A Life Cycle Assessment (LCA) – Based Approach in the Development of a Re-Circulation System for Secondhand Textbooks in the Philippines

Marvin I. Noroña and Mark Andrew D. Acot
School of Industrial Engineering and Engineering Management
Mapua University
Manila, Philippines
minorona@mapua.edu.ph, acot.markandrew@gmail.com

Abstract

Every year the production of textbooks continues as it is constantly demanded, especially by students. Every year the number of secondhand textbooks continue to increase. It contributes to the solid waste in the Philippines. The production and disposal of textbooks contribute to many impacts in the environment through global warming, acidification, and the likes. This study aims to contribute to the waste minimization through designing a life cycle assessment – based recirculation system for secondhand textbooks. This research incorporated reverse logistics with life cycle assessment to confirm that the design of the system is efficient regarding the impacts to the environment and human health. A survey was done with 404 respondents of various occupations. ANOVA was used to determine the significant relationship on the drivers of book recirculation and life cycle assessment - based practices with the sustainability performance of secondhand textbook recirculation system. In the design of reverse logistics, Analytic Hierarchy Process was used to determine the best collection method. The design was developed and assessed through life cycle assessment. The design of the life cycle assessment – based recirculation system for secondhand textbooks was concluded to be an efficient process considering the impacts to the environment and human health.

Keywords
Recirculation, Secondhand Textbooks, Analytical Hierarchy Process, Reverse Logistics, Life Cycle Assessment

1. Introduction

In the recent years, a considerable increase in the purchase of electronic books (e-books) by academic libraries was seen (Hanz et al., 2017). The global e-book market is the fastest growing submarket in the worldwide book publishing industry (ReportsnReports, 2014). E-books made a major effect on bookstores sales (Flores et al., 2014) and library users preferred books in digital format (Rao, 2016). Thus, electronic publications will be dominant, and therefore paper books will not be used a lot (Wilders, 2017). Due to the preference of e-books over paper books, in due time, the latter will be left to waste.

In the Philippines, paper books are still produced and are preferred over e-books (Flores et al., 2014). The published books in the Philippines increases yearly with highest demands on academic textbooks (Flores et al., 2014). According to the Department of Education (DepEd), the number of textbooks required equates to the number of learners enrolled. In public schools, textbooks are usually reused for the next academic year. The effectiveness of the adaptation of the prescribed textbooks both in public and private schools shall be in a span 6 (six) years according to D.O. 36 s.1990. This will maximize the use of the textbook besides being economical to the parents (Buhain, 2005). Obviously, due to the huge number of books being published annually, it is inevitable for it to be discarded as waste (Hickey, 2012). According to the National Solid Waste Management Status Report of the Department of Environment and Natural Resources (DENR), a significant 8.70% of paper and cardboard waste, in which books are classified into (Hickey, 2012), contributes to the country's composition of Solid Waste.

According to The Waste and Resources Action Programme (WRAP), books can't usually be recycled along with other paper recycling because of the glue and adhesive used to bind them. Instead, there are many possibilities for reusing,

donating or reselling books (Hickey et al., 2012). The study on the disposal and acquisition trends in secondhand products contribute to the preferred methods of disposal to discard used products depending on the perception of the person on the reuse value of the product and the disposal methods that are convenient and require low effort. The absence of specific collection services coupled with consumers lack knowledge about available disposal methods for unwanted secondhand products, contributes to the disposal of reusable products as waste (Fortuna et al., 2016).

Reusing books is essential to the sustainability of solid waste management. Consumers can discard their secondhand books with disposal methods which supports recycling and reusing. One of the most common disposal methods for secondhand books is through the internet (Fortuna et al., 2016). Using social media (Lindsey-Mullikin et al., 2017) in selling secondhand books online is popular among young adults (Fortuna et al., 2016). While other people, specifically older adults prefer going to thrift stores to purchase secondhand books (Fortuna et al., 2016). Some consumers, due to the lack of information on the disposal methods that leads to reusable secondhand items, books are discarded as waste. As studied, books have also multiple environmental impact (Kozak, 2003).

Paper book wastes contribute to global warming, ozone depletion and acidification (Kozak, 2003). Paper books contribute to the greenhouse gas emission (Tahara, et. al., 2018), as the paper degrades, it produces methane—a greenhouse gas with 21 times the heat trapping power of carbon dioxide (Berglund, 2003). Unscientific disposal practices leave waste unattended at the disposal sites which attract birds, rodents, fleas, etc. to the waste and creates unhygienic conditions like, odor; release of air borne pathogens; greenhouse gases (GHGs) emissions; breeding of disease vectors (e.g., flies, mosquitoes, cockroaches, rats, and other pests), etc. in the surroundings (Fortuna et al., 2017). Avoiding the disposal of goods in landfills directly contributes to reduction in emissions to land, air and water (Manfredi and Christensen, 2009) and lessen the burden on land use especially in densely populated areas (Cooper and Gutowski, 2015).

