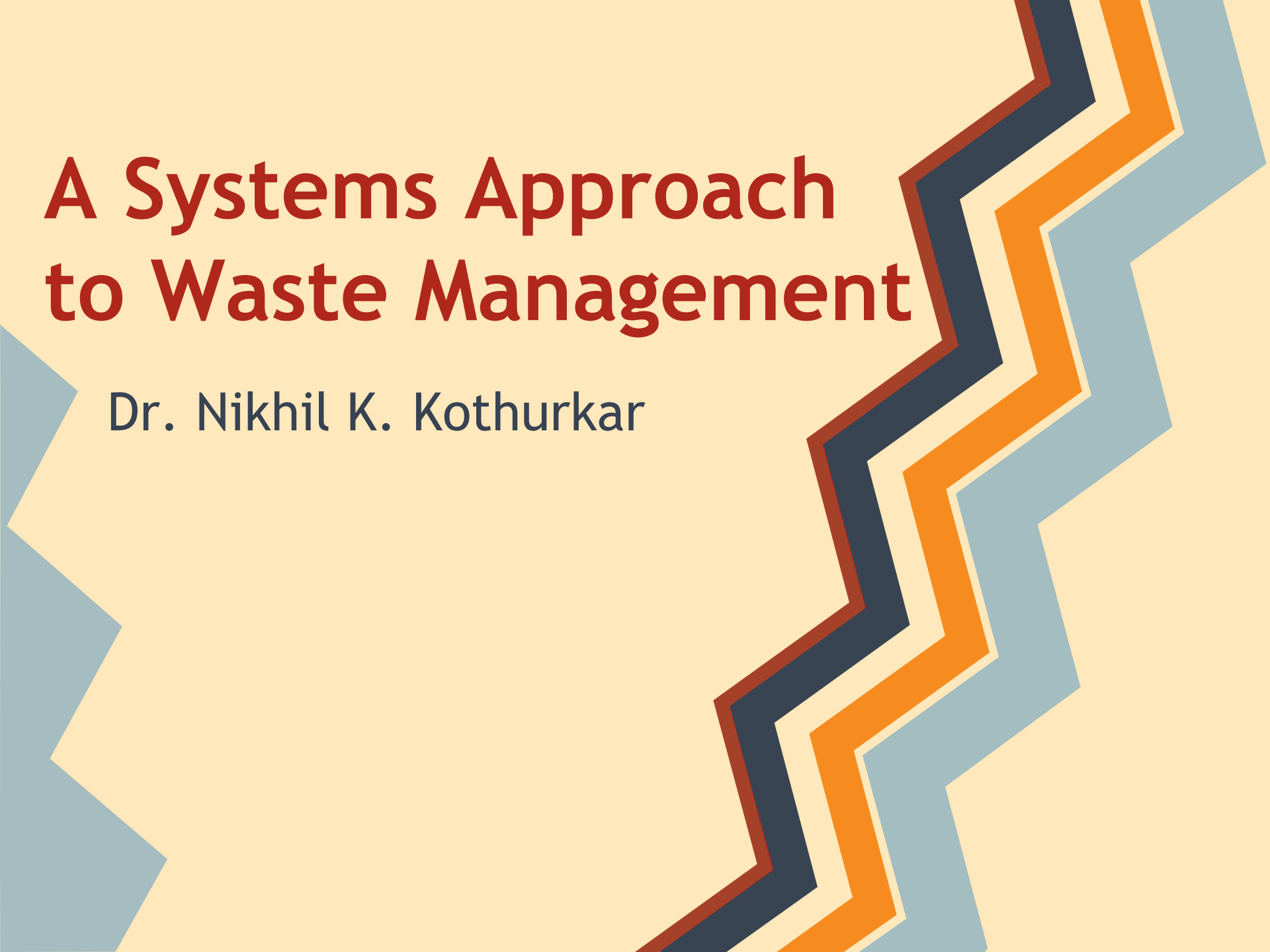


A Systems Approach to Waste Management

Dr. Nikhil K. Kothurkar



Outline

- Motivation
- Conventional Approach
- Systems Approach: Principles for Optimizing the Waste Management Method
- Example: Simple vs. Complex Systems
- Amplify Benefits
- Waste Disposal Priorities
 - Plastic Waste
 - Dry Biomass
 - Human Waste
 - Animal Waste
 - Organic Waste
- Towards a Sustainable Home

