Analysis of Life Cycle Cost of A White Cotton T-shirt

Yunchun Pan

October 23 2020

1 Introduction

As a member of a volunteer club based at UCSD, I participated in earth day event and surprisingly learned the fact from that it takes approximately 2700 liters of water to make a white cotton t-shirt. To analyze how a white cotton t-shirt can consume such huge amount of water and produce wastes to environment, I decide to construct a mathematical model for life cycle cost analysis of a white cotton t-shirt.

2 Research Question

By creating a model to analyze life cycle footprints of a white cotton t-shirt, I want to evaluate the degree of environmental impact by it, depending on resources growing, fabric manufacturing, customer use phases the t-shirt goes through. Then, I want to explore how I can optimize the environmental impact by the t-shirt in different phases.

3 Previous Work Done

[2] performs life cycle assessment of cotton T-shirts in China. In the article, authors identify cotton cultivation, textile manufacturing, and consumer use as three major phases in the life cycle of a t-shirt. They select energy, material, emission to air, emission to water, solid waste as their features. With the result from Life Cycle Impact Analysis, authors evaluate the environmental impact by t-shirts and find areas of great environmental impact in China.

4 Features Of The Model

After identifying all potential inputs in the life-cycle of a single, simple cotton t-shirt, I chose water consumption, CO2 emission, and chemical wastes as 3 measurable features.

5 Considerations of Other Possible Features

One possible feature for the model is energy, such as coal and electricity. Coal can be consumed when textile manufacturers weave, knit, and dye cotton fibers. Electricity would be used when consumers wash and dry t-shirt. But, the total consumption of energy resources is not as dominant as that of other 3 features, hence I decide to regard this feature as exogenous to my model and future life cycle analysis.

6 Mathematical Model

The project will be splitted into two parts. First part is to evaluate the degree of environmental impact by the white cotton t-shirt and Weighted Sum Model in decision theory will be used. According to [1], the impact score for each t-shirt can be computed by

$$S = \sum_{i=1}^{3} w_i * a_i$$

where a_1 is amount of water consumption, a_2 is amount of CO2 emission, a_3 is amount of chemical wastes. w_i is the assigned weight to a_i for i = 1, 2, 3 with $\sum_{i=1}^{3} w_i = 1$ and $w_i > 0$ for i = 1, 2, 3. S is the score of a t-shirt's environmental friendliness. A white cotton t-shirt with a higher score S has greater damage to environment, while a t-shirt with a lower score S has smaller damage. This model requires real data of water consumption, CO2 emission, and chemical waste.

In second part, Optimization Model will be used to minimize environment impact by the t-shirt. First, I would develop optimization equations for cotton production, clothing manufacturing, consumer use phases individually and include parameters in different steps. Then, I would explore how to control those parameters to minimize resource consumption and wastes in each step. For example, laborers and machines can both work on dyeing cotton fibres. I need to find a optimal number of laborers and machine so that values of 3 features mentioned above can be minimized.

7 Real Data For The Model

The data for this model is water consumption, CO2 emission, and chemical wastes measured in the unit of gallons per t-shirt. To gather the data, I need to:

- identify all steps in cotton production, clothing manufacturing, and consumer use phases:
  - Cotton production: type of cotton, use of pesticide and fertilizer.

  - Clothing manufacturing: weave and knit cotton fibers, dye, print, print after washing, finishing cotton fabric, and other clothing treatments.
  - Consumer use: wash and dry white cotton t-shirt.

- find scientific citations for water consumption, CO2 emission, and chemical wastes generated in these steps.
- convert those statistics to values in unit of gallons per t-shirt.

8 Timeline

- Week 3: Finish Project Proposal
- Week 4: Identify all phases in the life cycle of a t-shirt and collect data of 3 features
- Week 5: Construct Weighted Sum Model and input all data to model
- Week 6: Construct Optimization Model for each major phase in the life cycle of a white cotton t-shirt
- Week 7: Input data and find optimal values for parameters
- Week 8: Refine model setup and prepare presentation
- Week 9: Give presentation and write final report
- Week 10: Review and submit final report

References

[1] STIKOM TunasBangsaPematangsiantar. "Comparison of weighted sum model and multi attribute decision making weighted product methods in selecting the best elementary school in Indonesia". In: *International Journal of Software Engineering and Its Applications* 11.4 (2017), pp. 69–90.

[2] You Zhang et al. "Life cycle assessment of cotton T-shirts in China". In: *The International Journal of Life Cycle Assessment* 20.7 (2015), pp. 994–1004.