In the study on retail industry (Beh et al., 2016), the life-cycle approach (LCA) for commercial returns, overruns, end-of-use returns, or even end-of-life returns was considered. The LCA methodology is built around four major components: goal definition and scope; inventory analysis; impact assessment; and interpretation (Naicker et al., 2016). Resulting to environmental sustainability by avoiding the generation of large amounts of waste in landfill sites and maximizing efficiency by enhancing value proposition, value creation and delivery, and value capture (Beh et al., 2016). Also, in that study reverse logistics was adapted to offer a valuable alternative to waste, by turning normal waste streams into useful and valuable input for value creation and delivery and making better use of potentially under-utilized operational/logistics capacity (Beh et al., 2016). Reverse logistics (Guidini, 1996) aims at improving the exploitation of used products through recycling, remanufacturing or other forms of recovery; recapturing the value or value creation with new production systems that generate new markets and lead to a reduction in environmental degradation (Lee et al., 1995).

No studies pertaining to a sustainable system for the recirculation of secondhand textbooks was encountered. Therefore, the goal of this paper is to develop a sustainable system for the recirculation of secondhand textbooks. This study will be able to answer the questions "Is a life-cycle approach in the development of a sustainable system for the recirculation of secondhand textbooks possible to be implemented in the Philippines? And what are the drivers and benefits of such a system?" The study of the sustainable system for recirculation of secondhand textbooks will aim to contribute to the waste minimization and environmental sustainability. To achieve the purpose of this research, the key objectives are:

1. To assess the current environmental sustainability practices of handling secondhand textbooks in the Philippines.
2. To determine the significant factors that will drive the recirculation of secondhand textbooks in the Philippines.
3. To design a life cycle assessment (LCA) – based system for the re-circulation of secondhand textbooks in the Philippines.

This research aims to contribute to the waste minimization through the application of 3Rs (Reuse, Reduce, Recycle) in the RA 9003, the Philippine Ecological Solid Waste Management Act of 2000. The study will help encourage the consumer in recirculating secondhand textbooks. This study will give insights on the positive effects of the 3Rs and its potential to conserve resources gearing toward value creation with ecological sustainability. To the community, this study will help alleviate the waste generated and its environmental impact. To the government, the research will

aid as a reference on a sustainable system answering to the problem of waste management, specifically on secondhand textbooks.

This study will focus on the development of a sustainable system for the recirculation of secondhand textbooks in the Philippines. The rationale for this focus stems mainly from the fact that paper waste (including books) is by far the largest component in the collected waste material in Metro Manila (DENR, 2015). Since there is a burden on the consumer's part in the disposal of secondhand textbooks (Fortuna et al., 2016), this study will also devote a considerable attention on the consumer behavior in the disposal of the secondhand product. This study will be limited to the design of a sustainable system for the recirculation of secondhand textbooks in the Philippines.

2. Methodology

The study will adapt the life-cycle assessment (LCA) – based approach that will entail an understanding of the current system and practices of handling, storage and distribution of secondhand textbooks – the re-circulation of which is the focal point of this research with the end in view a sustainable system in the Philippine setting that will consider various stakeholders and the environmental concerns thereof. The conduct of the study will be guided by the conceptual framework as shown in figure 1.

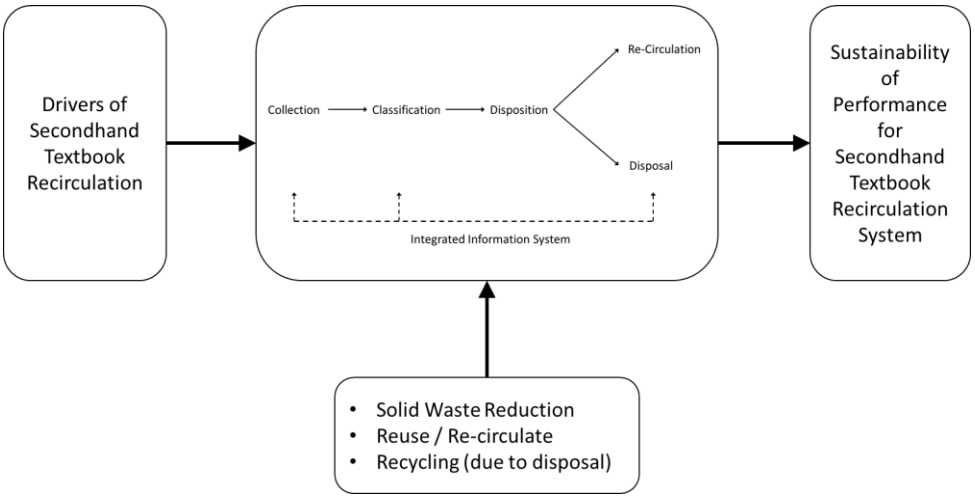

Figure 1. Conceptual framework for the LCA – based approach in the development of a recirculation for secondhand textbooks in the Philippines

Hypotheses that were derived from the conceptual framework are posited below:

H_{10}: There is no significant relationship between the drivers of book recirculation and the sustainability performance of textbook recirculation system.
H_{1a}: There is a significant relationship between the drivers of book recirculation and the sustainability performance of textbook recirculation system.
H_{20}: There is no significant relationship between the LCA – based practices and the sustainability performance of textbook recirculation system.
H_{2a}: There is a significant relationship between the LCA – based practices and the sustainability performance of textbook recirculation system.
To be able to test the hypotheses, the operational elements were identified to truly represent the drivers of book recirculation, LCA – based practices, and the sustainability of performance for textbook recirculation system.