- Solid Waste generated in Indian cities and towns:
 - In 1947 was 6 million tonnes
 - In 1997 about 48 million tonnes



India's Solid Waste Problem

- More than 25% of the municipal solid waste is not collected at all!
- 70% of the Indian cities lack adequate capacity to transport it
- There are no sanitary landfills to dispose of the waste
- ~50% of municipal solid waste is organic in nature (potential manure/compost).

**What an inheritance to leave
for our children!**



*Where do you think our milk comes from?
Oops! Do our kids drink this stuff?*



Ram Teri Ganga Maili Ho Gayi!



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CONVENTIONAL APPROACH

CHANGE OF ATTITUDE TOWARDS WASTE

- Waste is not waste. It is merely a misplaced resource
- It can be converted to manure, energy or other products.
- But for it to be used as a resource, it has to be separated

There is no waste in Nature. Nature converts, recycles and reuses all wastes. The waste of one organism is the food of another.

WASTE MANAGEMENT CASE STUDY: **AMRITA VISHWA VIDYAPEETHAM CAMPUS, COIMBATORE**

**BEFORE 2008, CAMPUS WASTE WAS DEPOSITED BY RESIDENTS IN
THE WASTE BINS WITHOUT SEGREGATION....**



Which recycler will accept soiled paper or plastic for recycling?



PROBLEMS WITH DUMPING OF MIXED WASTES

- **Health hazard** to waste pickers and sorters: Bad odour and the risk of infection
- **Socially Demeaning** and objectionable to sort through personal sanitary wastes and food waste, which are mixed with all the other waste.
- **Inefficient Recycling:** Many recyclable items cannot be recycled since they are heavily soiled
- **Environmental Damage:** Soiled recyclables have to be buried or incinerated leading to environmental damage.
- Sorting is a tedious and labor intensive process

A RESPONSIBLE WASTE MANAGEMENT STRATEGY

- Waste can potentially be a **boon** or a **bane** depending upon the **management strategy**.
 - **Boon:** it can yield energy, reusable materials, raw material for processes.
 - **Bane:** environmental damage and pollution, disease and health problems.
- Separate wastes at source (every house). Try to reuse at source, whenever possible.
- Collect different categories of waste and transport to central sorting center.
- Further sort into several categories at the sorting center.
- Find markets for selling the various categories of sorted wastes.
- Minimize exposure of workers to hazardous and offensive conditions

WASTE SEGREGATION AT SOURCE

- In 2008, waste segregation at source was implemented.
- In common areas, four categories of bins were placed.
- Bins for different categories were provided to residents, within their house.
- Training of campus residents, staff and house-maids was conducted.

SEPARATION AND BIN COLOR CODING

(AMRITA ETTIMADAI CAMPUS)

Organic/Food waste	kitchen waste, food leftovers, vegetables, flowers, leaves, fruits.
Recyclables	Only dry paper, plastics, carry bags, etc.
Sanitary Waste	Personal and hospital waste such as sanitary pads, cloth or bandages soiled with blood and other body fluids.
Other waste	Milk pouches, <i>badly soiled paper and plastic, coconut shells</i>, glass, metals, foil, paints, chemicals, bulbs, spray cans, fertilizer and pesticide containers, batteries, shoe polish, tubelights, old medicines.



