados, a las lagunas de conocimiento, y, por otra parte, definir programas de investigación para llenar estos vacíos. Por lo que el ACV se está convirtiendo en un marco de integración transdisciplinaria.

Bajo esta premisa, existe una propuesta metodológica desde finales de la década de los noventa, que se le denominó S-LCA (Social- Life Cycle Assessement), la cual ha sido un intento para establecer la cuantificación de los efectos sociales en los ACV (UNEP/SETAC, 2009).

A pesar del tiempo transcurrido, aún son escasos los avances en los aspectos sociales, ya que como se apunta en un reciente libro Muthu, Subramanian (2015) “las consecuencias sociales de la producción de un producto están llegando a tomar una nueva importancia en las agendas de investigación. El concepto de evaluación del ciclo de vida social (S-LCA) es cada vez más notorio. Sin embargo, S-LCA se encuentra aún en etapas iniciales, en consecuencia, aún se requiere de realizar estudios para muchos segmentos de las diferentes industrias”.

En materia de trabajos recientes de LCA en la producción de leche se han identificado diez investigaciones que con diferentes enfoques se dedican a estudiar: gases de efecto invernadero, ciclo de la energía, proceso del nitrógeno, entre otros aspectos: (Aguirre-Villegas et al. 2015), (Beauchemin & McGeough 2013)(Chobtang et al. 2016)(Heimersson et al. 2016)(Morais et al. 2016)(Nemecek et al. 2016)(Revéret et al. 2015)(Torres et al. 2016)(Yan et al. 2011) (Brunett et al. 2013).

Las principales conclusiones en aspectos metodológicos que se derivan de los trabajos mencionados son:

1.- Que no existen datos en los Inventarios de Ciclo de Vida para lácteos,
2.- Que los productores lecheros son reacios a compartir su información,
3.- Que los beneficios del estudio son difícil de explicar a los tomadores de decisiones, y
4.- Que un ACV es intrínsecamente interdisciplinario, por lo que se requiere de equipos de expertos.

ESTUDIOS DE CASO QUE UTILIZAN S- ACV EN LOS LÁCTEOS

Reporte: Social Life Cycle Analysis (S-LCA): Some Methodological Issues and Potential Application to Cheese Production in New Zealand 2009
Este es un trabajo que fue financiada por AgResearch. El objetivo del proyecto era desarrollar la capacidad AgResearch en la evaluación del ciclo de vida social (S-LCA) a través de un estudio de caso de la producción de queso de Nueva Zelanda. Este informe presenta el marco en el que se desarrolló y se analiza su aplicación al caso de estudio.
Concluyen que el S-LCA es doble: en primer lugar, llevar el pensamiento del ciclo de vida para el análisis de los impactos sociales de la producción, el consumo y la comercialización de los productos, procesos y servicios, y, en segundo lugar, desarrollar el pensamiento del ciclo de vida para que pueda ser más útil en la consecución del objetivo del desarrollo sostenible y el consumo. Tradicionalmente, la evaluación del ciclo de vida (LCA) se refería principalmente a los impactos ambientales. Sin embargo, el pensamiento de sostenibilidad es generalmente considerado para incluir también al menos otras dos dimensiones: la económica y la social. En el pensamiento del ciclo de vida, costo de ciclo de vida (LCC) ha sido desarrollado para examinar los impactos económicos y S-LCA está actualmente en desarrollo para incluir la dimensión social. No existe procedimiento normalizado para realizar una S-LCA, ni directrices, por lo que es necesario, desarrollar metodologías. Aún con ello, el S-LCA tiene el potencial para contribuir significativamente a la eficiencia ecológica y la producción y el consumo sostenibles de productos desde una perspectiva social.

Otro trabajo es el de (Revéret et al. 2015) el cual parte de que la producción de leche ha sido acusada por sus impactos ambientales, especialmente con respecto a las emisiones de gases de efecto invernadero, sin embargo, es importante considerar las repercusiones sociales y económicas con finalidad de aclarar el camino hacia la sostenibilidad de la producción de leche en el Canadá. El proyecto inició en 2010 y finalizó en septiembre de 2012, fue conducida como parte del Grupo de Investigación de Lechería. Los principales productos incluyen un perfil ambiental del promedio del kilogramo de leche producida en Canadá. En cuanto al S-LCA, concluyen que la participación de los granjeros hacia sus comunidades locales es significativa, con la inmensa mayoría participan en sus comunidades en muchas maneras diferentes. Sin embargo, se podría hacer más en términos de cohabitación, con productores para adoptar prácticas minimicen la difusión de olores, por ejemplo. Respecto a los trabajadores agrícolas. Aunque los granjeros lecheros proporcionan las condiciones generales de trabajo que vaya más allá de las normas del trabajo. Lo mismo puede decirse con respecto a sus proveedores y socios de la cadena láctea, dado que la mayoría de los productores lecheros no suelen tener en cuenta sus proveedores. En consecuencia, establecen que la responsabilidad social y el rendimiento socioeconómico del sector canadiense de productos lácteos es adecuada.

Respecto a nuestros avances de investigación, solo se ha podido avanzar en la revisión y análisis de literatura científica, así como en la identificación de la zona de estudio y en la capacitación del manejo del SimaPro 8, a través del Diplomado Gestión de Análisis de Ciclo de Vida, ya que anteriormente se había trabajado con el software GaBi.

