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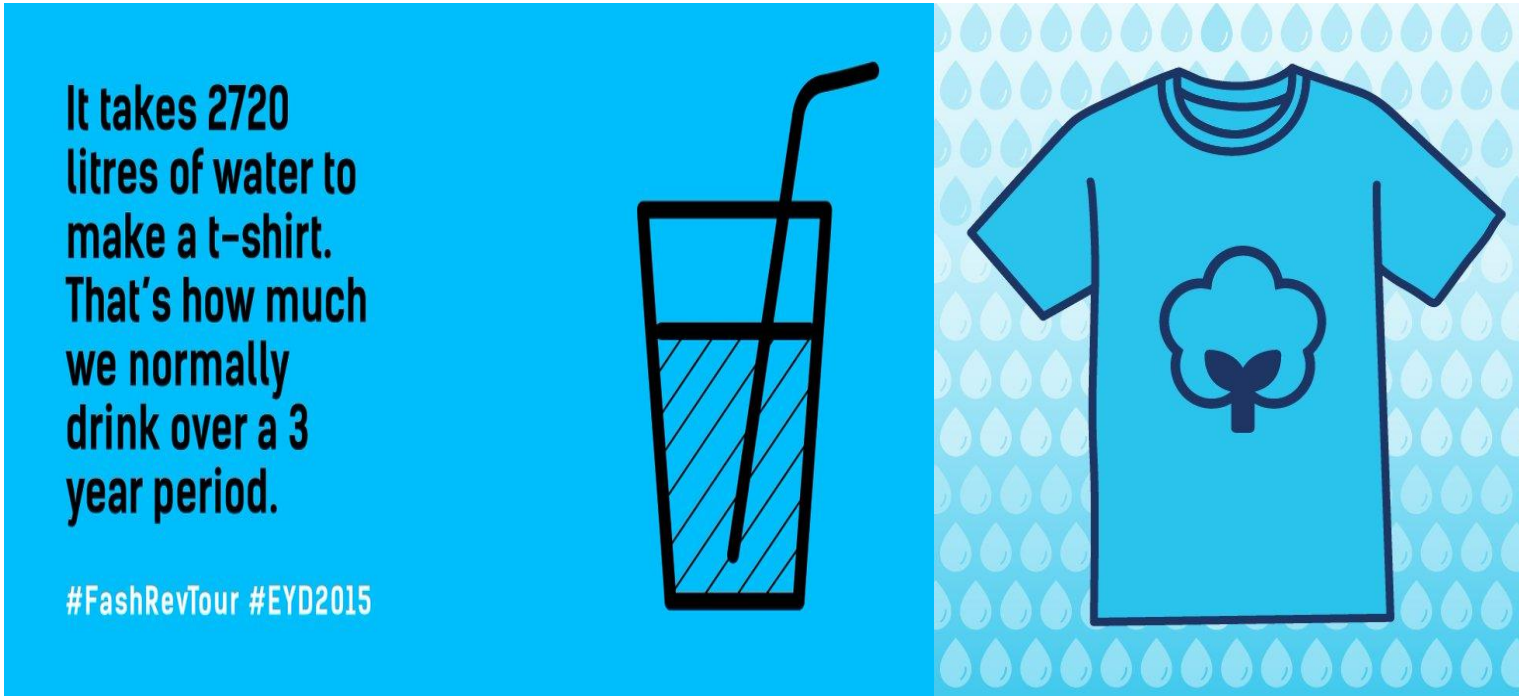
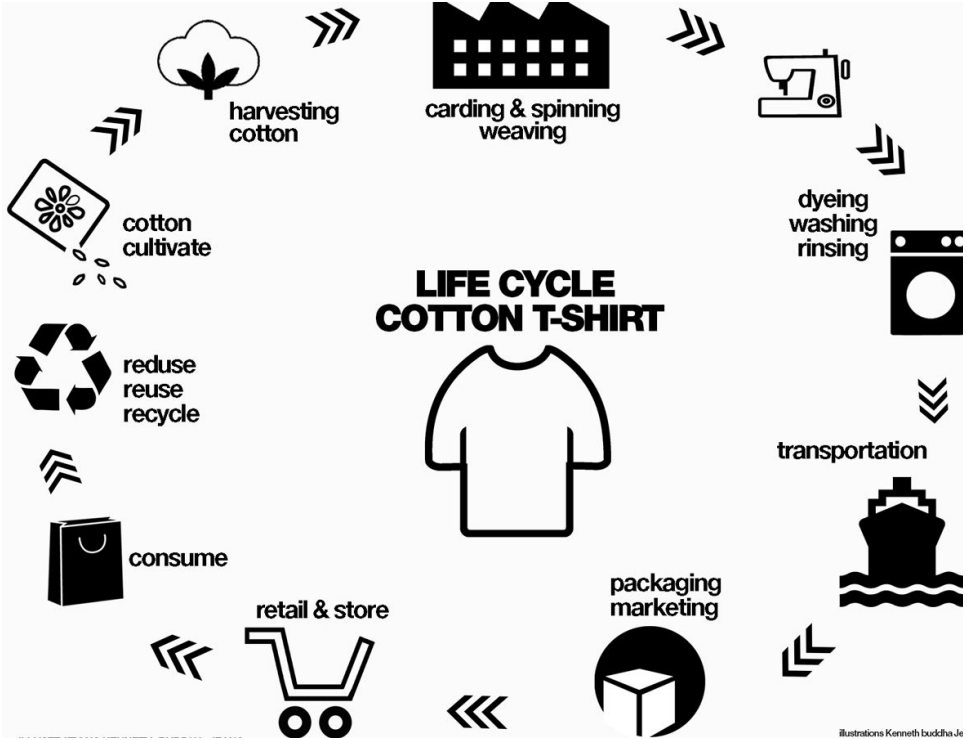