PAPER/PLASTIC WASTE

பேப்பர்/பிளாஸ்டிக் கழிவுகள்

NAPKIN WASTE

நாப்கின் கழிவுகள்

FOOD WASTE

உணவுப் பொருட்கள்

OTHER WASTE

தேர்வுப் பொருட்கள்



AMRITA RECYCLE CENTER (ARC)

Further Manual Sorting of Waste





AMRITA HAS MADE A DIFFERENCE

- Every bit of waste on campus is collected and taken to the **Amrita Recycle Center (ARC)**.
- Manual sorting of wastes
- Organic (food) waste is composted: manure for orchards
- Recyclables are recycled
- Non-recyclables are incinerated
- Effluent treatment plant for campus liquid effluent.

True to the teachings of Amma, we take responsibility for protecting Nature and our fellow-humans

RESULT

- A clean campus, free from litter and pollution.
- Organic gardens and orchards
- Protection of the environment
- Recycling of paper, plastics, scrap metal, glass and other recyclables

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Systems Thinking

- Systems thinking is necessary for solving interconnected problems.
- The WHOLE is more than just the sum of the individual PARTS.
 - E.g. Putting together all the parts of a car in any random order does not make a functional car.
 - Each part is related to other parts in a specific way and contributes to the functioning of the whole.
 - Design is necessary both at the component level and the system level. (e.g. each part must be properly designed and the entire car must also be properly designed.)
 - Diagnosing and correcting malfunctions in complex and interrelated problems requires systems thinking.
- Watch this video [Systems thinking: an introduction](#) (3.31 min)
- [Systems thinking: a cautionary tale \(cats in Borneo\)](#) (3.08 min)

Systems Approach

- Select the **best** among the several possible waste management strategies
 - Integrating solid waste management with gardening, milk production, water management and energy systems, can give *very high returns*.
 - Complex systems can give higher resource use efficiency but at a higher infrastructure and maintenance cost
 - Optimization is necessary.

Principles for Optimizing the Waste Management Method

- Segregate waste at source
- Collect spoilable (organic) waste from sources twice a day.
- Tertiary segregation at the collection center
- Reuse is better than Recycle
- Use each type of waste for the highest value application first.
- Use the same materials as many times as possible for relatively lower value applications each time.

Principles for Optimizing the Waste Management Method

- Convert wastes into value-added products
 - e.g. organic waste to compost for gardening.
- Amplify the benefits drastically by:
 - Including microorganisms, plants, small and large animals in the method.
 - Integrating waste management with food and energy production and water management.
- Balance between the high long term benefits of complex systems and the low immediate infrastructure cost of simple systems.
- Beware of introducing or cycling toxins or pathogens in the human food chain.