Lo anterior obedece a que aún no se liberan recursos económicos para realizar el proyecto y la adquisición del software SimaPro 8

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SOLVING THE CHALLENGES OF SOCIAL IMPACT ASSESSMENT

RESOLVIENDO LOS RETOS DEL ANÁLISIS DE IMPACTO SOCIAL

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RESUMEN:

Así como los métodos de producción pueden tener impactos positivos o negativos en nuestro medio ambiente, también pueden tener impactos en la salud y el bienestar de nuestra sociedad. A diferencia del Análisis de Ciclo de Vida que ha sido desarrollado por muchos años y cuenta con metodologías sólidas y robustas para el modelado de impactos ambientales, el análisis de ciclo de vida social (ACVS) es un campo apenas explorado en cual existen sólo unos pocos métodos desarrollados científicamente y los cuales son complicados de adoptar por compañías para su aplicación.

Uno de los retos del ACVS es identificar y medir impactos sociales a lo largo de la cadena de valor de una empresa o producto. Desde 2013, la Roundtable for Product Social Metrics, que es una colaboración entre líderes de mercado de diversos sectores e industrias, han trabajado para enfrentar el reto de desarrollar y evaluar una metodología pragmática para la evaluación del impacto social de productos o servicios. La clave en ésta tarea es la de simplificar y especificar un método fácil de implementar por organizaciones y empresas. Ésta metodología, denominada Product Social Impact Assessment (Evaluación de Impacto Social de Producto), permite una evaluación concreta del ámbito social para el desarrollo sustentable al evaluar diversas categorías sociales e indicadores de desempeño que reflejan los impactos positivos o negativos que experimentan: trabajadores, consumidores o comunidades locales.

El objetivo principal de éste trabajo es presentar la metodología, abordar los retos y oportunidades en el ACVS e ilustrar los beneficios para las compañías al incorporar la Evaluación de Impacto Social de Producto.

Palabras Clave:

análisis de ciclo de vida social; impacto social;

ABSTRACT:

Just like production methods have positive or negative impacts in our environment they also have positive or negative impacts on the health and well-being of our society. Unlike Life Cycle Assessment (LCA), which has been developed for many years and counts with solid and robust methodologies for modelling environmental impact, Social Life Cycle Assessment is still widely discussed, only a few methods are available in the scientific domain and they are difficult to be adopted by companies.

One of the challenges in SLCA is to make product social impacts visible and measurable throughout the value chain. Since 2013, the Roundtable for Product Social Metrics, a multi-industry group of market-leading companies, has taken up this challenge to develop and test a pragmatic methodology that assesses the social impact of products or services. The key challenge was to simplify and further specify the methods to get something that can actually be implemented in organizations. This methodology, called the Product Social Impact Assessment method, allows reasoned assessment of overall social sustainability performance by assessing social topics and performance indicators reflecting the product's positive and negative impacts experienced by three stakeholder groups: workers, consumers and local communities.

The main objective of this work is to share the methodology, discuss the challenges and opportunities in SLCA and present the benefits for companies when incorporating the Product Social Impact Assessment method.

Keywords:

social impact assessment; methodology; social life cycle impact;

1| INTRODUCTION

Consumers are acutely aware of the provenance of the goods they purchase. They have greater access to product information than ever before, and are empowered to make more responsible purchase decisions. Increasingly, businesses find that consumers favour products with ethical or environmental attributes. Hence, there is now an opportunity for businesses to develop products and services that have demonstrable ecological and/or social benefits.

Eco-labelling and environmental impact evaluation of products and services have been developed since the last decades. These are typically based on life cycle assessments (LCAs) that quantify the environmental impact of a product. In contrast to the range of methodologies used for environmental impact, there is still a scarcity of tools and metrics to estimate the social impact of these products. The main literature on social impact assessment of products throughout the life cycle uses the term Social Life Cycle Assessment (SLCA) which is defined as a technique to assess the social-economic aspects of products and its potential impact, positive or negative, along their life cycle (UNEP/SETAC, 2009)

Attempts to develop metrics for social impacts have often resulted in instruments that can be applied to a company as a whole, but are not easily translatable for the products within an industrial context and the daily practices of product developers and marketers. The main reason for this is that measurements of how a product or service affects society and individuals are difficult to quantify. For example, to prove that a product contributes to the wellbeing of end-users, a company would need consumer research to assess their increase in perceived wellbeing when using the product.

Triggered by these practical shortcomings, a group of experts from different market leader companies of various sectors decided to join forces and form the Roundtable for Product Social Metrics. Since 2013, the group has been working in a consensus building process to create a simplified and operational method for assessing a product's social impacts throughout its life cycle. The method integrates corporate standards and frameworks used at the Roundtable companies (GRI, 2013; ISO, 2010), global standards such as the Guidelines and Methodological Sheets from UNEP/SETAC (UNEP/SETAC, 2013) scientific literature and external consultation. The complete methodology and guidelines has been published in the Handbook for Product Social Impact Assessment (Fontes, 2006)

2| METHODOLOGY

The first step for the method development was the definition of the most relevant stakeholders that experience the most social impacts at different life cycle stages, these are: workers, consumers and local communities (Figure 1)

1The companies participating in the roundtable include: AkzoNobel, BASF, BMW Group, Covestro, DSM, Mahindra Sanyo, Nestlé, Philips, Solvay, Steelcase, Vattenfall and Vebego.