Selection of The Most Environmental Friendly Treatments of Cotton T-shirts Using Optimization Model

Yunchun Pan



cotton production, cotton manufacturing, distribution, and consumer use phases are the main contributors to the environmental impacts in the life cycle of the white cotton t-shirt.

Features & Data

- Identify the steps in cotton production, manufacturing, distribution, and use phases
- Collect data of water consumption, chemical consumption, and CO2 emission

Use-Phase						Water Use	Water Low	Water Hig	CO2 Emiss	CO2 Low	CO2 High	Chemical	Chemical	Chemical High
	Washing Machine													
		New	Medium Heat			12.9444	12.9444	12.9444	1.875 kg c	1.875	1.875			
		5 years old	Medium Heat			17.4354	17.4354	17.4354	2.16 kg cc	2.16	2.16			
		10 years o	Medium Heat			22.1905	22.1905	22.1905	2.36 kg co	2.36	2.36			
		20 years o	Medium Heat			35.3991	35.3991	35.3991	2.64 kg co	2.64	2.64			
		30 years o	Medium Heat			47.551	47.551	47.551	2.90 kg co	2.9	2.9			
		Chemicals												
			Detergent											
				Size of Load										
					Small/Medium							0.007813	0.007813	0.007813
					Large							0.023438	0.023438	0.023438
					Full							0.039063	0.039063	0.039063
	Dryer													
		Heat Level												
			30Â°C						0.6 kg CO2	0.6	0.6			
			40Â°C, dried on a line						0.7 kg CO2	0.7	0.7			
			40Â°C, tumble dried						2.4 kg CO2	2.4	2.4			
			60Â°C, dried in combined washer/drier						3.3 kg CO2	3.3	3.3			
Aggregates						12.9444 -	12.9444	47.551	2.475 - 6.2	2.475	6.2	0.007813 -	0.007813	0.039063

Scaling Function

$p \in$ {cotton production, manufacturing, distribution, consume use}

for each $y_p \in \{w_p, co_{2,p}, c_p\}$, finds c such that

$$(c-1) * \frac{(Y_{p,max} - Y_{p,min})}{10} < y_p - Y_{p,min} \leq c * \frac{(Y_{p,max} - Y_{p,min})}{10};$$

