Can Waste Management Practices be Adapted and Aligned to Perform as Efficiently and Sustainably as *Ecosystem Services*?

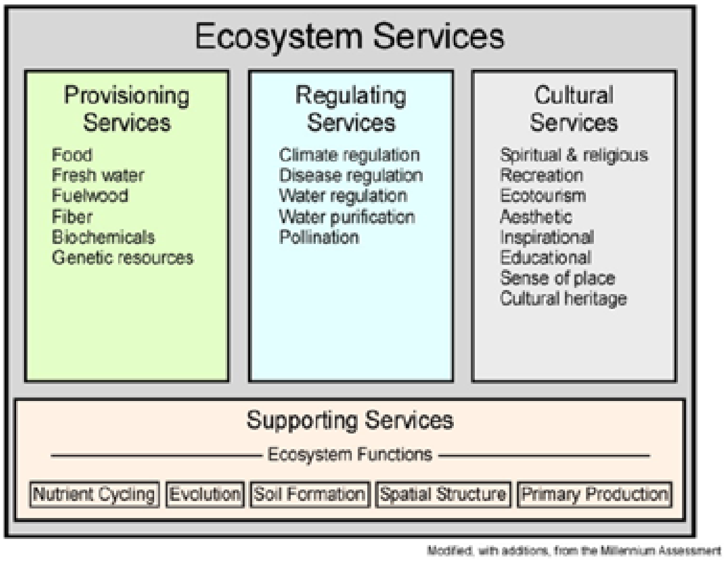
Carmen Nottingham. BA (Languages), HDPM (WITS), Permaculture, Organics, Earthworm Farmer, Earthworm Waste Management (NPO), Postgraduate studies UNISA (Dept. Environmental Sciences), South Africa. carmen@fertilis.co.za ; www.fertilis.co.za ; www.facebook.com/fertilis

ABSTRACT:
Human settlements both urban and rural are dependent upon the services of natural ecosystems, such as the provision of clean air, clean water, healthy soils and plants, regulated climate, decomposition and detoxification of wastes, and so on. Over the past 50 years a direct correlation has been found between human activities and severely threatened ecosystem services. One such consequence of human activities is how we deal with our Waste. Simply "dumping rubbish" is now seen as the last resort, according to environmental and waste legislation in South Africa and the adoption of the Waste Hierarchy ('cradle-to-grave' and 'cradle-to-cradle' principles). This relates to the handling of waste and pollution not as the *output*, but rather to design and plan them as "unused resources", or specifically, as *regenerate-able inputs*.

An ongoing case study is presented through a series of photographs. These show steps taken over an 18-month period towards the conversion of a 1ha property with dwellings to manage and align the waste outputs into ecosystem services. The design is based on Permaculture [1] methods which includes rain & roof run-off harvesting, grey water harvesting, sewage treatment, soil rehabilitation, organic crops and livestock, etc. These are the first steps illustrating a journey towards being "off-the-grid".

1. INTRODUCTION

The functions that ecosystems perform, such as the cycling of nutrients, formation of soils and biomass, are the SUPPORT functions (the foundation) for the PROVISION of food, fuel, water; and the REGULATION of climate, disease, water availability and quality, and even pollination. These functions also support us in a CULTURAL sense such as recreation, education, ecotourism, and so on. *See Figure 1*: the four categories of ecosystem services based on the popularised Millennium Ecosystem Assessment Report of 2005 [2].



The above concepts have been derived from a study published in Nature in 1997, which was one of the first major attempts to quantify ecosystems in monetary/economic terms: below is a quote from the Abstract:

"*The value of the world's ecosystem services and natural capital*" [3]: "The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. We have estimated the current economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. *For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US$16–54 trillion per year, with an* for 16 biomes, based on published studies and a few original calculations. *For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US$16–54 trillion per year, with an average of US$ 33 trillion per year.* Because of the nature of the uncertainties, this must be considered a minimum estimate.

Global gross national product total is around US$18 trillion per year."

According to this, the annual services that Ecosystems provide can be valued at *between two to three times the global Gross National Product.*

The 17 ecosystem services studied are tabled below:

Table 1 Ecosystem services and functions used in the above study

Nr Ecosystem service*	Ecosystem functions	Examples
1 Gas regulation	Regulation of atmospheric chemical composition.	CO_2/O_2 balance, O_3 for UVB protection, and SO_x levels.
2 Climate regulation	Regulation of global temperature, precipitation, and other biologically mediated climatic processes at global or local levels	Greenhouse gas regulation, DMS production affecting cloud formation.
3 Disturbance regulation	Capacitance, damping and integrity of ecosystem response to environmental fluctuations.	Storm protection, flood control, drought recovery and other aspects of habitat response to environmental variability mainly controlled by vegetation structure.
4 Water regulation	Regulation of hydrological flows.	Provisioning of water for agricultural (such as irrigation) or industrial (such as milling) processes or transportation.
5 Water supply	Storage and retention of water.	Provisioning of water by watersheds, reservoirs and aquifers.
6 Erosion control/ sediment retention	Retention of soil within an ecosystem.	Prevention of loss of soil by wind, runoff, or other removal processes, storage of stilt in lakes and wetlands.
7 Soil formation	Soil formation processes.	Weathering of rock and the accumulation of organic material.
8 Nutrient cycling	Storage, internal cycling, processing and acquisition of nutrients.	Nitrogen fixation, N, P and other elemental or nutrient cycles.
9 Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds.	Waste treatment, pollution control, detoxification.
10 Pollination	Movement of floral gametes.	Provisioning of pollinators for the reproduction of plant populations.
11 Biological control	Trophic-dynamic regulations of populations.	Keystone predator control of prey species, reduction of herbivory by top predators.
12 Refugia	Habitat for resident and transient populations.	Nurseries, habitat for migratory species, regional habitats for locally harvested species, or overwintering grounds.
13 Food production	That portion of gross primary production extractable as food.	Production of fish, game, crops, nuts, fruits by hunting, gathering, subsistence farming or fishing.
14 Raw materials	That portion of gross primary production extractable as raw materials.	The production of lumber, fuel or fodder.
15 Genetic resources	Sources of unique biological materials and products.	Medicine, products for materials science, genes for resistance to plant pathogens and crop pests, ornamental species (pets and horticultural varieties of plants).
16 Recreation	Providing opportunities for recreational activities.	Eco-tourism, sport fishing, and other outdoor recreational activities.
17 Cultural	Providing opportunities for non-commercial uses.	Aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems.

Simply put, the planet is a giant life-supporting and self-sustaining organism. Everything on, in and around it is connected in a myriad of intricately complex ways and systems, forming part of the cycles of life, death and regeneration. Natural systems *tend to* flow in continuous cycles, where the output of one thing provides the input for something else.

Some examples of these cycles are: plants use sunlight and carbon dioxide for photosynthesis. The 'waste product' is oxygen, which we inhale and provide the plants in turn with carbon dioxide.

On a global scale the forest systems are the lungs of the planet. Ancient forests have formed the fossil fuels that have used (depleted?) to build this civilisation. Water (H2O) is constantly cycled whether in the form of ice, liquid or gas.

Waste management within natural systems exists *differently* to the methods that are used in human settlements. We create landfills, rubbish dumps and islands of waste floating in the middle of the Pacific ocean, not to mention radioactive toxic dumping grounds worldwide, or oil slick accidents – the list is extensive. The challenges that we now face are to adapt and align our living practices (and hence waste management) within the cyclic regenerative and rehabilitative services of natural systems.

This raises many questions: "How possible is it to do so? On what scale? Where do we start?"

2. The Past: Economy versus Ecosystems
The Future: Economy of Ecosystems
The Present: Transition

Within the past 20 years, SA's legislation on the Environment and Waste has become extensive and forward-thinking. These acts and laws are slowly filtering into the market-place of everyday living and 'business-as-usual'. Green consumerism and green capitalism have evolved since the popularisation of the Millennium Development Goals of "People, Planet & Prosperity" – or in other words: Social, Environmental and Economic 'development'.

Companies that conform to these standards of triple-bottom-line reporting receive higher ratings by the Johannesburg Stock Exchange.

We are in a transition phase, where it is evident that in order to see Renewable Waste Projects become viable and mainstream a healthy and equal combination of scientific facts, political will (therefore investment) and individual actions are needed.

One such example in South Africa is the campaign run by GreenPeace (2013/2014) for the implementation of renewable energy in the face of continued and greater government investment into coal and nuclear. (www.greenpeace.org/renewableenergy)

This campaign gives sound and feasible answers to the 6 main arguments used by Government against RE, effectively showing that a clean, green economy is "viable, reliable and ready-to-go" and can be phased in almost immediately: (RE = Renewable Energy)

RE is too expensive	38000 jobs can be created by RE. There are substantial hidden costs in coal & nuclear
RE is still science-fiction	Germany and Portugal use 75%+ electricity from RE
RE can't supply 24 / 7	RE can – with a mix of solar, wind, natural gas, anaerobic digesters
SA grid can't handle RE	The existing grid needs repair and replacement. Investing in a SMART grid is more feasible.
RE is bad for environment	Coal / nuclear pose greater danger
Can't turn off coal / nuclear today	Not necessary. A phased plan started now will result in 94% RE by 2050

As of end May 2014, Germany received 75% of its electricity from renewable energy resources: considering its climate, this proves a powerful point. Portugal already uses 70% from renewables. And South Africa? We are rated the world's 3rd best location for solar power – what are we waiting for?