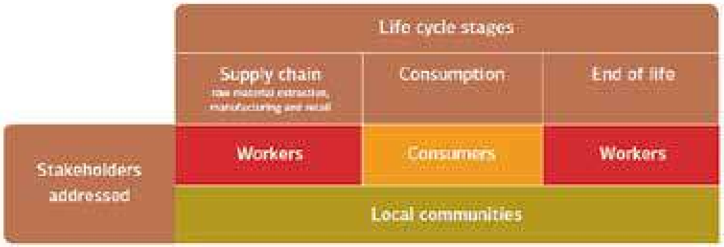

Figure 1 *stakeholder groups through the product life cycle*

Afterwards, a set of indicators was chosen with a combined top-down and bottom-up approach (Dreyer L, 2006). For the top-down approach, the indicators or social topics were selected giving priority to those that have a significant value for society and also for a company's strategy. Then, a second screening of the indicators was done for feasibility and data availability using a bottom-up approach. The result was 19 meaningful social topics relative to the 3 stakeholder groups along with 71 specific indicators, of which 30 were quantitative and 41 were qualitative, respectively. These topics represent a priority in terms of actions and assessment for social sustainability.

One of the main features in the method is the inclusion of a 5-point scale, for each performance indicator. This scoring system is composed of a dimensionless number that represents the impact of the product with regard to a social topic. The overall social topic score is calculated by aggregating performance indicators. For example, for the workers group in the topic of employment relationships, the assessment is done by measuring the percentage of employees with a documented or permanent relationship with the employer. Based on the results, the scale will give a positive, neutral or negative score (Figure 2).

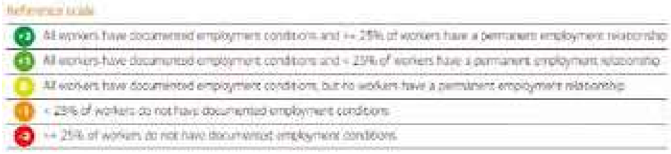

Figure 2 *example of 5-point scoring for scale approach*

In the last step the methodology was divided into stages, shown in Figure 3, these allow for aggregation of performance indicators into social topic scores and a total score.

Figure 3 *methodology stages for Product Social Impact Assessment*

The handbook also includes communication recommendations and a guidance for interpretation of results. These are important as the results should be presented in a way that decision-makers along the whole supply chain can understand and thus transfer them in their decision-making processes. After finalizing the methodology, third parties were involved for the review process. Subsequently, members of the roundtable tested and validated the methodology by performing case studies, included in detail in the handbook.

3| RESULTS AND DISCUSSION

The method is applicable in numerous scenarios, from understanding improvement opportunities and steering product development in different stages, to providing support for decision making and external communication. Ultimately, by supporting the assessment of social performance, the handbook aims to enable organisations to achieve greater transparency on the social impacts of their products.

While the methodology describes the steps that have to be followed, it should not prescribe how companies apply the assessment to their normal business processes. Moreover, although it may be associated with the acronym social LCA, it does not prescribe full alignment with the recommendations of the ISO 14040 norm for life-cycle assessment.

4| CONCLUSIONS AND RECOMMENDATIONS

Product Social Impact Assessment allows companies to analyse positive and negative social impacts throughout the life cycle of a product, and identify risks, improvement opportunities and points of excellence. It also supports communication at a product level, and contributes to overall sustainability assessment and sustainable product development. Likewise, the integration of this method improves the way companies collaborate with business partners and provides insight for supplier selection. In overall, the methodology described here is a starting point to help companies solve sustainability questions the social sphere and how they can balance social compliance, social responsibility, and product development.

Unlike other methods, Product Social Impact Assessment looks at the product level instead of the corporate level. The method identifies social hotspots and improvement opportunities throughout the life cycle of a product, and does not just focus on the supply chain and managing risks. In the future more case studies will be done following the method guidance and thus enable the roundtable to further refine the methodology, also the group is currently working in expanding the stakeholder groups to include farmers, as this will make the method applicable for companies in the agri-food sector.

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IMPACTS OF FUNCTIONAL UNIT DEFINITION IN SOCIAL HOUSING LCA: A BRAZILIAN CASE STUDY

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ABSTRACT:

Purpose: The main goal of this paper is to establish a comparison of three possible approaches regarding functional unit (FU) definition for buildings and to raise a discussion regarding the FU definition and its consequences to LCA studies. Methods: The comparison between impact results of the two most common types of social housing construction in Brazil - houses and apartament buildings - is the core of this study. Two buildings case studies were carried in Porto Alegre (BR) metropolitan area, considering a cradle-to-gate analysis. Data were collected from Ecoinvent database and assessed using 7 impact methods from EN15804. Results and discussion: When buildings have similar construction systems, there is a relation between areas and results. Although when it comes to buildings with different systems and materials, this relation is unclear, and materials selection can represent greater impacts on the results than the unit dimension for the FU definition. Conclusions: The FU without clear statement of definitions might lead to inaccurate interpretation of results, especially for comparison purposes. While the FU is individual to each study, it should also be based on the possibility to establish a logical comparison.

Keywords:

Functional unit; LCA social housing; Unidade funcional; ACV habitação social; Unidad funcional; ECV vivienda social.