with $c \in Z^+$ and $1 \leq c \leq 10$

$Y_{p,max}$ and $Y_{p,min}$ are the upper and lower bound of y_p

returns $\{c_1, c_2, c_3\}$ - impact scores of three features

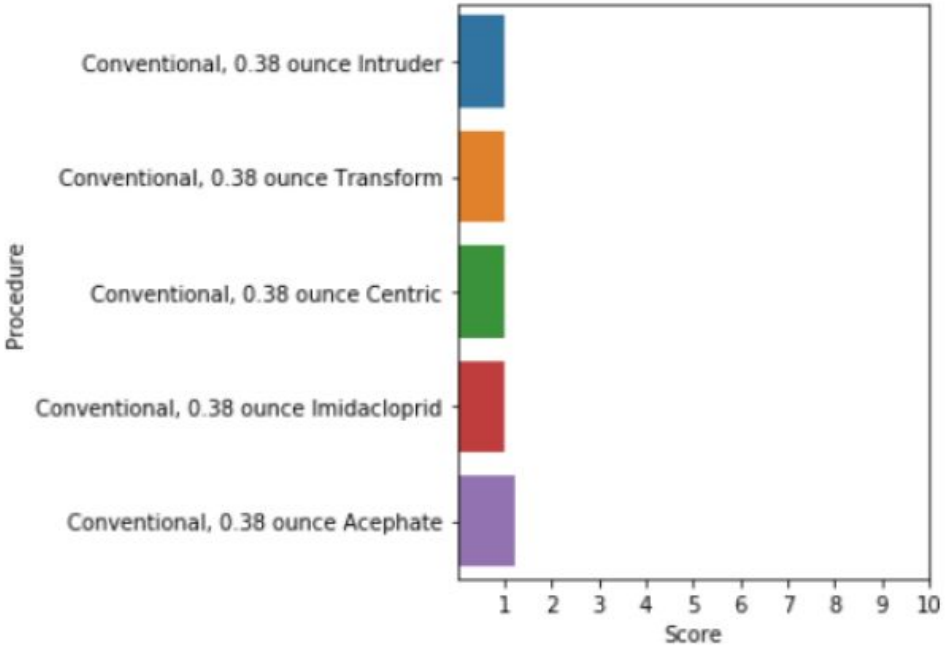
Optimization Model

$$\min_{(\alpha,\beta,\gamma)} (c_1, c_2, c_3)(\alpha, \beta, \gamma)^T$$

$$\text{s.t.} \begin{cases} \alpha + \beta + \gamma = 1 \\ 1 \leq (c_1, c_2, c_3)(\alpha, \beta, \gamma)^T \leq 10 \\ \frac{1}{3} - \frac{1}{10} \leq \alpha, \beta, \gamma \leq \frac{1}{3} + \frac{1}{10} \end{cases}$$

- $\{c_1, c_2, c_3\}$ - Impact scores of three feature calculated by scaling function
- α, β, γ - Weights of each score
- $(c_1, c_2, c_3)(\alpha, \beta, \gamma)^T$ - The overall impact score to be minimized

Results: Cotton Production Phase



Most Environmentally Friendly Treatments

Conventional cotton, recommend to:

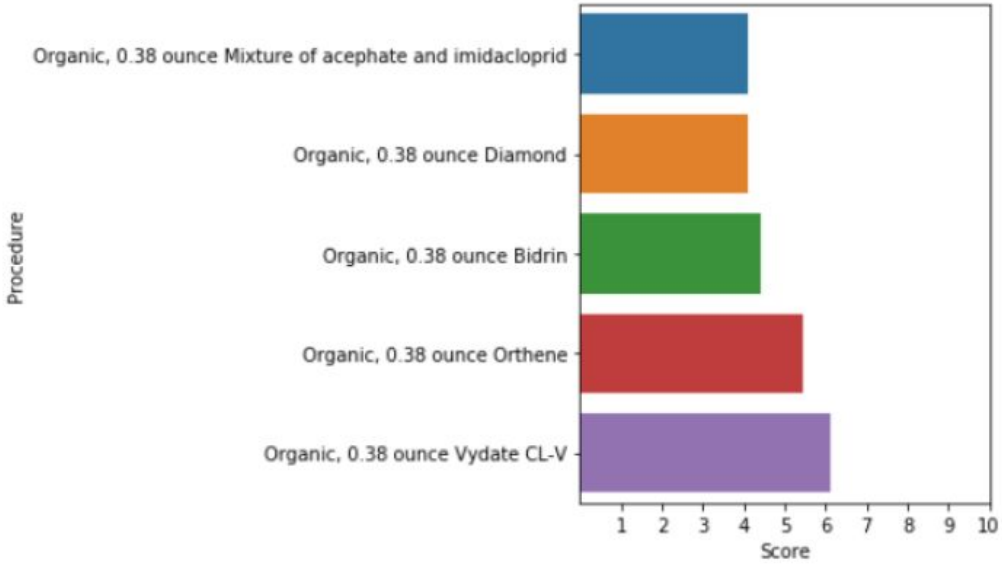
- Pesticide = Intruder, Transform, Centric, Imidacloprid