In the operational elements, the variables are presented. Under the set of drivers of book recirculation, the following are defined:
Space Utilized – is the area consumed by secondhand textbooks.

Cost Minimization – selling secondhand textbooks provide substantial monetary gain, while buying secondhand textbooks provide a cheaper alternative than purchasing a new one.
Solid Waste – The number of secondhand books ending up in landfills, incinerated, and discarded as waste.

The LCA based sustainability model will integrate reverse logistics, the elements involved are posited as follows:
Environmental Impact of Reverse Logistics Network – Considering the environmental performance of the reverse logistics network in the recirculation rate of secondhand textbooks.

Since reverse logistics will be integrated in the LCA based system for the recirculation of secondhand textbooks, the following stages of reverse logistics are defined:

Collection - is the first and an important element of the reverse logistics (Schwartz, 2000; Wojanowski et al., 2007). It refers to all activities rendering used products availability and moving them physically to some point where further treatment is conducted for product recovery (Sasikumar and Kannan, 2008). Two factors were considered in the collection process – acquisition and disposal. The alternatives for the collection process in consideration to the factors are through online, thrift store, garage sale/event sale, and from friends, acquaintances, neighbors, family.

Classification - consists of operations that determine whether a given product is reusable or not, and if yes, then to what extent.

Disposition – this stage decides whether to recirculate the secondhand textbook or dispose.

Information Exchange – according to Cambridge Dictionary, the act of people, companies, and organizations passing information from one to another, especially electronically, or a system that allows them to do this.

The sustainability of performance for textbook recirculation system will be affected by the two elements that was mentioned. Under the sustainability performance, the following are defined:

Decrease of Solid Waste – solid waste, specifically in secondhand textbooks will decrease in number.

Space Reduction – due to the disposal of secondhand textbooks, the space it consumes will be reduced.

Increase in Secondhand Textbook Recirculation – refers to the positive rate of recirculation of secondhand textbooks.

An online survey was conducted in gathering the data for this study. In determining the sample size, Slovin's formula will be used with a margin of error "e" of 5%. Using Slovin's formula, the target sample size is 400. The target population for the study are librarians, college students, and parents, that are adults 16 years old and above living in Metro Manila.

The survey questions were formulated to gather information about the participant and with the following; duration of ownership of books before disposition, space utilized by secondhand textbooks, characterization of the books commonly discarded, methods used for discarding books, methods used for acquiring secondhand books, usage of mobile-apps (Response to mobile-apps), reuse potential of secondhand books, preference between paper books and e-books.

ANOVA was used in testing the hypotheses for this study. An ANOVA test is a way to find out if survey or experiment results are significant (Diez et al., 2017).

Since reverse logistics will be integrated in the proposed system, its fundamental stages were identified: 1) collection, 2) sort-test and 3) processing (Flapper, 1996; DeBrito et al., 2003; Fleischmann et al., 2004). A reverse logistics framework for network design decisions is shown in figure 2.

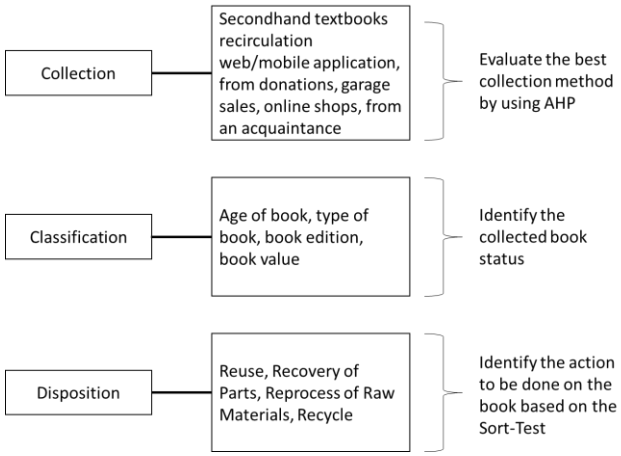

Figure 2. Reverse Logistics Framework for Network Design Decisions

In choosing the best collection method for secondhand books, AHP (Analytic Hierarchy Process) will be used. AHP is one of the Multi Criteria decision making method that was originally developed by Prof. Thomas L. Saaty. AHP is a method which is used to solve complex decision problems by determining the relative importance of a set of activities in a problem (Chenayah et al., 2010).

The expected outcome for this study is a system based on the LCA practice in the recirculation system for secondhand textbooks in the Philippines, integrated with reverse logistics network.

3. Results and Discussion

Survey Monkey was utilized in the data collection process, specifically through online survey. The total number of participants were 404 and categorized based on their occupations which are librarians, teachers, students, and others. This would permeate a point of view from the major users of textbooks. Also, this will ensure no uniformity of answers thus making the survey more significant. The number of librarians who answered the survey were 53; the number of teachers who answered the survey were 117; the number of students who answered the survey were 151; and the number of other occupations who answered the survey were 83.