1| INTRODUCTION

A considerable part of worldwide environmental impacts is attributed to the construction industry (CABEZA et al., 2014; BRIBIÁN et al., 2009). Brazillian largest low-income housing plan named My House My Life Program (MHMLP) allowed the construction of more than 2.3 million housing units, causing significant environmental impacts (BRASIL, 2016).

According to ISO 14040, functional unit (FU) is a LCA element to be defined in the study scope. The FU makes possible to measure functional performance of the product system output quantified as a reference unit. Its primary purpose is to establish a reference connecting inputs and outputs. However, the FU definition a priori can lead to inconclusive results, especially for complex products, such as constructions. Buildings must perform a set of different functions (e.g. shelter, habitability, durability), not to mention its construction involves a wide spectrum of industries, processes and intermediate materials. In this instance, the FU definition is a key issue, which can affect the whole results analysis and thus the LCA study (KHASREEN et al., 2009)

The main goal of this paper is to establish a comparison of three possible approaches regarding FU definition for buildings and to raise a discussion regarding the FU definition and its consequences to LCA studies. This comparison is based on LCA results of two common types of social housing in Brazil: a single-family house (SFB) and a multi-family apartment building (MFB), both with similar unit sizes and built in the metropolitan area of Porto Alegre (south of Brazil) for MHMLP.

2| METHODOLOGY

The study assesses the embodied impacts of constructions i.e. a cradle-to-gate analysis. Products inventory data were gathered from global market. The results, on one hand, don't represent local construction characteristics of buildings, but they show construction systems impacts contribution and clarify the differences related to the FU choice. The inventory considered the same systems for both cases, namely, slabs, walls, ceiling and roofing. These systems represent over more than 99% of the buildings masses. Since, painting and window frames are similar for both cases, they were not considered. Foundation and soil movements are out of the scope because their definition is variable according to the construction site, and consequently, they could bring more uncertainty to the model.

2.1. Functional Unit

The FU has the main purpose of providing a functional reference, to ensure equivalent comparability of LCA results (ISO 14040). FU statement can vary among different studies, since several options are eligible to be considered, e.g. gross floor area or internal area, building units, number of occupants, etc. (KHASREEN et al., 2009). Consequently, it is difficult to harmonize methodological choices for the building sector. Then, for proper functional comparison, FUs selection encourages researchers to seek clear methodological approaches. Therefore, in order to analyze and compare results between the two case study buildings, three scenarios were considered for FU selection in this study. The FU definitions are shown in Figure 1, they consist in:

- Scenario 1: 1 m² of gross floor area (GFA) in a residential building;
- Scenario 2: 1 m² of gross internal area (GIA) in a residential building;
- Scenario 3: 1 m² of net internal area (NIA) in a residential building.

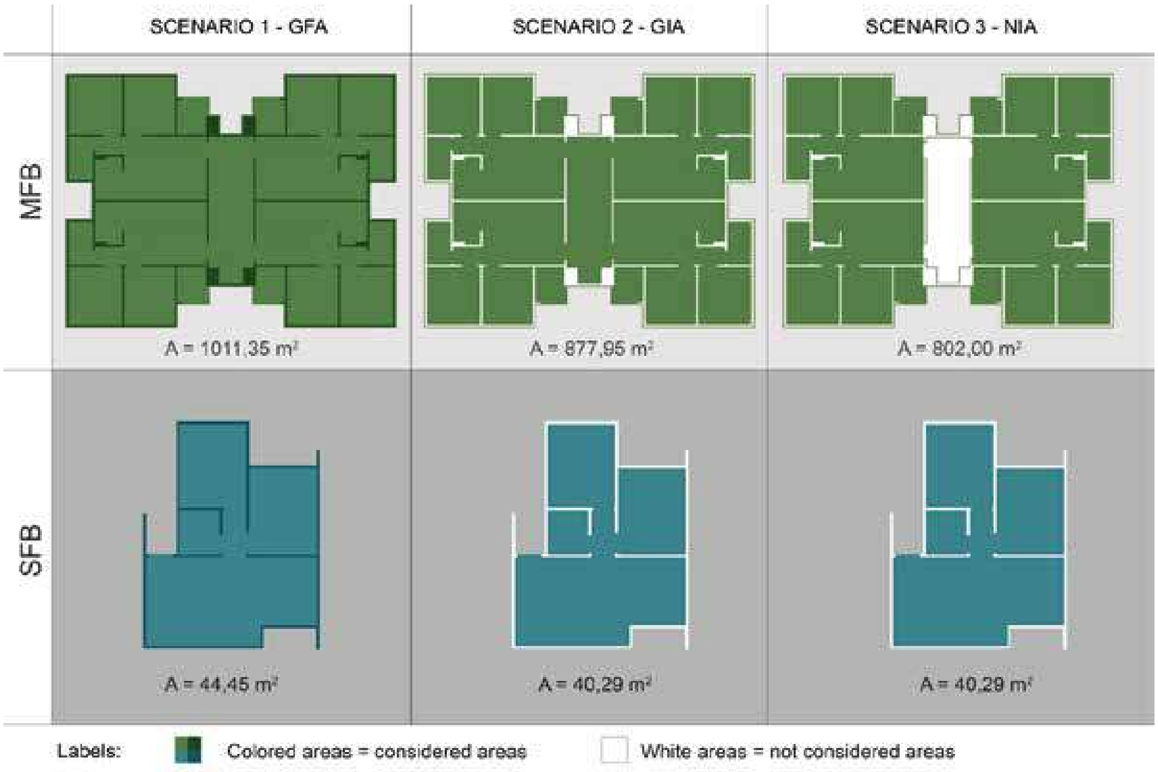

Figure 1 – *Floor plans of both types of social housing and considered area*

2.2. Life cycle inventory and impact assessment

The SFB is a detached one-story house unit of two dormitories, a combined living room and kitchen area and a bathroom. The MFB typology corresponds to a five-story building with four apartment units per floor. Each apartment consists of two dormitories, living room and kitchen combined, bathroom and a balcony.

