



**GCSM 2014 12<sup>th</sup> Global Conference on Sustainable Manufacturing**

**Terra Preta Sanitation System International Competition AWARD**

**TERRA PRETA PACKAGING SYSTEM:  
A NEW “BLUE” WASTE MANAGEMENT**

Johor Bahru, Malaysia, 2014, September

The University of Bologna Blue Team

DIN, Department of Industrial Engineering  
DiSA, Department of Management



University of Bologna  
Bologna, Italy



- a. The University of Bologna Blue Team (UB Team)**
- b. Social and Market Survey and Analysis**
- c. The Terra Preta Packaging System (TPPS) Business Model**
- d. The Packaging Toilet System (PTS): technical description**
- e. The Movie**

a. The University of Bologna Blue Team (UB Team)

b. ...

c. ...

d. ...

e. ...



# Internal structure of the University of Bologna Blue Team, UB Team



## Coordinator

*Eugenio Baccarini<sup>Ma</sup>*

**Ma = student  
Management  
Engineering**

**Me = student  
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Business Model Office and Logistics

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Biochair and Legislation analysis Office

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a. ...

b. Social and Market Survey and Analysis

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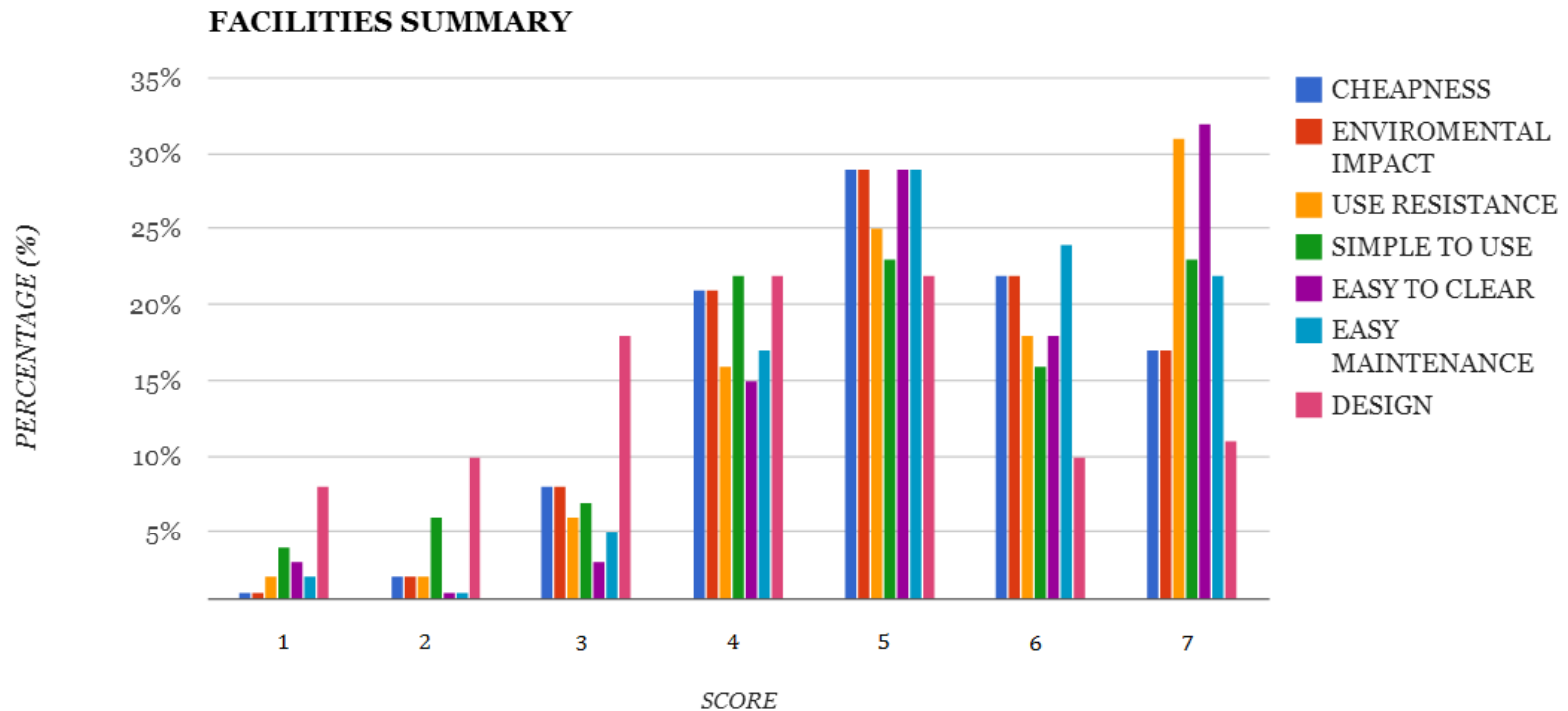
# Social and Market Survey and Analysis: the questionnaire