The first objective of this study was to assess the current environmental sustainability practices of handling secondhand textbooks in the Philippines. The current practices observed for the secondhand textbooks in the Philippines that leads to environmental sustainability are the following:

1. Donation of secondhand textbooks to libraries. Specifically, public libraries.
2. Giving of secondhand textbooks to others.
3. Selling of secondhand textbooks.
4. Dispose as waste
5. Storage at Home

The aim of the environmental sustainability for secondhand textbooks is to bring unused textbooks back into circulation. In the survey collected, the respondents were made to answer their preferences on the identified environmental sustainability practices. Table 1 shows the summary of the responses for the questions relating to the current environmental sustainability practices.

Table 1. Summary of Responses for the Current Environmental Sustainability Practices

Current Environmental Sustainability Practices	Average Scores			
	Librarian	Teacher	Student	Others
Donating of Secondhand Textbooks to Libraries	4.23	3.32	3.84	3.77
Giving of Secondhand Textbooks to Others	4.47	4.03	4.03	3.99
Selling of Secondhand Textbooks	3.19	3.59	3.88	3.37
Dispose as Waste	1.77	2.52	2.13	3.31
Store at Home	3.57	3.14	2.9	3.76

In the first practice – donating of secondhand textbooks to libraries, especially public libraries exist. The average answers of all respondents are 3.68. It means that it likely happens.

In the second practice – giving of secondhand textbooks to others instead of disposing exists. The average answers of all respondents are 4.09. It means that it likely happens.

In the third practice –commerce exists in the handling of secondhand textbooks. The average answers of all respondents are 3.6. It means that it likely happens.

In the fourth practice – disposing of secondhand textbooks as waste is the end-of-life of a textbook. It contributes to solid waste in the Philippines. The average answers of all respondents are 2.44. It means that the respondents are aware that disposing secondhand textbooks doesn't contribute to sustainability.

In the fifth practice – storing of secondhand textbooks prevents the books from being recirculated and until such time it would be classified as unusable and will be discarded as waste. The average answers of all respondents are 3.23. It means that is in the middle of likely or unlikely to happen.

It was observed that the highest preference for the five-identified current environmental sustainability practices is by giving secondhand textbooks to others. It's average answer for all respondents is 4.13 which is a little above likely and below very likely. There are no researches encountered regarding the recirculation of secondhand textbooks.

The second objective of this study was to determine the significant factors that will drive the recirculation of secondhand textbooks in the Philippines. Hypotheses was drawn from the conceptual framework. In testing the hypotheses, ANOVA was used to compare the answers of the respondents based on their occupation. If there is a significant relationship to their answers, therefore it leads to a significant relationship with the sustainability performance of secondhand textbook recirculation system.

In the results of the ANOVA test, the P-values above 0.05 has no significant relationship with the sustainability performance of secondhand textbook recirculation system. There are 5 out of 53 questions that have p-values above 0.05. These questions belong to cost minimization, solid waste prevention, utilization of space, and information exchange. These 5 factors were not considered in the analysis of the study. The answers of the respondents for these questions are not significantly related, thus it does not relate to the sustainability performance of textbook recirculation system. For the rest of the questions that have P-values below 0.05, the null hypotheses will be rejected and thus, there is a significant relationship with the sustainability performance of textbook recirculation system.

The third objective of this study was to design a life cycle assessment (LCA) – based system for the re-circulation of secondhand textbooks in the Philippines. Reverse logistics was incorporated in the design of life cycle assessment (LCA) – based system for the recirculation of secondhand textbooks in the Philippines. The reverse logistics framework for network design decisions is shown in figure 2.

AHP (Analytic Hierarchy Process) was used in identifying the best collection method for secondhand books. Figure 4 shows the AHP schematic. The goal is the choosing the "Collection Method for Secondhand Textbooks". The factors are disposal and acquisition. The alternatives are disposal and acquisition of secondhand textbooks through online, thrift store, garage sale/event sale, and from friends, acquaintances, neighbors, family. Weights included for the alternatives were based on the answers of the respondents in the survey regarding the acquisition and disposal trends.