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Food Waste

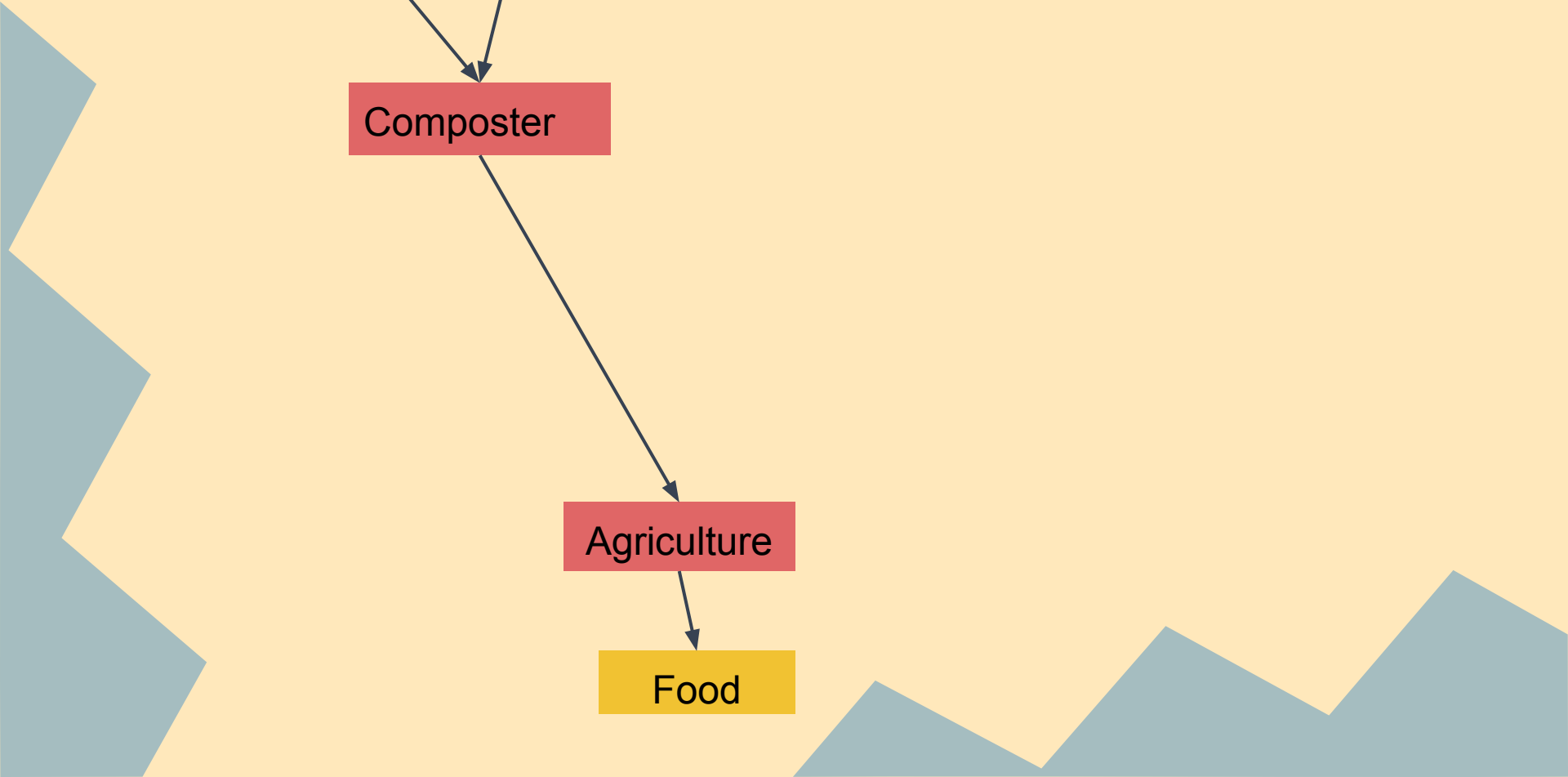
Garden/
Biomass Waste

Composter

Agriculture

Food

- **Simple system**
- Low output of value-added products
- Lower infrastructure
- Lower long-term profitability



Food Waste

Garden/
Biomass Waste

- **Complex system**
- Very high output of value-added products
- Greater long-term profitability
- Higher infrastructure
- *Complexity is not always advantageous*

Cow

Pyrolyzer

Biogas
Plant

Agriculture

Milk

Food

Heating/ Power
generation

Cattle-edible

Cattle-inedible

Dung

Mulch

Biochar

Syn Gas

Biogas

Urine

Slurry

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Amplify the Benefits

1. Food waste --> Landfill with other solid waste --> Pollution and GHG emissions, breeding of vectors and diseases, loss of value of recyclables, contamination of groundwater --> **net loss.**
2. Food waste --> composting --> sell compost --> **earn profits.**
3. Food waste --> Cow --> milk and dung
 - Sell milk (or consume) --> **earn profits** (or displace expenses)
 - AND compost the dung
 - --> sell the compost --> **earn profits**
 - OR --> grow vegetables **on greywater** --> sell vegetables --> **greater profits**

Amplify the Benefits

For a certain type of organic waste:

- Identify an organism (plant or animal) that consumes it and yields a human-useful product e.g. a cow, goats, egg-laying birds
- Among the alternatives, choose the organism which:
 - is robust and requires minimal care,
 - has a high resource conversion efficiency
 - yields products of high value.
- Explore if an integrated management of solid waste, energy, food, liquid effluent gives any significant advantages.