The inventory of construction materials used in SFB and MFB are specified in Table 1. Ecoinvent (v 3.2) was the source database and OpenLCA (v.1.5.0) managed data inventory. Data selection consisted in "market" assumptions for global localization with aggregated inventory. Inventory represents production and associated transportation by statistical extrapolation of average world production. Since the purpose of this study is to assess FU choice, no data adaptation was made.

1GFA is the total floor area within the building perimeter, measured from walls external faces.
2GIA is the GFA with wall areas discounted.
3NIA is the GIA with common areas discounted (i.e. stairs, access corridors, lifts, ducts, etc).

Table 1 – *Inventory of construction materials for SFB and MFB*

Systems		SFB mass			MFB mass		
		Per system (kg)	Contribution		Per system (kg)	Contribution	
Considered	Slabs	14573,8	31,94%	99,31%	270693,9	32,52%	99,60%
	Walls	26950,7	59,06%		503552,6	60,50%	
	Ceiling	586,1	1,28%		0	0%	
	Grade beams	0	0%		42244,4	5,08%	
	Roof	3204,1	7,02%		12509,9	1,50%	
Not Considered	Openings	247,5	0,54%	0,69%	2092	0,25%	0,40%
	Paintings	68	0,15%		1211,8	0,15%	
Total		45630,1	100%	100%	832304,7	100%	100%

Life cycle impact assessment methodology attends EN 15804:2012 standard. Characterization factors stand for 7 potential impacts from CML 2001 and IPCC 2007: abiotic resources depletion (ADP fossil and ADP non-fossil); acidification (AP); ozone depletion (ODP); eutrophication (EP); photochemical ozone creation (POCP); climate change (GWP100).

3| RESULTS AND DISCUSSION

Results presented in Figure 2 show differences in impact categories according to the selected FU scenario and typology. Among differences between typologies, MFB has common circulation areas on each floor to access the apartments. While, SFB has no common areas, so it presents equal values for GIA and NIA. Since the MFB has the greatest GFA, less impact than the SFB was the expected outcome on scenario 1. A growth trend regarding impacts in comparison with the SFB was the expected result on scenarios 2 and 3.

Higher impact results on GWP100, AP and ADP fossil are closely related to cement use in concrete and mortar. Since both typologies presented similar cement consumption, they both share similar impacts for cement energy intensive production, as high use of fossil energy, lime decarbonation process ($CaCO_3$ $CaO + CO_2$) and SO_x emissions (gypsum additions).

EP, POCP and ADP non-fossil on the other hand showed the influence of constructive systems and didn't meet previous expectations. Their results are all associated with the higher use of steel for SFB typology. The SFB's roof structure and reinforcement in concrete walls accounted for an impact contribution greater than 50%. This result is because MFB has only one roof for several dwellings while SFB has one roof per dwelling.

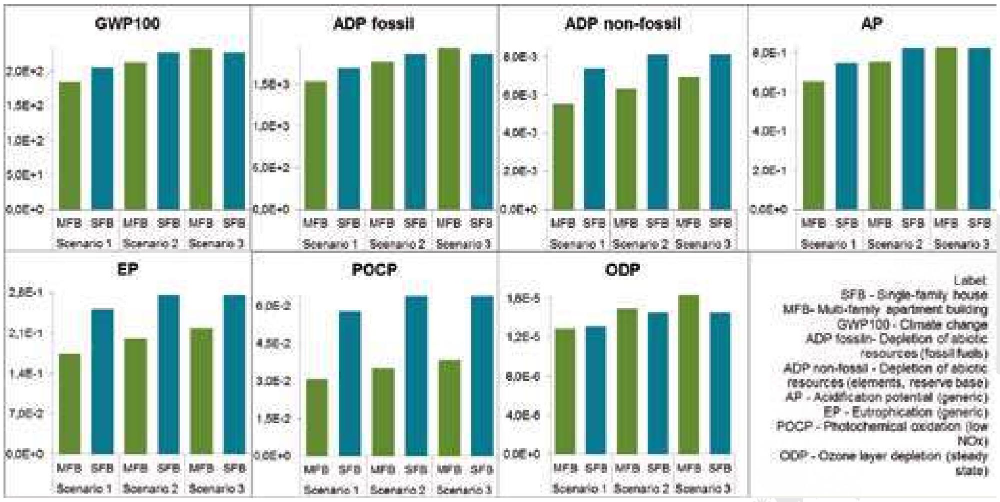

Figure 2 – *LCIA results according to each FU*

ODP analysis showed a higher impact for the MFB typology on scenarios 2 and 3 due to firing process of the clay brick production. The brick uses natural gas and propane as burning fuels, according to Ecoinvent (WERNET et al., 2016).