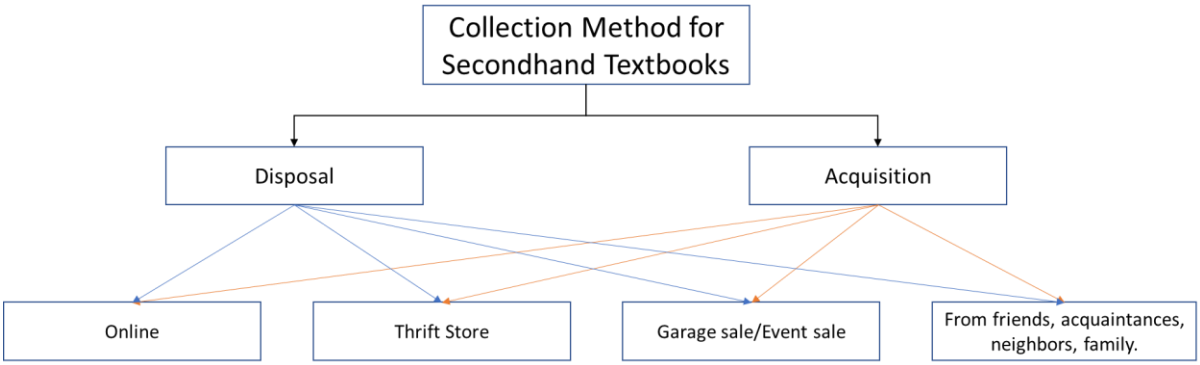

Figure 4. AHP Schematic

The basis for the comparison of the 2 factors – disposal and acquisition, came from the survey results on the selling and buying of secondhand textbooks respectively. The average rating for disposal is 3.53, while for acquisition is 3.87. To assess basing on the fundamental scale which is shown in table below, there is moderate importance of one over the other. In other words, the experience and judgement favors one activity over the other.

As identified using AHP, the collection of secondhand textbooks from friends, acquaintances, neighbors, and family is preferable compared to the remaining alternatives.

The preferred collection method has been identified using AHP. The second step for the reverse logistics model is the classification of collected secondhand textbooks. In the classification stage, the collected secondhand textbooks will first be evaluated into two categories. The first category – to check the condition of the secondhand textbook. If it is good, then it will proceed with recirculation. Otherwise, the secondhand textbook will be subject for recycling or disposal. After evaluating the condition of the secondhand textbook, the type of book, edition, and value will be identified before disposition.

The last stage in the reverse logistics model is the disposition. It involves the decision-making process on the classified secondhand textbooks. If the books were sorted at a good condition, then it will be processed for recirculation. Otherwise, it will be processed for recycling and/or disposal. Figure 5 shows the reverse logistics model designed in this study.

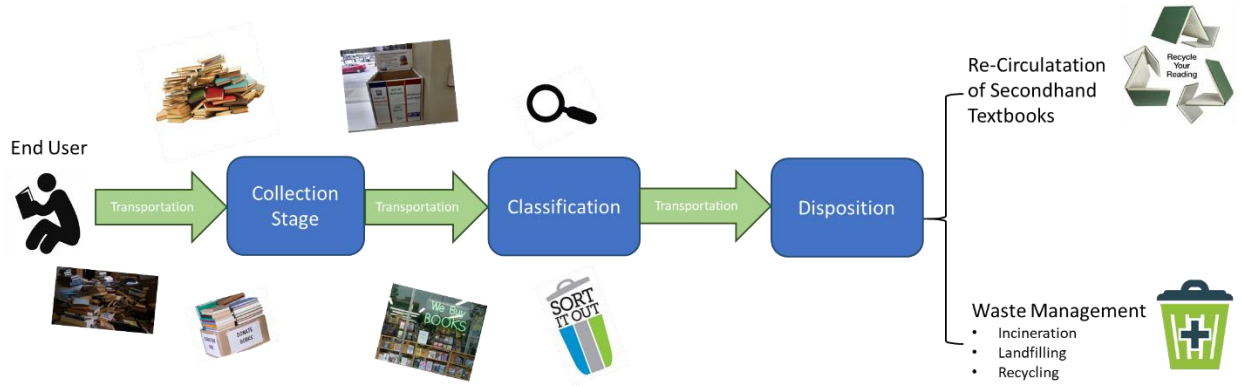

Figure 5. Reverse Logistics Model for Secondhand Textbooks

In the reverse logistics model, the textbooks to be collected are from the end users (students, teachers, librarians, others). The unused textbooks will be classified for inspection and processed depending on the condition of the book. Deciding what to do with secondhand textbooks can be through re-circulation, and waste management. In this research, the focus is on the re-circulation.

Focused on the design of the re-circulation model of secondhand textbooks, a life cycle assessment (LCA) was used to analyze its effectiveness regarding environmental impacts. The procedure in doing LCA are posited below (Goedkoop et al., 2016).

1. Goal Definition and Scoping
2. Life-cycle Inventory Analysis
3. Life cycle Impact Assessment (LCIA)
4. Interpretation

Goal definition and scoping is identifying the LCA's purpose and the expected products of the study, and determining the boundaries (what is and is not included in the study) and assumptions based upon the goal definition.

The goal of this LCA is to create an awareness about the dominant aspects that determine the life cycle of secondhand textbooks. The information from this assessment will be used to focus the effort in the confirmation of the design of a recirculation model for secondhand textbooks in the Philippines. To attain the confirmation of recirculating secondhand textbooks, an LCA is made for the standard production, distribution, and disposal of textbooks; and the developed recirculation system for secondhand textbooks.

Life-cycle inventory analysis is quantifying the energy and raw material inputs and environmental releases associated with each stage of production.