UB Team analysed the social impact and the market need concerning “new toilets” through a self-designed questionnaire:

1<sup>st</sup> Section: Overview --> Age, Gender, Job

2<sup>nd</sup> Section: Environmental Sustainability --> Questions concerning interest in environmental sustainability

3<sup>rd</sup> Section: Toilet Facilities --> Cheapness, Environmental impact, Use resistance, Simple to use, Easy to clear, Easy maintenance, Design



a. ...

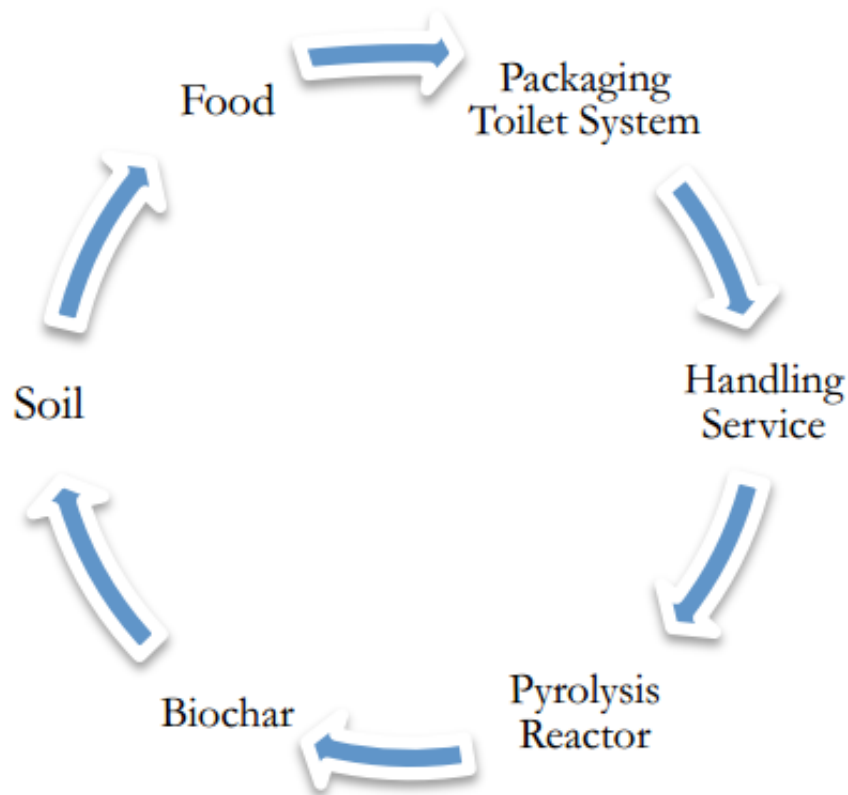
b. ...

c. The Terra Preta Packaging System (TPPS) Business Model

d. ...

e. ...

# The Terra Preta Packaging System (TPPS) Business Model (1)



**TPPS** creates a **loop system** among food, excrement and soil closing a “**blue**” non-polluting cycle and creating value by selling **Biochar**.