3. GLOBAL REALITY – LOCAL APPLICATION

RE (Renewable Energy) and the 5 R's: RE-think RE-use RE-duce RE-cycle and RE-generate are people-powered as well as being aligned to ecosystem values and services.

People-power is made up of individuals making choices and thereby collectively, acting accordingly.

In Permaculture terms, one creates one's own change by literally starting outside one's kitchen door.

If we were to suppose that the current definition of N.I.M.B.Y (NOT in my backyard) describes past waste management practices; then the RE, or future definition of N.I.M.B.Y would be "NATURALLY – IN MY BACK YARD". The remainder of this paper illustrates this point: a series of photographs recording steps taken will make up a power point presentation for the WasteCon conference in October.

Case study: 120 Lourens drive

Since December 2012, we have embarked on a project to 'retro-fit' a one hectare property towards the ultimate goal of running off-the-grid, without extensive capital input, and to be self-sustaining. As far as is possible, each step that has been taken along the way was investigated at the time to be as cost effective, feasible and possible to be implemented by the average person and in the broadest sense of fitting in with the Ecosystem Services outlined above and within the methods of Permaculture. It is too early to make any quantitative analyses – data will be collected over a minimum period of 2 years

The two most relevant services regarding this paper are the Supporting and Regulating services. We will also mention the Provisioning and the Cultural services as far as they relate to the waste recycling activities.

4. SUPPORTING SERVICES

Garden waste on average can form between 40 to 70% of landfill waste (excluding the extra costs of collection, transport and disposal). This is a valuable resource which builds the foundation of ecosystem functions – the support.

4.1 Soil Formation

The soil on the property was very sandy and compact, typical of highveld grassland, with severe erosion and lacking in nutrient quality. Through the accumulation of organic material (constant application of horse stable muck from the neighbours, earthworm compost, and mulch); through erosion control structures such as terraces and swales, soil rehabilitation has shown positive results.

4.2 Nutrient Cycling

All garden "waste" is composted. No trees have been cut down unnecessarily, and any cutting back has been stockpiled for re-use: firewood, compost heaps, mulch, etc. Biomass is encouraged and with the above soil formation measures, nutrients cycle from the plants to the soil, through water and osmosis, back up to the plants. Photosynthesis in the leaves creates energy, more nutrients, transpiration occurs affecting the climate and helping to create precipitation, all the while biological cycling of wastes is incorporated and the cycle renews with ever greater efficiency as the system evolves.

4.3 Biological Control / Pollination

- The more elements introduced that can co-exist the greater the evolution into a stable environment occurs. Bat houses, bird logs and owl boxes have been placed in strategic areas.
- Bees were introduced and given a hive near the orchard.
- Chickens were introduced and allowed to roam and free-range over the total property for the whole of the first year (except in the earthworm trenches, obviously). This effectively allowed them to forage in the mulched soils, to control insects, and to fertilize at the same time.
- Natural wildlife in the form of animals, birds and insects also increased during this time as the services established.

5. REGULATING SERVICES

This includes water regulation, water purification, waste treatment, climate regulation.

5.1 Water Regulation

The regular application of thick layers of mulch to all exposed soils and the measuring and digging of swales to trap, spread and sink rainwater has helped to build up the underground water supply. (photo's)

5.2 Water Purification and Waste Treatment

Grey water: Water from the kitchen sinks, the washing machine, the basin and bathroom is channeled into a pit which has water plants and acts as a reed bed/ wetland. This seepage feeds downslope to replenish the underground soil for the veggie, berries and crop garden areas.

Black water from the toilets is channeled to the biogas digester. (photographs). It is treated anaerobically by the micro-organisms and creates biogas which is piped to the kitchen for cooking. The liquid outflow from the biogas bag is effectively treated water. This flows into the previous septic tank container. From here it is pumped out regularly for the watering of the fruit trees, the mulched soil and the compost heaps. This helps to create further breakdown of any possible pathogens. For obvious reasons, we do not use this water directly on any vegetables.

5.3 Waste Treatment – Other

Recycling, reuse and reduction of 'external' inputs occurs regularly. Very little is collected by the municipality. The dry recycling (paper, plastic, metal, glass) goes to the buy-back centre in Diepsloot, thus supporting local community initiatives.

All kitchen waste is placed into earthworm bins, both small and large, and composted. Garden waste is mixed with horse manure and composted for use on the soils. The dog 'poops' are converted by earthworms in a separate bin. (Earthworms folder)

The main income generation for the property is the production of Fertilis earthworm castings. Trenches have been established where earthworms convert cow manure into castings, which are packed and sold. (Earthworm trenches folder).