Organic cotton, recommend to:

- Pesticide = Acephate

1<= Scores <= 1.3, good

Results: Cotton Production Phase



Organic cotton, recommend not to:

- Pesticide = Mixture of Acephate and Imidacloprid, Diamond, Bidrin, Orthene, and Vydate CL-V

Least Environmentally Friendly Treatments

Results: Manufacturing Phase

Most Environmentally Friendly Treatments

After weaving and knitting, recommend to:

- Dye methods = pad-batch dyeing
- Dye chemicals = fiber-reactive dye powder, caustic potash, salt

After dyeing and printing procedure, recommend to:

- Treatment = desizing, mercerizing

Results: Manufacturing Phase

Least Environmentally Friendly Treatments

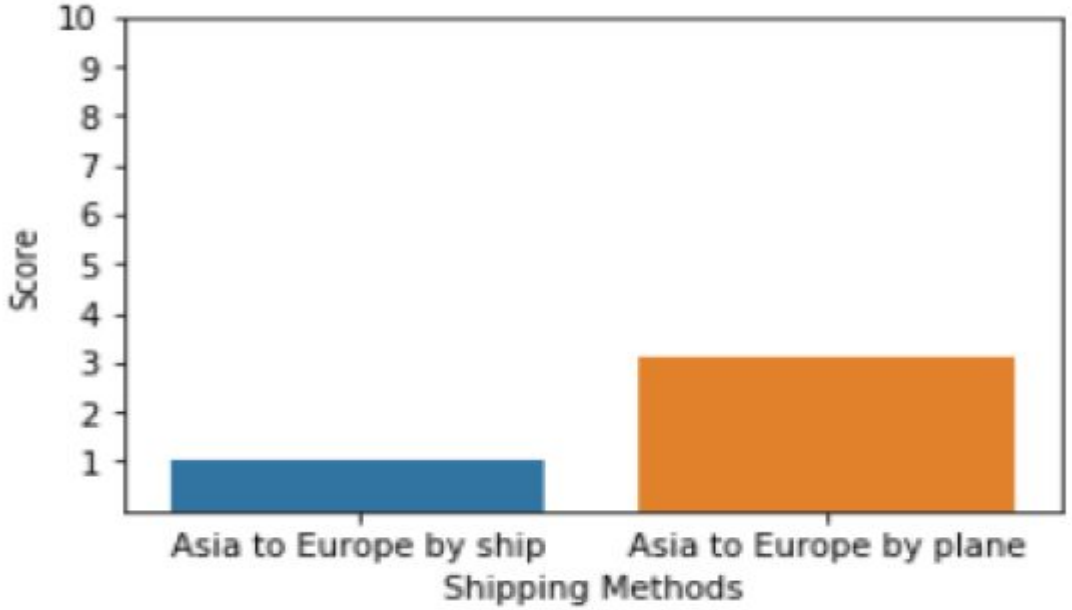
After weaving and knitting, recommend not to:

- Dye methods = skein dyeing, package dyeing, paddle dyeing, jet dyeing
- Dye chemicals = contains zinc

After dyeing and printing procedure, recommend not to:

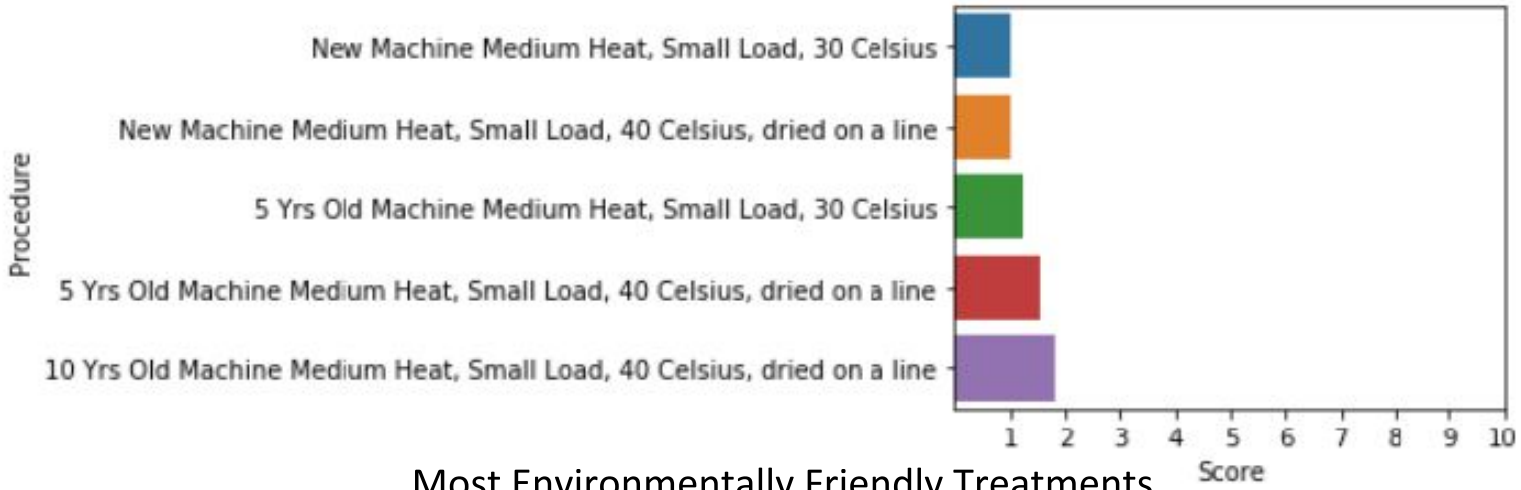
- Treatment = scouring, bleaching

Results: Distribution Phase



delivering t-shirts by ship has less environmental impact than delivering by plane

Results: Use Phase

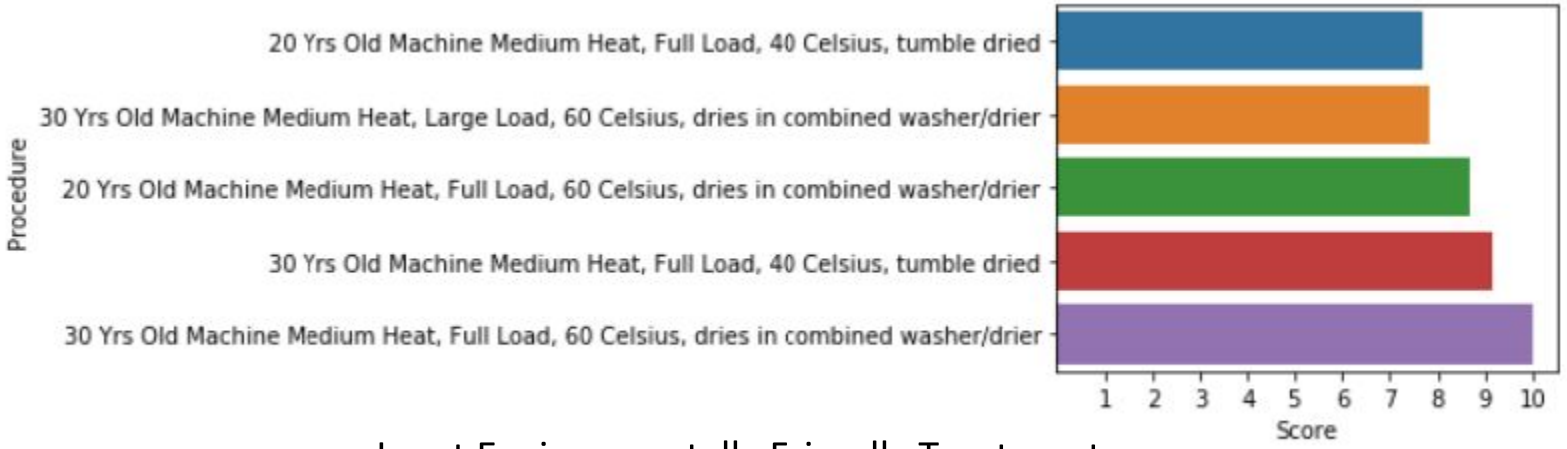


Most Environmentally Friendly Treatments

Recommend to:

- Washing load size = small
- Drying temperature = 30 or 40 Celsius (Low and Medium Heat)
- Try line-drying

Results: Use Phase



Least Environmentally Friendly Treatments

Recommend not to:

- Washing load size = large or full
- Drying temperature = 60 Celsius (High Heat)
- Drying mode = tumble drying, drying in combined washer or drier

Recommend to:

- Replace old washing machine if need one

What To Improve

- Find more and reliable data of three features in each phase
- Derive more accurate bounds for weights of three features
- Include energy consumption as one feature and perform optimization

Reference

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