Lastly, the FU definition in construction sector can affect LCA outcomes. The comparison between the buildings shows that depending on the chosen FU scenario, the result's ranking changes. When buildings have similar construction systems, there is a relation between areas and results. Although when it comes to buildings with different systems and materials, this relation is unclear, and materials selection can represent greater impacts on the results than the unit of dimension for the FU definition.

According to EN 15978:2012, comparisons between the results of buildings assessments should be made only based on their functional equivalency (CEN, 2012b). The choice of common reference unit for all buildings being compared showed itself relevant. For proper comparison, the seeking of a common reference unit should be encouraged. Therefore, the assessment of results with different functional equivalents could also be compared, based on a common unit of reference (e.g. pattern of use) (CEN, 2012b).

Commonly the housing market applies the useful private area as FU scenario, while the potential impacts deal with all building construction, with no “useful” differentiation. In this sense, considering that ISO 14040 encourages marketing use of LCA studies, FU definition needs to be thoughtful and transparent.

4| CONCLUSIONS AND RECOMMENDATIONS

Buildings are complex products with a wide spectrum of suppliers. The FU without clear statement of definitions might lead to inaccurate interpretation of results, especially for comparison purposes. While the FU is individual to each study, it should also be based on the possibility to establish a logical comparison which is one of the concernments of LCA studies.

In buildings with similar systems and materials, FU can vary according to the unit dimension (m2, net m2, etc.). However, for future comparison among studies with different constructive systems and materials, the material type may influence more than the unit dimension. A possible solution to this issue is the declaration of more than one unit dimension inside the FU definition, e.g. the simultaneous declaration of NIA or GFA. If to see further, we need to stand on shoulders of giants, as Isaac Newton said, the best we can make is state transparency in our LCA studies, assuring therefore, reproducible tools.

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CONTRIBUTION OF SOCIAL LIFE CYCLE ASSESSMENT TO REACH THE SUSTAINABLE DEVELOPMENT GOALS

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ABSTRACT:

The Sustainable Development Goals 2016 (SDG) are more than ever focused on social needs including improvements in education, health and job opportunities. All governments shall strive to reach these targets. Besides, in a world dominated by global product life cycles, especially large and multinational companies are encouraged to adopt sustainable practices. Social Life Cycle Assessment (S-LCA) seems to be a convenient method towards reaching the social SDG. However, its application in practice is still hampered, for several reasons.

The presentation examines how and to what extent S-LCA can contribute to achieving the SDG. Taking the example of Goal 5 “Gender equality and women´s empowerment”, an S-LCA of a T-shirt “from cradle to gate” was carried out. Specific indicators, e.g. “Women in the labour force” or “Gender wage gap”, allowed to measure the positive and negative performance of the T-Shirt along its life cycle. Impacts were presented and interpreted for the foreground system separately and for the entire supply chain.

Results showed that including the entire upstream chain revealed additional social hotspots that were not detectable in the foreground system. The full life cycle perspective in S-LCA illustrated interwoven international connections in supply chains. Therefore, S-LCA is an important foundation to pave the way for a faster achievement and even management of the SDG. On a business as well as on a governmental level, the method reveals spheres of influences, for better sustainable business practices, and for adapting national and international laws and trade regulations to the SDG.

Keywords:

Social Life Cycle Assessment; S-LCA; Sustainable Development Goals; Case study; Sustainability; Businesses; Governments

SOCIAL LCA OF A GOVERNMENT GRANT FOR FOOD CROPS IN GUATEMALA
LCA SOCIAL DE UNA SUBVENCIÓN GUBERNAMENTAL PARA CULTIVOS ALIMENTARIOS EN GUATEMALA

LCA SOCIAL DE UM SUBSÍDIO DO GOVERNO PARA CULTURAS ALIMENTARES NA GUATEMALA

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ABSTRACT:
We present a case study examining the social life cycle impacts of growing tomatoes in Guatemala using a mesh greenhouse. The mesh greenhouse is developed by Vista Volcanes, an awardee of the US Department of State grant for innovative solutions in Latin America. By excluding many pests that plague Guatemalan farmers, dramatically higher yields are obtained with far lower use of pesticides and fertilizers. The project's Sustainability Return on Investment (S-ROI) is assessed, including economic, societal and environmental impacts. While carrying out the S-LCA and S-ROI here, the current study also explores their relationship to assess the value of social hot-spot analysis and how the S-LCA results may inform the S-ROI. The study indicates that in addition to substantially higher incomes for growers and significant environmental improvements, crime reduction and improved food security are societal benefits outside of the direct impacts of the grant and that S-LCA can streamline and guide S-ROI.

Keywords:
S-LCA, S-ROI, social impacts, greenhouse mesh, Guatemalan farmers.

Palabras claves:
Ciclo de Vida Social; Retorno sobre la Inversión Sustentable; los impactos sociales; capilla malla; productores guatemaltecos; micro y macro tuneles

Palavras-chave:
Avaliação do ciclo de vida sociais, Retorno da sustentabilidade do investimento, Impactos sócio-econômicos, Desenvolvimento sustentável, malha de estufa, agricultores guatemaltecos.