Horse manure is a free commodity in large supply from the neighbours. Trials have been carried out with earthworms to convert horse manure, however, it seems to work better in the biomass compost heaps (for creating hot water flow to the geysers), in normal compost production, and using it as mulch. Horse manure is in large supply, which is regularly spread onto the soils in a thick layer as mulch. This effectively adds to the ecosystem supporting services……

5.4 Climate Regulation

In the design and planning of the different areas and structures, use is made of niches and micro-climate areas. For example, hardy plants and trees are placed out in the open, whereas sensitive plants are protected. Orientation, position and slope are taken into account as well as the links between them. The entire property is surrounded by tall trees. No existing trees or plants have been removed (whether 'alien' or indigenous) because the trees have created a canopy for birds and wildlife, as well as being an effective windbreak. The natural veldgrasses have been encouraged to grow. (photographs: From 'garden' to nature and veld folder).

6. PROVISIONING SERVICES

As far as is possible, the provision of energy, water and food is derived from the previous ecosystem services, such as soil rehabilitation water harvesting, waste treatment, etc.

6.1 Energy

The greatest energy consumption needs are: the stoves for cooking and the geysers for hot water.

The costs to install a complete solar system upfront were prohibitive, since the major costs involved are the batteries and inverters. The electricity power supply to the property is currently recorded on a digital meter. An analog meter would have worked with solar panels, since the meter would be able to run backwards, effectively removing the cost of needing to install batteries. (However, technically, this is illegal, but then so was the installation of a biogas digester).

Energy for Cooking comes from the biogas digester (photos from Biogas folder)

The energy needed to heat the geyser water is greatly reduced by directing the water pipes through compost heaps. The water running through the pipes in the compost heaps provide hot water straight into the geyser when the hot water taps are opened. The thermostat is kept at 50 degrees C, thus saving electricity. The shower heads are low-flow. (photo's from Biomass folder)

Lighting: all bulbs are energy savers and LED.

House insulation: Ceilings have insulation and the walls are double-bricked.

Double glazing the large windows facing north was too costly: therefore thick floor-to-ceiling curtains were hung for evenings. During the winter day the sun heats up the cement floors through the large windows, trapping heat and warming the area.

In summer the sun does not enter the house and there is good cross-ventilation for hot summer days.

6.2 Water

There is no borehole, the water supply is currently municipal.

Water is harvested from rain roof runoff into 3 x 5000 litre tanks. This is used for irrigation purposes (Water tanks folder)

Storm water run-off is channeled onto the property from the road (Water harnessing folder).

This water is then directed into swales, which run across the slope of the property along contours. The water spreads and sinks, thus building up the underground water supply which will over time filter to the future dam, envisioned at the bottom of the property (Swales folder)

If and when a borehole will be needed, the underground water supply will be readily available and also regularly replenished.

6.3 Food

Vegetable / herb gardens were planted (Veggies, fruit & herbs folder)
Orchards – trees and vines were planted.

Chickens provide eggs, pest-control and food (orchards & chickens folder)

Fish: The swimming pool is being slowly converted into a pond, with the creation of floating islands of water plants as a bio-filter and the addition of Tilapia fish which are edible (Pool to Green Pond folder).

A dam has been shaped and dug out at the bottom of the property and the water run-off and rainwater is being directed towards it.

Aquaculture with Chinampas and aquaponics are longer-term goals.

7. CULTURAL / EDUCATIONAL SERVICES

This project is evolving towards the next step: to serve as a demonstration site to inspire those seeking to align themselves more with nature within an urban environment. In the near future, hands-on and practical workshops will be offered.

8. CONCLUSION

Waste Management practices have undergone change from a simplistic "dump" (literally) into a hierarchical structure, even though waste is still largely managed as an afterthought. This will transition to the next step: where "waste" will be seen as regenerate-able inputs / outputs that can be incorporated into the planning and design aspects of a project. The management of waste will become more integrated right from the start.

This paper has not sought to apply answers to all waste and the large-scale management thereof, (radioactive, toxic, diseased, etc) but I do believe that over time, as society's practices evolve, bio-technology will afford us the answers to deal sustainably on a large scale with all human activity output.

The waste management activities shown in this case study, where photographs have been taken over time, proves that, no matter how small the scale or simple the application, waste management practices can be aligned to Ecosystem Services. It is simply a matter of desire and application to enlarge the scope of this paper to apply to large-scale activities. If it is feasible and possible to be implemented by individuals, then it is only a matter of time before it can be applied within groups, workplaces, communities, cities, provinces, countries, and to grow from there. Wherever there is Value, it can be nurtured to Grow into a Sustainable system.

REFERENCES

[1] Permaculture Design Manual and Introduction to Permaculture Handbook by Bill Mollison.

[2] United Nations Environment Programme, www.unep.org/ecosystem management

[3] Costanza *et a*l (1997), the value of the world's ecosystem services and natural capital, *Nature magazine*, volume 387, pages 253 – 260.