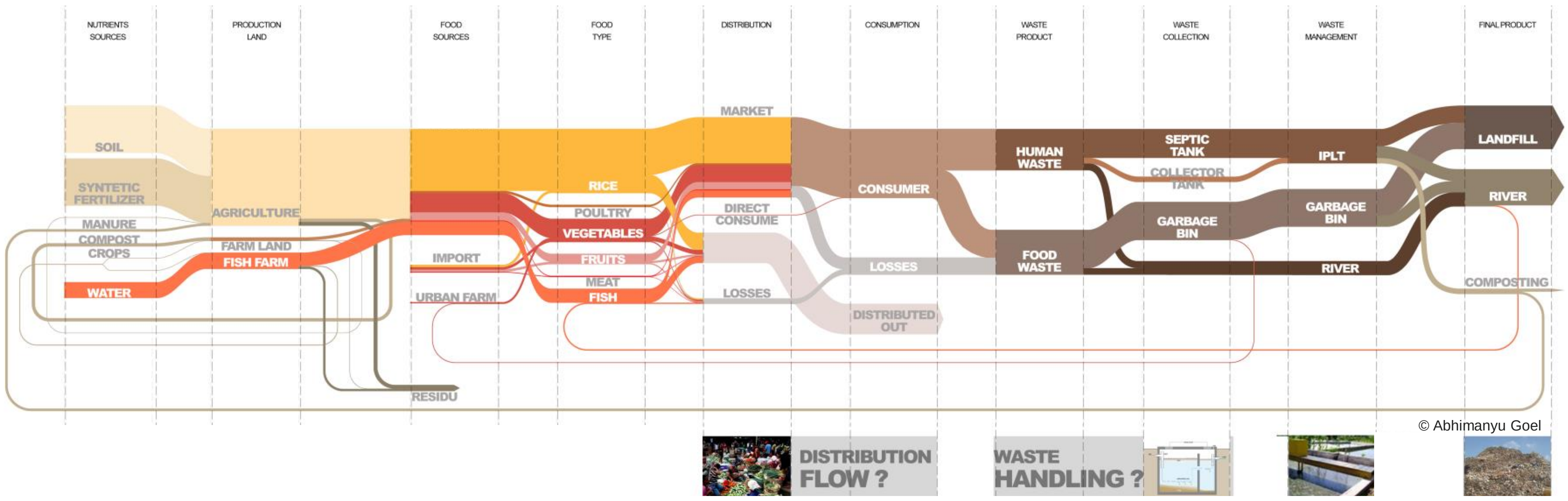
Urban Metabolism Analysis

at Energy and Environmental Sustainability for Megacities (E2S2) Program



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Urban Metabolism Analysis as a pathway to assess overall environmental sustainability of waste utilization strategies

Background

Urban Metabolism Analysis (UMA) is an important tool for studying the use of energy and resources in urban ecosystems (Wolman, 1965). Applying methods such as material flow analysis, substance flow analysis and energy flow analysis, UMA is able to quantify, describe and evaluate the sustainability of different flows and stocks (that is, accumulation) of energy and materials within an economy or geographical boundary. UMA is also effective in tracing any evolutions of these variables with time. Broadly speaking, large metabolic throughput, low metabolic efficiency, and disordered metabolic processes are known to cause an urban system to become “unhealthy” and unsustainable. State-of-art UMA methodology combines flow and stock analyses with top-down economic input-output analyses (an example is shown in the diagram above) and bottom-up process-based life cycle assessment (LCA), in order to evaluate the state of sustainability due to the use of materials and energy by the waste utilization technologies

Research Questions

a) What are the current *inflows* of materials and energy into the waste utilization sectors for food and non-food organic waste in Singapore and Shanghai? What are the environmental impacts caused by these inflows, vis-à-vis variables such as biotic depletion of fossil fuel, eutrophication, and human toxicity potential and ecotoxicity potential?

b) What are the current *outflows* of materials and energy from the waste utilization sectors for food and non-food organic waste in Singapore and Shanghai? What are the environmental impacts caused by these outflows, vis-à-vis variables such as biotic depletion of fossil fuel, eutrophication, and human toxicity potential and ecotoxicity potential?

c) If the respective appropriate waste utilization technologies are adopted by Singapore and Shanghai in lieu of current methods over a large scale, how will the *sector-level materials and energy inflows* and *outflows*, and their respective environmental impacts, change over the near (next 5 years) and long term (next ten years or more)?

d). In reaction to the findings to (c) above, how can we ensure that large-scale and long-term adoption of waste utilization technologies will result in lower negative environmental impacts?

Methodologies

LCAs will then be conducted to evaluate the environmental impacts due to these inflows and outflows. Generic LCA databases, such as Gabi and Ecoinvent, will be used to provide this information (in the form of life cycle inventory items). However, to ensure that data used is as specific to Singapore as possible, process and catalogue analyses will be done as well – that is, the inflows and outflows of waste utilization technologies will be quantified onsite.

The comparison of environmental impacts due to the current and proposed technologies will be done based on a functional unit (e.g. 1 kg of the food waste recycled). This will form the basis for estimating the difference in impacts when our proposed technologies replaced current technologies.

Scenario analysis will be applied to help scale up the waste utilization, and so the net environmental impacts, caused by the technologies. An example of such a scenario may be that by 2020, Singapore will target to recycle and utilize an additional 20% of its horticultural waste into compost, by applying a combination of AD and composting technology.

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