Domestic Effluent
(Sewage)

- **Simple system**
- Low output of value-added products
- High external inputs
- Lower infrastructure
- Lower long-term profitability

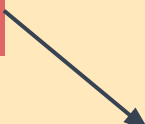
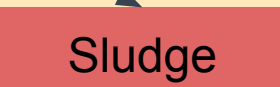
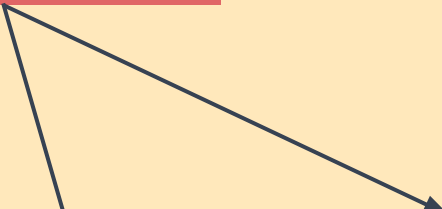
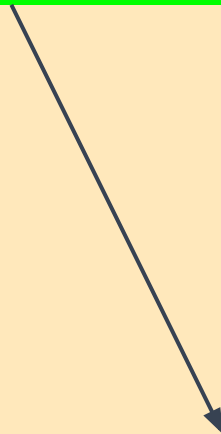
Effluent Treatment
Plant

High electricity, inputs

Sludge

Land Application
(Pollution?)

Reclaimed
Water



Domestic Effluent
(Sewage)

Open wetland with
ducks



Plant Biomass (e.g. water
hyacinth, algae)

Biogas or Pyrolysis
Plant

Reclaimed
Water

Eggs

Energy

- **Complex system**
- High output of value-added products
- Low external inputs
- Higher infrastructure
- Drastically higher long-term profitability

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Plastic Waste Usage Priorities

Plastic waste should be used in the following order of priority. Only if unfit for one category should it be used for the next:

1. Reuse the plastics (materials and products) for a lower value application. **Caution: Do not reuse plastics for food or drinking water applications due to toxicity hazard.**
2. Segregate based on type and recycle to make lower quality products.
3. Poor quality plastic waste can be converted to fuel (gas or liquid) by pyrolysis techniques.

Dry Biomass Waste Usage Priorities

Agricultural biomass residue or garden waste biomass should be used in the following order of priority. Only if unfit for one category or present in excess or requirements should it be used for the next:

1. Feed and bedding for milch animals.
2. Ground mulch (shredded or unshredded as convenient) for agriculture...cattle bedding is ideal.
3. Feed for biogas plant...use effluent slurry for food farming.
4. A small fraction of dry biomass can be converted to fuel (gas or liquid) by pyrolysis techniques.

Human Waste Usage Priorities

Human waste should be disposed of and used in the following order of priority. Only if the first is not feasible should the subsequent ways be adopted:

1. Use urine separation, dry composting toilets. Apply urine directly to trees and to herbaceous crops only if using drip irrigation. Use compost after due ageing (eliminate pathogens) to fertilize tree crops. Avoid applying to herbaceous and root crops.
2. Send mixed human waste from flush toilets to wetlands or photobioreactors. Harvest biomass and convert to energy by pyrolysis or biomethanation. Residual biochar or waste sludge can be used for gardening.

Human Waste Usage Priorities

3. Send mixed human waste from flush toilets to a biogas plant. Waste sludge can be used for gardening.
4. Send mixed human waste directly into compost pit.

Check WHO Guidelines for the safe use of wastewater, excreta and greywater

Animal Waste Usage Priority

Animal waste should be disposed of and used in the following order of priority. Only if the first is not feasible should the subsequent ways be adopted:

1. Separate urine (esp. cow urine) and use for fertigation directly or after preparing liquid biofertilizers like Panchagavya via drip irrigation.
2. Send solid waste to biogas plants and recover energy (gas) as well the spent slurry. The slurry can be used as fertilizer preferably after vermicomposting or ageing.