Three life-cycle inventories were analyzed. First is for the Standard Textbook Process – this process is the basic life cycle of text books, from production, distribution, and disposal. Second is for the Recirculation Process for Secondhand Textbooks (Disposition: Recirculation) – this process is for the life cycle of textbooks considering the designed reverse logistics model for secondhand textbooks, and the end stage is recirculation of secondhand textbooks. Third is for the Recirculation Process for Secondhand Textbooks (Disposition: Recirculation) - this process is for the life cycle of textbooks considering the designed reverse logistics model for secondhand textbooks, and the end stage is disposal of secondhand textbooks. Refer to Appendix D for the detailed presentation of the inventory analysis.

The life cycle impact assessment (LCIA) phase establishes links between the life cycle inventory results and potential environmental impacts. The LCIA calculates impact indicators, such as global warming potential and smog. These impact indicators provide general, but quantifiable, indications of potential environmental impacts. Environmental impacts are determined using the TRACI method (Bare et al., 2011). TRACI is the abbreviation for Tool for the Reduction and Assessment of Chemical and other environmental Impacts.

The life cycle impact assessment was based on the identified life cycle inventory of each processes. The same with life cycle inventory, the impact assessed were also of the three processes involved.

Interpretation is evaluating the opportunities to reduce energy, material inputs, or environmental impacts at each stage of the product life-cycle.

Gathering all the results of the impact assessment, a comparison can be made for analysis. To be able to confirm the design of a recirculation model for secondhand textbooks in this study is better regarding the impacts on human health and the environment, a comparison was made. Table 2 shows the comparison of the impact assessment results using TRACI.

Table 2. Summary of the impact assessment result for all processes

Impact Category	Unit	Standard Textbook Process	Recirculation Process for Secondhand Textbooks (Disposition: Recirculation)	Recirculation Process for Secondhand Textbooks (Disposition: Recirculation)
Global warming	kg-CO2 Equiv.	2,867.20	2,610	2,910
Acidification	kg-SO2 Equiv.	16	13.8	16
Ozone depletion	kg CFC 11-Equiv.	2.60E-04	1.21E-04	2.70E-04
Eutrophication	kg N-Equiv.	10.2	9.51	10.2
Ecotoxicity	CTUe	51.4	46.7	51.4
Human Health Particulate	kg PM2, 5-Equiv.	3.77E-03	4.01E-03	4.01E-03
Human Toxicity, Cancer	CTUh	172	165	172
Human Toxicity, Non Cancer	CTUh	170	161	170
Photochemical smog	kg O3-Equiv.	124	113	125

Looking at the table above, it can be concluded that in most impact category, the recirculation process for secondhand textbooks has the lowest values. This means, that the design of the recirculation of secondhand textbooks in the Philippines integrated with reverse logistics is confirmed to be efficient considering the environmental and human health impacts.

4. Conclusion

This study focused on the life cycle assessment (LCA) – based approach in the development of a recirculation system for secondhand textbooks in the Philippines. Reverse logistics was considered and its theoretical framework was studied to be integrated in this design. Life Cycle Assessment was used to prove that the design is efficient in terms of the impact to the environment and human health.

There are existing sustainability practices in the recirculation of secondhand textbooks as identified in the first objective of this study. However, there is no guide or research found on implementing it on a wide scale. It is only implemented on a personal initiative and interest. The awareness for the recirculation of secondhand textbooks is low based on the questionnaire. It had an average score of 3.17, which is near the “unlikely” level.

The first objective of this study was met since the assessment of the current environmental sustainability practices of handling secondhand textbooks in the Philippines was done. It was identified and analyzed. The highest preference of the identified current environmental sustainability practices is by giving secondhand textbooks to others. As a culture in the Philippines, most students give their secondhand textbooks to lower class students, their younger siblings or members of the family and friends.

The existing practices in handling secondhand textbooks were identified, and were found to be contributing to environmental sustainability. However, there is something that needs to be identified – what factors will drive the people to implement such sustainable efforts. The existing practices in handling secondhand textbooks is not enough to eliminate or lessen the potential increase in solid waste. Therefore, the drivers were identified in the second objective of this study.

Hypotheses from the conceptual framework were drawn. Basically, to identify if there are significant relationships on the drivers of book recirculation and LCA - based practices with the sustainability performance of secondhand textbook recirculation system. In this study, it was tested using ANOVA that there are significant relationships on the drivers of book recirculation and LCA - based practices with the sustainability performance of secondhand textbook recirculation system.

The factors that will drive the recirculation of secondhand textbooks were determined, the LCA-based recirculation system for secondhand textbooks was designed. This is the third objective of the study. It connects to the first and second objective by studying first the existing practices of handling secondhand textbooks and determining the factors that will drive further.

Since the focus of this study is the end usage of textbooks, therefore classified as secondhand. Reverse logistics is a useful tool in the design since it involves collection, classification of secondhand textbooks, and disposition – the decision stage in determining if the textbook would be recirculated or disposed. The focus of this study is on the recirculation. The design was run through a life cycle assessment. This was compared to the standard process of textbooks – from production, distribution, and disposal. In the life cycle impact assessment (LCIA), the method used was TRACI. This identified the impacts specifically (1) Global warming, (2) Acidification, (3) Ozone depletion, (4) Photochemical smog, (5) Eutrophication, (6) Ecotoxicity, (7) Human health particulate, (8) Human toxicity, cancer, (9) Human toxicity, non-cancer.