The **keys** of the TPPS are:

- The Packaging Toilet System (**PTS**)
- The Handling Service (**HS**)
- The Green Pyrolysis Area (**GPA**)
- The Biochar



**Biochar** is an innovative product for agriculture.

It has a crucial role in UB TPPS Project.

Why the use of Biochar is so important?

- Up to 100% crop productivity enhancement and N-fertilizers use efficiency increase
- Soil improvement against pollution, landslides and floods
- Reduction of greenhouse gases emission and protection against climate change





# The Terra Preta Packaging System (TPPS)

## Business Model - Canvas Model (2)



<b>Customer Segments:</b> <ul style="list-style-type: none"> <li>• Agricultural businesses;</li> <li>• Small farmers with a passion for organic local products;</li> <li>• Lovers of gardening.</li> </ul>	<b>Customer Relationships:</b> <p>The goal is to create a bond with each market segment served.</p>	<b>Channels:</b> <ul style="list-style-type: none"> <li>• The retail store on the place of production to serve small users (BtoC);</li> <li>• Selling agents and e-commerce for big users (BtoB).</li> </ul>
<b>Value Proposition:</b> <ul style="list-style-type: none"> <li>• Environmental benefits;</li> <li>• Water retention;</li> <li>• Enrichment of nutrients;</li> <li>• Better stability of soils;</li> <li>• Agronomic benefits for the industrialised countries;</li> <li>• Increase of sanitation and primary requirements as electricity for the emerging countries.</li> </ul>	<b>Key Partners:</b> <p>Partnership relationship marked by trust and long term with two different companies to pursue goals such as:</p> <ul style="list-style-type: none"> <li>• Access to specialized suppliers;</li> <li>• Focus on the core competences;</li> <li>• Search of cost advantages;</li> <li>• Risk diversification.</li> </ul>	
<b>Key Resources:</b> <p>Intellectual capital.</p>	<b>Cost Structure:</b> <ul style="list-style-type: none"> <li>• Purchase cost of the Packaging Toilet System from the supplier company;</li> <li>• Green Pyrolysis Area cost;</li> <li>• Marketing costs;</li> <li>• Sales Agents costs;</li> <li>• System of material handling cost;</li> </ul>	<b>Key Activities:</b> <ul style="list-style-type: none"> <li>• Engineering process operated by the technical office;</li> <li>• Distribution channels;</li> <li>• Customer relationships;</li> <li>• Service offered to the client.</li> </ul> <b>Revenue Streams:</b> <p>The only activity that allows to get the revenue is the sale of Biochar which before of the fourth year permits the company to reach the breakeven point.</p>





# The Terra Preta Packaging System (TPPS) Business Model (3)



REVENUES	
BIOCHAR sale	UOM
Daily production of biochar	
1000	kg/day
Sale price	
€ 6.00	€/kg
Daily potential Revenue	
€ 6,000.00	€/day
Annual potential Revenue	
€ 2,190,000.00	€/year
Annual actual Revenue	
€ 2,190,000.00	€/year

COSTS					
Toilet	UOM	Pyrolyzer	UOM	Pyrolyzer Maintenance	UOM
Total inhabitants		Power to install (kW)		€ 50,000.00	€/y per operat
20000	inhab	150	kW	Maintenance operator	
Mean value of distributed toilet		Cost €/KW		2	operators
8333	toilet	2500	€/kW	Total Cost of Pyrolyzer Maintenance	
Toilet Cost		Pyrolyzer Cost		€/year	
151.84	€/toilet	€ 375,000.00	€	€ 100,000.00	€/year
Total Cost of distributed toilet		Years of Depreciation			
€ 1,265,333.33	€	11			
Years of Depreciaton		Pyrolyzer Depreciation€/year			
5		€ 34,090.91	€/year		
Toilet Depreciation €/year					
€ 253,066.67	€/year				