1| INTRODUCTION

Social impacts of products and business decisions, despite their importance for sustainable development, are difficult to measure. Traditionally excluded from LCAs, codified guidelines and improved available databases make analysis of social and environmental impacts both more manageable and meaningful.
This study assesses the social impacts of growing tomatoes in Guatemala using a mesh greenhouse developed by Vista Volcanes - an agricultural technology company developing solutions for producers in Guatemala to reduce pesticide use, increase yields, and reduce other food contaminants. Vista Volcanes was been awarded a U.S. Department of State grant to fund and expand the greenhouse mesh program in Guatemala and into Nicaragua and El Salvador.
The social impacts of this grant are evaluated using the Social Life Cycle Assessment (S-LCA) methodology. This preliminary S-LCA study captures only the foreground social impacts of the greenhouses, ignoring the upstream and downstream social impacts associated with greenhouse production, distribution and disposal. A study was conducted by EarthShift Global using the Sustainability Return on Investment (S-ROI) methodology (Laurin and Prado 2015) to understand the social and environmental risks and benefits that may accrue from the grant's investment

2| METHODOLOGY

S-LCA is a social impact assessment technique to assess the social and socio-economic aspects of products and their potential positive and negative impacts along their life cycle including extraction and processing of raw materials; manufacturing; distribution; use; re-use; maintenance; recycling; and final disposal. A framework for social LCA has been developed by UNEP-SETAC that includes a set of stakeholder categories and social impact indicators (UNEP-SETAC 2009). Here, this framework is used to identify stakeholders and quantify the indicators.

The system boundary for the study included the use phase of the mesh greenhouses. Other upstream stages associated with production of the greenhouses such as raw material extraction, manufacturing, distribution and disposal were excluded, in keeping with the study's preliminary focus. Data for the social indicators were collected from international databases as indicated in the results. From these, a risk factor for each indicator was calculated by using an ordinal risk scale of 6 different risk levels (Ciroth and Eisfeldt 2016).

S-ROI builds on fundamentals of corporate return on investment accounting and adds an accounting of uncertainties, to allow for the enumeration and quantification of uncertain events with their concurrent costs and benefits using Bayesian statistics. By considering how different stakeholders might be affected by the decision, companies explore potential risks and opportunities and how they may affect the financial return.

In this case, the study assesses the situation where Vista Volcanes received the grant in comparison with the hypothetical situation where they did not. Five basic stakeholder groups were considered: Workers, the Local Community, society, value chain actors and consumers. Table 1 lists all the stakeholders.

Table 1: *Stakeholders involved in the study.*

Represented Stakeholder Groups	
Producers (farmers)	Community
Families	Micro Transporters
Municipalities	Schools
AgExport (Guatemala Exporters Association)	Youth (education + reduced emigration to the capital and elsewhere
Cooperatives	Long term unemployed (elderly)
Associations	Health care system/government
NGOs	**Environment**
Agrequima (certifiers)	Water consumers
Supermarkets	Tourism
Local Markets	Producer competitors
Consumers	**US Department of State**
Vista Volcanes	

A panel of representatives of the stakeholder groups was convened to identify risks and benefits of using the greenhouse mesh for growing vegetables. These experts collaboratively considered risks and opportunities for the affected groups including the participating farmers, businesses, employees, local and regional governments, surrounding communities and the environment.

3| RESULTS AND DISCUSSION

The S-LCA results showed that Workers and Society are at a high social risk in Guatemala. Table 2 shows each subcategory's resulting risk factor. When these categories are assessed for tomato farming with the greenhouse mesh, the expected outcome is positive for nearly all the subcategories. The greenhouse mesh program also benefits the Local Community. Data available was too limited to allow assessment of sector-wide indicators for the Value Chain Actors and Consumers stakeholders. Positive social impacts are expected for the Value Chain Actors and Consumers from the greenhouse mesh program.