The result was in favor of the designed recirculation system for secondhand textbooks in the Philippines. It has only a higher value in the Human health particulate impact, due to the additional transportation and electricity usage. However, in a futuristic view, this impact can be compensated since the textbook will be recirculated and eventually will reduce the production of new textbooks which has greater impact in the environment and human health.

The objectives of this study were met. To answer the research question "Is a life-cycle approach in the development of a sustainable system for the recirculation of secondhand textbooks possible to be implemented in the Philippines?" – it is possible to be implemented in the Philippines, with the support of the government, students, librarians, teachers, parents, and other green organizations. The expected outcome of this study as shown in figure 6, is met. With existing policies especially, the Philippine Ecological Solid Waste Management Act of 2000 (RA 9003) that needs to be strictly implemented, the support of the government and private sectors, this study of the LCA – based approach in the development of a recirculation system for secondhand textbooks in the Philippines will have an impact to ecological sustainability.

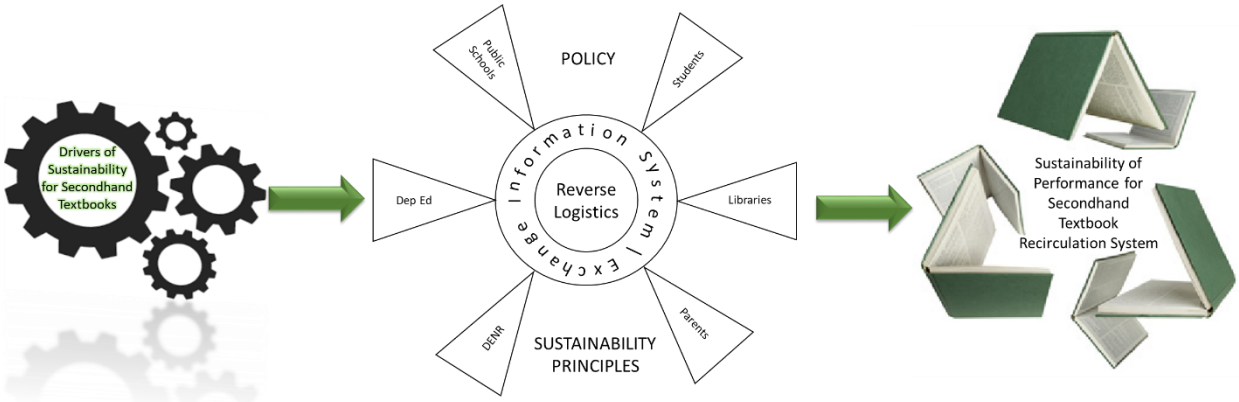

Figure 6. Outcome of the Study

References

Andrea Pasion-Flores, Maria Natividad I. Karaan, Jason Rafael I. Karaan, Katherine Bercasio, Ranielle Espiridion (2014). Charting the Future of Books in the Philippines. *A Road Map of the Book Industry of the Philippines (2014) p 35 – 37.*

Chris Affeldt, Austin Leung, Ke Yang (2016). Life Cycle Assessment of Stone Paper, Polypropylene Film, and Coated Paper for Use as Product Labels.

Christer Berglund (2003). Economic Efficiency in Waste Management and Recycling.

Coen Wilders (2017). Predicting the Role of Library Bookshelves in 2025. *The Journal of Academic Librarianship 43 (2017) 384–391.*

Cooper, D.R., Gutowski, T.G., 2015. The environmental impacts of reuse: a review. *J. Ind. Ecol. 00, 1–19.* Guidini, R. (1996), "An introduction to reverse logistics for environmental management: a new system to support sustainability and profitability", *Total Quality Environmental Management, Vol. 5 No. 3, pp. 81–7.*

Development of the Philippines National Solid Waste Management Strategy 2012-2016. *Procedia Environmental Sciences 16 (2012),* 9 – 16.

Dominador D. Buhain (2005). Publishing Today (Philippines). *Philippine Educational Publishers Association 2005.*

Jacoby J, Berning CK, Dietvorst TF (1977). What about disposition? *J Mark 1977;41:22– 8.*

Joan Lindsey-Mullikin, Norm Borin (2017). Why strategy is key for successful social media Sales. *Business Horizons (2017) 60, 473—482.*

Johannes G. Paul, Joan Arce-Jaque, Neil Ravena, Salome P. Villamor (2012). Integration of the informal sector into municipal solid waste management in the Philippines –What does it need? *Waste Management 32 (2012),* 2018–2028.