Marketing	UOM	Sale Agents	UOM	Pyrolyzer Insurance	UOM	Handling	UOM
Percentage of total revenues		€ 30,000.00	€/y per agent	Percentage of Pyrolyzer Total Cost		Total Handling Cost €/year	
40.0%		Number of agents		10.0%		€ 90,315.35	€/year
Total MKTG investement		2	agents	Total Cost of Insurance €/year		Vehicle Cost	
€ 876,000.00	€/year	Total Cost of sale agents €/year		€ 37,500.00	€/year	€ 40,000.00	€
		€ 60,000.00	€/year			Year of Depreciation	
						8	year
						Vehicle Depreciation €/year	
						€ 5,000.00	€/year

Revenues and  
general costs





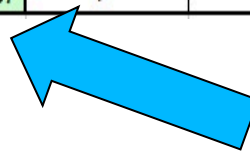
# The Terra Preta Packaging System (TPPS) Business Model (4)

INCOME STATEMENT (20,000 inhabitants)	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
<b>REVENUES</b>						
Biochar sale	€ -	€ 2,190,000.00	€ 2,233,800.00	€ 2,278,476.00	€ 2,324,045.52	€ 2,370,526.43
<b>TOTALE REVENUES</b>	€ -	€ 2,190,000.00	€ 2,233,800.00	€ 2,278,476.00	€ 2,324,045.52	€ 2,370,526.43
<b>COSTS</b>						
Toilet Cost	€ 1,265,333.33	€ -	€ -	€ -	€ -	€ -
Toilet Depreciation	€ -	€ 253,066.67	€ 253,066.67	€ 253,066.67	€ 253,066.67	€ 253,066.67
Pyrolyzer Cost (150 kW)	€ 375,000.00	€ -	€ -	€ -	€ -	€ -
Pyrolyzer Depreciation	€ -	€ 34,090.91	€ 34,090.91	€ 34,090.91	€ 34,090.91	€ 34,090.91
Maintenance Operator Cost	€ -	€ 100,000.00	€ 102,000.00	€ 104,040.00	€ 106,120.80	€ 108,243.22
Marketing Cost	€ -	€ 876,000.00	€ 832,200.00	€ 790,590.00	€ 751,060.50	€ 713,507.48
Sale Agent Cost	€ -	€ 60,000.00	€ 61,200.00	€ 62,424.00	€ 63,672.48	€ 64,945.93
Pyrolyzer Insurance	€ -	€ 37,500.00	€ 38,250.00	€ 39,015.00	€ 39,795.30	€ 40,591.21
Handling Cost	0	€ 90,315.35	€ 92,121.66	€ 93,964.09	€ 95,843.37	€ 97,760.24
Vehicle Cost	€ 40,000.00	€ -	€ -	€ -	€ -	€ -
Vehicle Depreciation	€ -	€ 5,000.00	€ 5,000.00	€ 5,000.00	€ 5,000.00	€ 5,000.00
<b>TOTAL COSTS</b>	€ 1,680,333.33	€ 1,455,972.93	€ 1,417,929.23	€ 1,382,190.67	€ 1,348,650.03	€ 1,317,205.64
<b>INCOME BEFORE TAXES</b>	-€ 1,680,333.33	€ 734,027.07	€ 815,870.77	€ 896,285.33	€ 975,395.49	€ 1,053,320.79
Taxes (40%)	€ -	€ 293,610.83	€ 326,348.31	€ 358,514.13	€ 390,158.20	€ 421,328.31
<b>NET INCOME</b>	€ -	€ 440,416.24	€ 489,522.46	€ 537,771.20	€ 585,237.29	€ 631,992.47