Organic Waste Usage Priorities

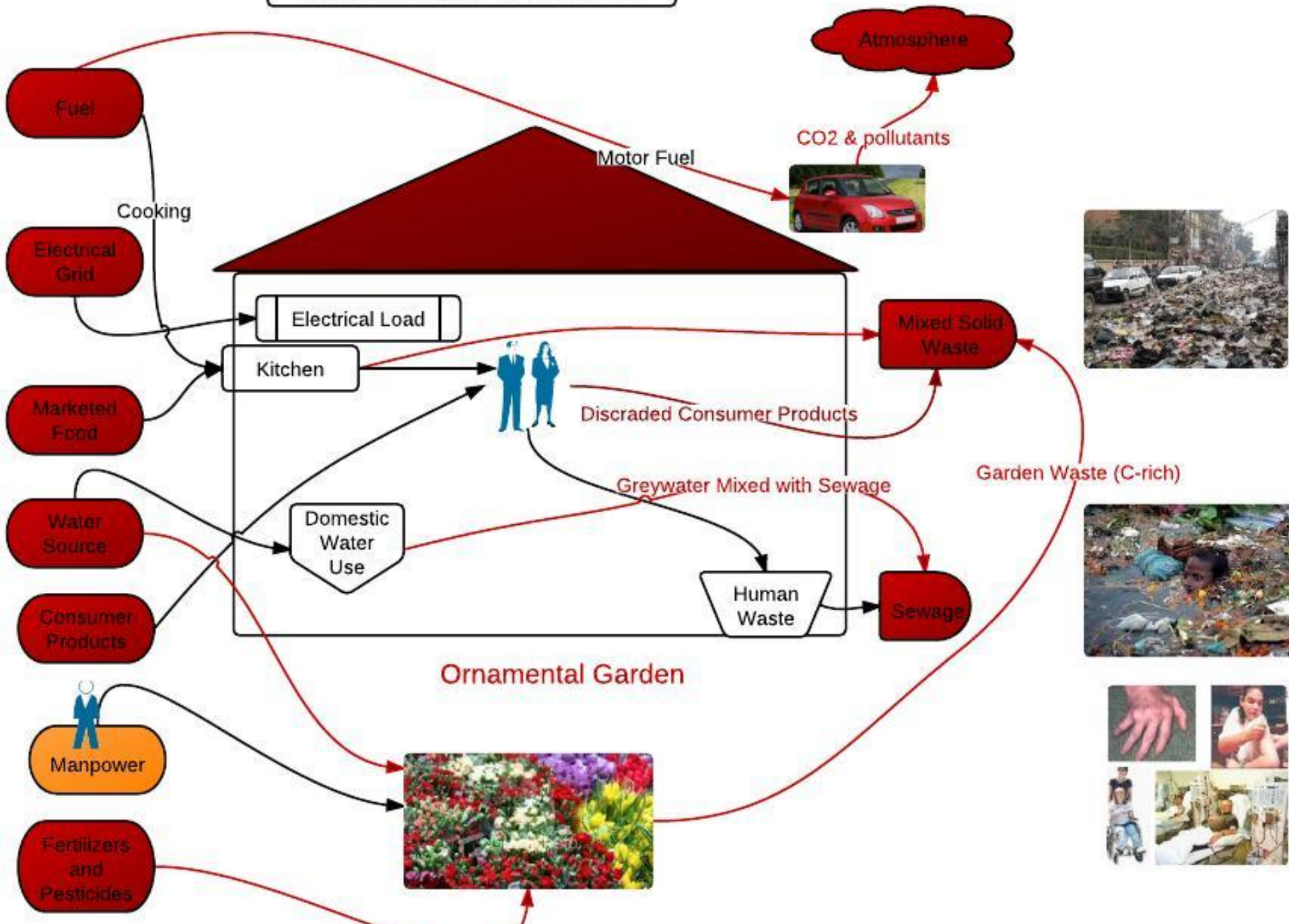
Kitchen and food waste should be used in the following order of priority. Only if unfit for one category should it be used for the next:

1. Feed for milch animals (collect the milk and send dung to biogas plant)
2. Feed for egg-laying birds (recover the eggs and send the excreta to the biogas plant)
3. Feed for Biogas plant (recover the gas and use the waste slurry for agriculture)
4. Direct Composting (use the compost for agriculture)
5. Feed for pyrolyzer/gasifier (recover the gas and use the biochar for agriculture)