Justin G. Bull, Robert A. Kozak (2014). Comparative life cycle assessments: The case of paper and digital media. *Environmental Impact Assessment Review 45 (2014) 10–18.*

Katherine Hanz, Dawn McKinnon (2018). When Librarians Hit the Books: Uses of and Attitudes Toward E-Books. *The Journal of Academic Librarianship 44 (2018) 1–14.*

Kiyotaka Tahara, Hirokazu Shimizu, Katsuhito Nakazawa, Hiroyuki Nakamura, Ken Yamagishi (2018). Life-cycle Greenhouse Gas Emissions of E-books vs. Paper Books: A Japanese Case Study. *Journal of Cleaner Production 189 (2018) 59 – 66*

Kozak G. Printed scholarly books and e-book reading devices: a comparative life cycle assessment of two book options. Center for Sustainable Systems. University of Michigan; 2003

Laura S. Hickey, Kristy M. Jones (2012). *A Research Study on Textbook Recycling in America.* Recommendations for Proper Disposal and Repurposing at the End of a Textbook's Useful Life.

Lee, J. J., O'Callaghan P. and Alien, D. (1995). Critical review of life cycle analysis and assessment techniques and their application to commercial activities. *Resources, Conservation and Recycling, Vol. 13 No. 1 pp., 37-56*

Lilliana Abarca Guerrero, Ger Maas, William Hogland (2012). Solid waste management challenges for cities in developing countries. *Waste Management 33 (2013),* 220232.

Loo-See Beh, Abby Ghobadian, Qile He, David Gallear, Nicholas O'Regan (2016). Second life retailing: a reverse supply chain perspective.

Lorena M. Fortuna, Vasil Diyamandoglu (2016). Disposal and Acquisition Trends in Secondhand Products. *Journal of Cleaner Production 142 (2017) 2454 – 2462*.

Lorena M. Fortuna, Vasil Diyamandoglu (2017). Optimization of greenhouse gas emissions in second-hand consumer product recovery through reuse platforms. *Waste Management 66 (2017) 178–189.*

Manfredi, S., Christensen, T.H., 2009. Environmental assessment of solid waste landfilling technologies by means of LCA-modeling. *Waste Management. 29, 32–43.*

Maureen Puettmann, Elaine Oneil, Richard Bergman (2013). Cradle-to-gate life cycle assessment of softwood lumber production from the northeast-north central. Consortium for Research on Renewable Industrial Materials. *University of Washington. Seattle, WA.April 2013. 33 p. 2013*

Mohammad Sujauddin, S.M.S. Huda, A.T.M. Rafiqul Hoque (2017). Household solid waste characteristics and management in Chittagong, Bangladesh. *Waste Management 28 (2008)* 1688–1695.

Nageswara Rao, Manorama Tripathi, Sunil Kumar (2016). Cost of Print and Digital Books: A Comparative Study. *The Journal of Academic Librarianship 42, Issue 4, July 2016, Pages 445-452*

Rafiq, M., & Ameen, K. (2013). Digitization in university libraries of Pakistan. OCLC Systems & Service. *International Digital Library Perspectives, 29(1), 37–46.*

ReportsnReports. (2014). E-Book Market Growing at 17% CAGR &Will Dominate Global Book Publishing Industry With 27.8% Share by 2019. Retrieved from https://libguides.library.usyd.edu.au/c.php?g=508212&p=3476096.

Saira Hanif Soroya, Kanwal Ameen (2018). What do they want? Millennials and role of libraries in Pakistan. *The Journal of Academic Librarianship 44 (2018) 248–255.*

Tobias Schultz (2015). Life Cycle Assessment of Reincarnation 100 Coated Freesheet Paper, Compared to Virgin Paper Baseline. *SCS Global Services.*

Voltaire Acosta, Johannes Paul, Crispian Lao, Emelita Aguinaldo, Maria Delia Cristina Valdez (2012).

Vinesh Naicker, Brett Cohen (2016). A life cycle assessment of e-books and printed books in South Africa. *68 Journal of Energy in Southern Africa • Vol 27 No 2 • May 2016*

Biographies

Marvin I. Noroña is an Industrial Engineering and Engineering Management Professor at the Mapúa University in Manila, Philippines. He holds a Bachelor of Science degree in Industrial Engineering and a Master degree in Business Administration from the University of the Philippines. He is also a candidate to earn a Doctor degree in Business Administration at the De La Salle University in Manila, Philippines finishing his thesis entitled "Lean and Green in the Philippine Automotive Industry." He is a Professional Industrial Engineer certified by the Philippine Institute of Industrial Engineers and was a member of the Board of the Production & Operations Management Association of the Philippines. With 30 years of industry experience working for leading business firms in the packaging, food & beverage and engineering services industries, he is a recognized professional management consultant in the areas of manufacturing, operations and quality improvement, strategic management, lean systems and logistics & supply chain management. In addition this areas, he handles the courses in entrepreneurial engineering, product design & development and project management. His research interests include service quality, operations & supply management, technopreneurship and sustainability.

Mark Andrew D. Acot is a Project Manager of Sun Expert Inc. Mr. Acot holds a Bachelor of Science degree in Electronics Engineering from Colegio San Agustin – Bacolod and currently taking up a Master of Science degree in Engineering Management at Mapua University. He has experience working in the field of Project Management, Telecommunications and Renewable Energy Industry. He has interests in Project Management and Process Improvement. His research focuses on attaining sustainability through developing a recirculation system for secondhand textbooks in the Philippines.