## Income Statement

# The Terra Preta Packaging System (TPPS) Business Model (5)

CASH FLOW ANALYSIS	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	WACC
NET INCOME	€ -	€ 440,416.24	€ 489,522.46	€ 537,771.20	€ 585,237.29	€ 631,992.47	5%
Operating Activities (Depreciation)	€ -	€ 292,157.58	€ 292,157.58	€ 292,157.58	€ 292,157.58	€ 292,157.58	
(-) Increase of stock		-€ 36,500.00	-€ 730.00	-€ 744.60	-€ 759.49	€ -	
(+) Decrease of stock		€ -	€ -	€ -	€ -	€ 39,508.77	
(-) Increase trade receivable		-€ 547,500.00	-€ 10,950.00	-€ 11,169.00	-€ 11,392.38	€ -	
(+) Decrease of trade receivable		€ -	€ -	€ -	€ -	€ 592,631.61	
(-) Decrease of debt		€ -		€ -	€ -	€ -	
(+) Increase of debt			€ -	€ -	€ -	€ -	
Financing Activities	€ -	-€ 584,000.00	-€ 11,680.00	-€ 11,913.60	-€ 12,151.87	€ 632,140.38	
Purchases of property, plant and equipment	-€ 1,680,333.33	€ -	€ -	€ -	€ -	€ -	
Cash Flow for Investing Activities	-€ 1,680,333.33	€ -	€ -	€ -	€ -	€ -	
Operating Cash Flow	-€ 1,680,333.33	€ 148,573.82	€ 770,000.04	€ 818,015.18	€ 865,243.00	€ 1,556,290.43	
NPV	YEAR 0 -€ 1,680,333.33	YEAR 1 € 141,498.88	YEAR 2 € 698,412.73	YEAR 3 € 706,632.26	YEAR 4 € 711,837.56	YEAR 5 € 1,219,394.27	
SUM OF ACTUALIZED CASH FLOW	€ 1,797,442.37	>	0				



Net Present Value

a. ...

b. ...

c. ...

d. The Packaging Toilet System (PTS): technical description

e. ...

# The Packaging Toilet System (PTS): the technical description



## What is a Packaging Toilet?

The Packaging Toilet is a waterless toilet which separates the urine from the faeces, thanks to an urine separator: the urine is canalized in a pipeline and guided to the urine tank, while the excrements are collected at first into a single use bag which is immediately sealed and sent to the tank.

## Design Guidelines

Adaptability to Urban Areas --> Hygienic Problem, Odour Problem

Adaptability to a wide range of geographies and cultures --> Behaviour Issue, Logistic Issue



# The Packaging Toilet System (PTS): the technical description



The Packaging Toilet Unit can be divided into five sub assemblies:

- **The Mechanism Box**
- **The Toilet Shell**
- **The Recharge Column Group**
- **The Rear Guide**
- **The Base Cabinet**



# The Handling Service (HS)

HS takes excrements from single users thanks to Bag Containers, which are brought to a Green Pyrolysis Area.

HS costs have been estimated using the Vehicle Routing Problem (VRP) Model.

## VRP MODEL:

### INDICES:

CP (customer):  $i = 0, \dots, n;$

Vehicles:  $k = 1, \dots, m;$

Pyrolysis Reactors:  $j = 1, \dots, q;$

### PARAMETERS:

$V_i$  = Volume to be taken from each CP<sub>i</sub> (m<sup>3</sup>)

$M_k$  = Capacity of vehicle k (m<sup>3</sup>/vehicles)

$dist_{i-i_1}$  = Distance between CP<sub>i</sub> and CP<sub>i<sub>1</sub></sub> (m)

## VARIABLES:

$$F_{i-i_1}^k = \begin{cases} 1 & \text{if vehicle } k \text{ covers route } i-i_1 \\ 0 & \text{instead} \end{cases}$$