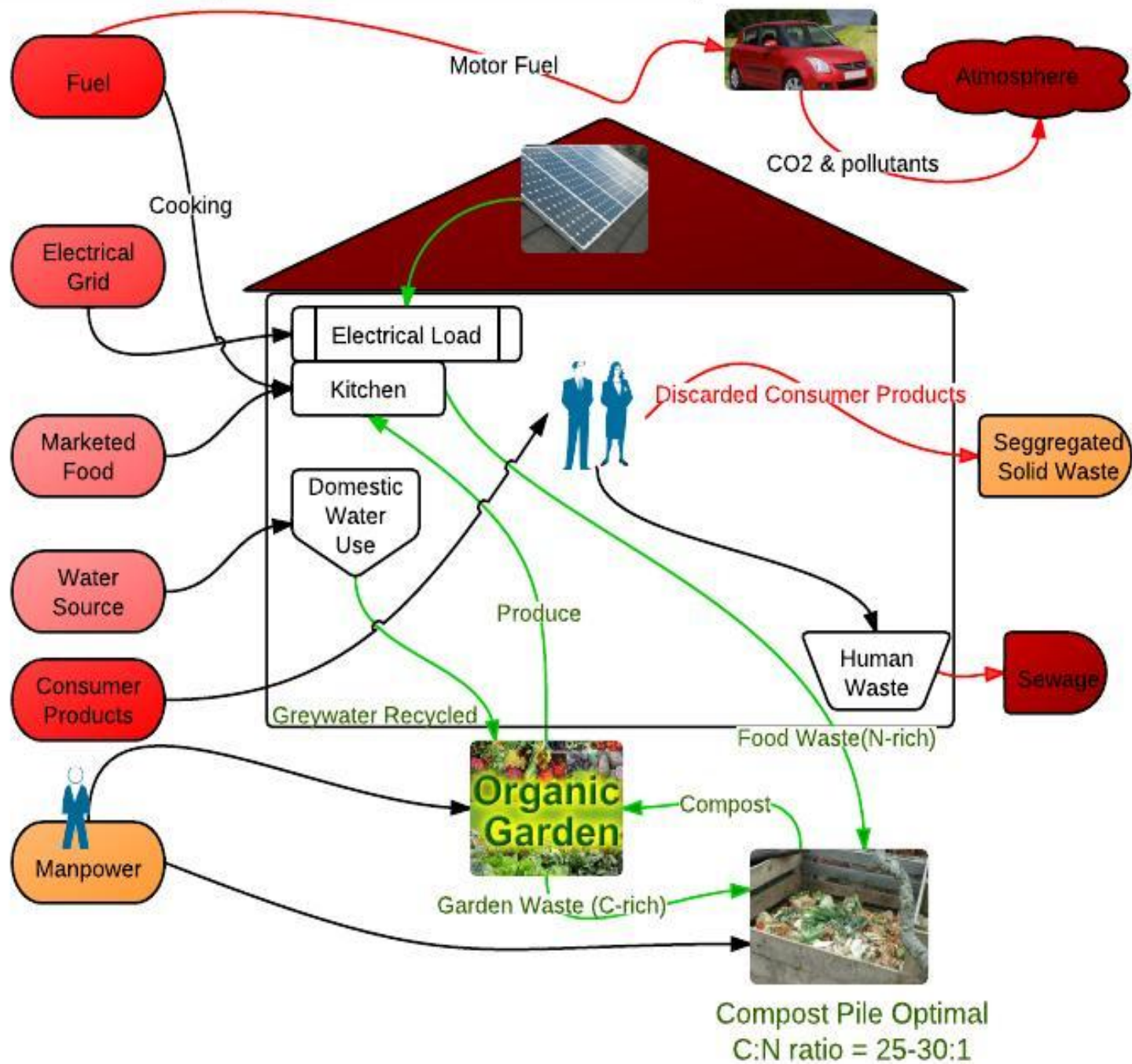
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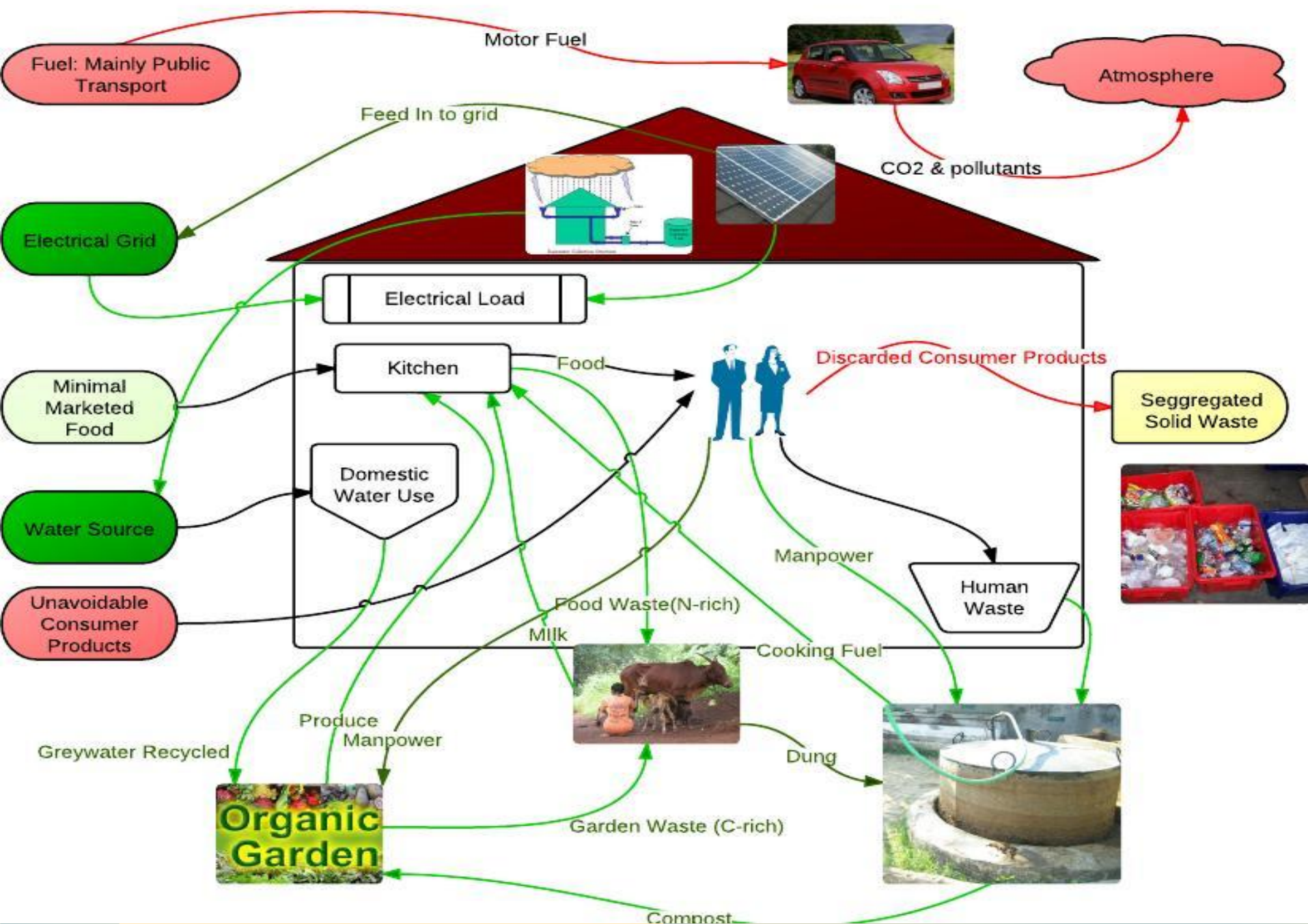
Conventional Home



Partially Sustainable Home



Nearly Sustainable Home



LINKS

Paradigm Environmental Strategies (P) Ltd.:
Implementing sustainable and eco-friendly
development projects including integrated waste
management