Table 2: *Stakeholders and their Risk Factors*

	Stakeholder Subcategories	Sector-wide data	Risk factor (sector-wide)	Risk factor (Greenhouse mesh project)
Workers	Child labor[1]	20- 22%	Very high risk (5)	Increase in child labor but will be educated/ trained (0)
	Forced labor[2]	2	Medium risk (1)	No forced labor (0)
	Fair salary[3]	$258	High risk (2)	30x higher income (0)
	Working time	40- 48 hrs.	Low risk (0.5)	No change
	Discrimination[4]	11.8	Medium risk (1)	Pro-women (0)
	Health and safety[5]	14252	Medium risk (1)	Unknown (0.5)
	Social benefits/social security[6]	4.40%	High risk (2)	No likely change
	Workers' rights[7]	2.5	Very high risk (5)	No likely change
Notes	1 Children in employment, 7-15 2 number of cases per 1000 people 3 minimum wage per month 4 gender wage gap		5. frequency of non-fatal occupational injury per 100,000 insured 6 Public social protection expenditure as a percent of GDP 7 Trade union density rate (%)	
Sources	(ILO)			
Local Community	Access to material resources - level of industrial water use[1]	18	Low risk (0.5)	Improved water and resource usage (0.25)
	Access to material resources pressure on water resources[2]	0.47	Low risk (0.5)	Improved water usage (0.25)
	Access to other resources[3]	26 t/cap	Medium risk (1)	Improved resource use (0.25)
	Human rights issues faced by indigenous peoples	-	Discriminated against (insufficient data)	Respect for indigenous population (0)
	Safe and healthy living conditions[4]	71	High risk (2)	No likely change
	Secure living conditions/ sanitation[5]	97%	Low risk (0.5)	Improves (0)
	Drinking water converge	93%	Medium risk (1)	No likely change
	Unemployment rate	3.50%	Low risk (0.5)	Improves (0)
Notes	1 industrial water withdrawal/total industrial water withdrawal (10^9 m3/yr) 2 industrial water withdrawal/total fw resources (10^9 m3/yr)		3 extraction of fossil fuels 4 Pollution level (pollution index) 5 Portion of population that has access to sanitation facility	
Sources	(ILO) (FAO) (WU) (Numbeo)			
Society	Youth illiteracy rate	6%	Medium risk (1)	Opportunity for education (0)
	Health expenditure, total (% of national GDP)	6.2%	Medium risk(1)	No likely change
	Health expenditure, public (% of the total health expenditure)	37.6%	High risk(2)	No likely change
	Health expenditure out of pocket (% of the total health expenditure)	52.2%	Very high risk(5)	No likely change
	Health expenditure external resources (% of the total health expenditure)	2%	Low risk(0.5)	No likely change
	Sources: (Mundi) (ILO)			
Value chain actors	Fair competition1	-	No GT data (0.5)	Expected favorable results (0)
	Corruption	-	No GT data (0.5)	Expected favorable results (0)
	Promoting social responsibility	-	No GT data (0.5)	Expected favorable results (0)
Consumers	Health and Safety		-	Consumers expected to be benefited (0)
	Transparency		-	High transparency (0)
	End of life responsibility		-	-

The results of the S-ROI study show that the project is expected to benefit all stakeholders with few risks (Table 3) and (Figure 1). In the first two years, municipalities can expect to see on the order of Q31 million (US $4 million), primarily from the increase in direct and indirect wages. The producers have a 75% probability of have a gain of Q17 million (US $2 million), primarily from direct wage increases. The environment is difficult to assess since impacts may occur long after the emissions. However, the total gain from the first two years' emission and resource reduction has a 75% probability of generating Q103 million (US $13 million) in return. Vista Volcanes and women in the region stand to reap social benefit as well.

Table 3: *SROI results - risk and opportunities for producers*

Risk or opportunity	Cost or benefit
Opportunity: Building of technical capacity Opportunity: Exposure and access to new technology Opportunity: Better money management capability	Increased profits
Opportunity: Food security	Better Health
Risk: May revert to traditional techniques	Lower revenues due to lack of technical growth
Risk: May be robbed or vandalized	Robbery or vandalism
Risk: Crop losses	Crop loss
Opportunity: Youth education	Kids get better jobs
Opportunity: Loans will be easier to get	Reduced interest rates
Opportunity: Crop Diversification	Higher revenues from alternative crops
Opportunity: Low academic requirement Risk: Can't get product to market due to lack of transportation	Not quantified

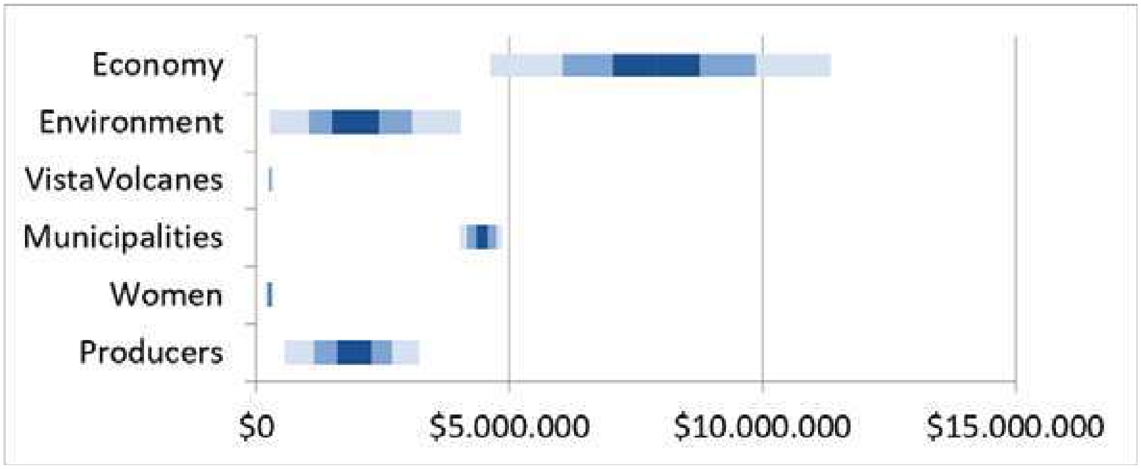

Figure 1: *SROI results - Overall Results of Using Greenhouse Mesh Over a 2 Year Period*

4| CONCLUSIONS

S-LCA and S-ROI are two different methodologies but they have a similar approach for the assessment of social impacts. The results show that both evaluations identify significant social benefit with the greenhouse mesh program. Based on these results, we find that an initial S-LCA can be useful for informing the S-ROI work.
The social databases provide valuable information on existing country or sector wide conditions. These data can be used pre-stakeholder meeting to understand regional/sector wide conditions and to fill the gaps in the stakeholder meeting. It is also concluded that the S-LCA databases cannot replace the need for a stakeholder workshop in S-ROI as the workshop gathers pertinent social data.

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