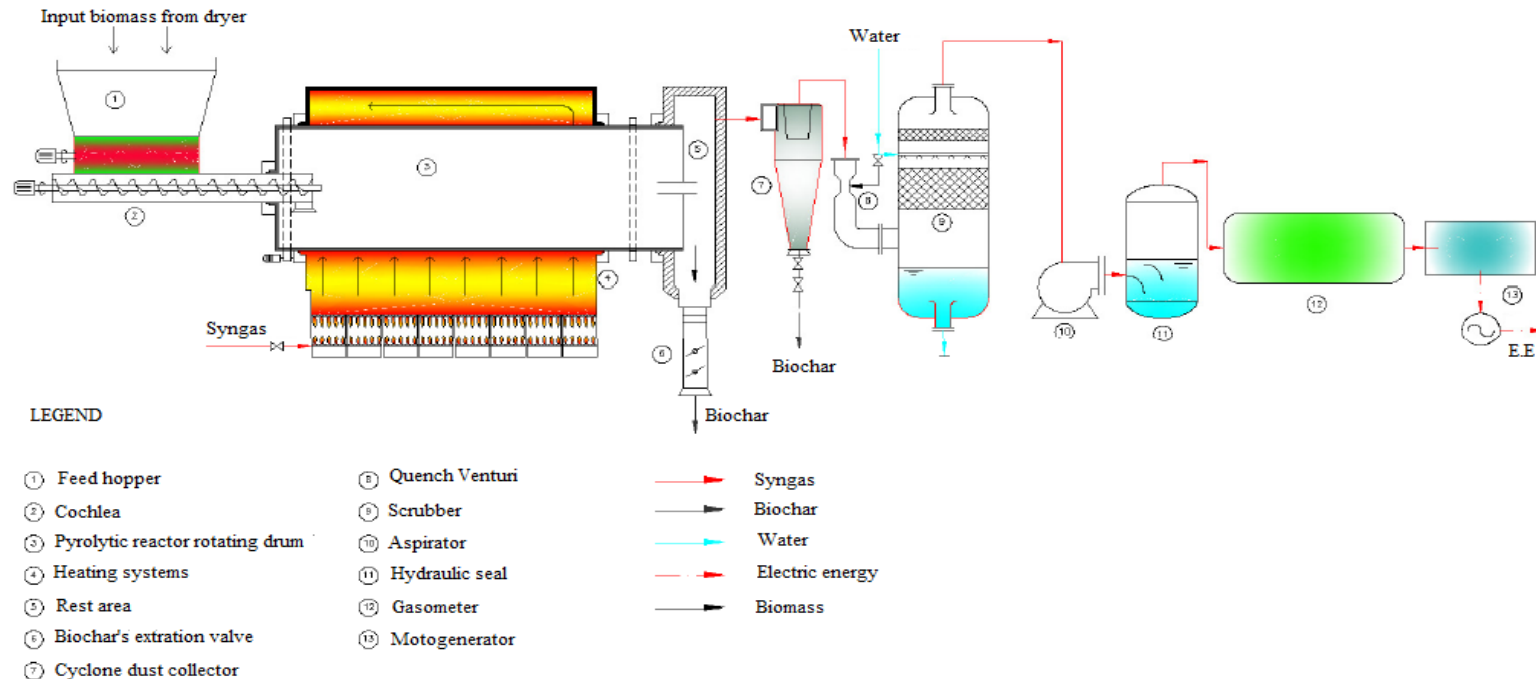
$$Z_i^k = \begin{cases} 1 & \text{if CP}_i \text{ is served by vehicle } k \\ 0 & \text{instead} \end{cases}$$

## OBJECTIVE FUNCTION:

$$\min \sum_k \sum_i \sum_{i_1} dist_{i-i_1} \times F_{i-i_1}^k$$

## Green Pyrolysis Area (GPA)

The **GPA** has a surface area of about 50 square meters and includes: area of waste collection, drying, pyrolysis, engine for the production of electricity supplied to Syngas and the final area of stocking of finished product (Biochar).





# Coordinator, Tutors and Supervisors at the University of Bologna



The UB Team would like to thanks  
tutors and supervisors (alphabetical order):

Marco **B**ortolini<sup>1</sup> - logistics

Giampaolo **C**ampana<sup>1\*</sup> - design & technology - supervisor

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# The UB Team meets the Italian Design Summer School 2014 (9<sup>th</sup> edition) University of Bologna, 3<sup>rd</sup> September 2014



THE UB TEAM  
WOULD LIKE TO THANK YOU  
FOR YOUR KIND ATTENTION





# Outline



a. ...

b. ...

c. ...

d. ...

e. The Movie

