Vermicomposting: The Future of Sustainable Agriculture and Organic Waste Management

Lessons from the USA & Cuba

Anna de la Vega

Winston Churchill Memorial Trust Fellow 2016

Vermiculture sign, Finca de Paradise, Pinar del Rio, Cuba, 2016

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SUMMARY

The rising economical and environmental cost of agricultural chemicals, coupled with the ever increasing cost of landfill calls for a reorientation of management. The process of utilising surface dwelling species of earthworms to efficiently and ecologically break down organic waste, producing a superior organic fertiliser as a by product, referred to as vermicomposting, is successfully providing sustainable solutions in food production and organic waste management in the USA and Cuba. The integration of vermicomposting in agriculture and mainstream waste management presents economical, environmental and social benefits for the UK, building resilience in response to the impacts of climate change, natural resource depletion, and desertification.

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The nation
that destroys its soil
destroys itself.

Franklin D. Roosvelt

Introduction

Climate change, natural resource depletion and desertification present very real challenges for the future of food production, within the UK and throughout the world. The foundations of all life are held within the soil, yet for too long our agricultural practices have failed to recognise this interconnection, resulting in alarming levels of topsoil depletion. Every minute we are loosing 35 football pitches of fertile land, equating to the loss of 75 billion metric tons of fertile soil per year (Shiva, 2015). The reality stands that 70% of global topsoil has been lost leaving a mere 60 years before total depletion (Crawford, 2012). Global exploitative industrial agriculture, reliant on the excessive use of agrichemicals is attributed to be the key contributor to the widespread destruction of the soil and is accountable for 50% of total GHG emissions (Koont, 2011).

Whilst the invention of synthetic fertiliser was once celebrated as genius, winning the chemists Fritz Haber and Carl Bosch the Nobel Prize in 1918 for doubling crop production, the reality of dependency on limited natural resources undermines national and global food security. The production of the synthetic fertiliser known as NPK (Nitrogen, Phosphorus and Potassium) is reliant on the increasingly costly process of mining phosphate rock. Global phosphate reserves are known to reach complete exhaustion within the next 50—100 years, hitting peak extraction by 2030 (Cordell et al, 2009). Since 2006 the price of phosphate has doubled and between 2007—2008 the cost of synthetic fertiliser rose 800% (Tomlinson, 2010) coinciding with the global food crisis leading to riots in 40 countries (Brown, 2011). Due to high levels of depletion the USA and China have halted all exports of the resource, today Morocco hold 80% of the worlds total phosphate reserves, with none to be found in the UK or Europe.

There has never been a greater need to address and work towards finding and implementing practical solutions that assist in responding to food insecurities undermined by water scarcity, peak oil, peak phosphate and peak soil. Furthermore we are facing an ever increasing swell of urbanisation, with 2/3 of the worlds population expected to inhabit cities by 2025. Localising food production within the urban environment becomes a necessary component for building food secure cities.

Breeding facility, Eisenia Fetida, aka Tiger Worms or Red Wigglers. Monroe Correctional Complex, Monroe, Washington, 2016

It is the belief that harnessing the power of the earthworm to provide the foundations to transform our food system that underpins the purpose of this research. Worm composting, otherwise known as vermicomposting delivers the foundations for building a local organic food movement that simultaneously provides sustainable solutions in organic waste management.

As a commercial enterprise vermicomposting in the UK was first introduced in the 1980's although today it remains to be a relatively under utilised process for managing organic waste and for application in agriculture. Throughout the world however it is gaining great momentum; one facility in Australia is processing 200 tons of human waste a week and India now boasts over 200,000 worm farmers, generating livelihoods and building resilience against the rising cost of synthetic agrochemicals.

Here research explored vermicomposting in the USA and Cuba. Research in the USA primarily focused on the application of vermicomposting in institutional onsite organic waste management including visits to mid-large scale commercial worm farms. Although vermicomposting throughout the USA is fast developing and becoming a growing area of enterprise research undertaken focused on the West Coast, an area with the highest density of vermicomposting programmes, with two additional visits to upstate New York.

In political and cultural contrast to the USA research in Cuba focused on the role of vermicomposting as an integrated model within agriculture, looking at both urban and rural farming within the private, co-operative and state governed sector. The majority of research was undertaken in La Havana with additional visits to Pinar del Rio and Sancti Spiritus.

1. What is Vermicomposting?

Vermicomposting (vermis from the Latin for worm) is the process of harnessing earthworms to break down organic waste, producing a nutrient rich, organic fertiliser and compost as a byproduct. Worm manure, otherwise known as worm castings or vermicompost is rich in minerals, nutrients and beneficial microorganisms essential for healthy plant growth and disease suppression. Due to the nutritional superiority of worm castings farmers and gardeners often refer to it as 'Black Gold', with a particular reference to its high market value.

Baby Eisenia Fetida aka Tiger Worms or Red Wigglers, it takes 60 days to reach sexual maturity. Santa Monica Community College, Santa Monica, California, 2016

Among the 8000 known species of earthworm only seven are suitable for use in composting, all belonging to the epigeic category. Throughout the world the most commonly employed species is the Tiger Worm, sometimes referred to as the Red Wiggler or Californian Red (Eisenia Fetida). Native to Europe the Tiger Worm has exceptional adaptability and tolerance to a range of food sources, temperature variation (12—35°) and moisture content (60—90%). A prolific breeder the Tiger Worm has the capacity to double its population every 60 days and consume up to half their body a day, particularly suitable for the application in the management of organic waste.

Vermicomposting for Agriculture

The value and importance of earthworms in agriculture was first recognised in writing by the father of ecology Charles Darwin, who in 1881, one year before his death published his findings in The Formation of Vegetable Mould through the Action of Earthworms. With an understanding of the intrinsic relationship between soil health and human sustenance he famously declared.

"Worms are powerful than the African Elephant and are more important to the economy than the cow".

Darwin calculated earthworms to produce 10 tons of humus per acre (Darwin, 1945) although Sir Albert Howard, (Howard, 2006) the early pioneer and advocate of organic agriculture later thought this figure to reach 25 tons per acre. There now exists vast volumes of publications on the importance and benefits of earthworms in agriculture and for their role in organic waste management. Notably, and with great relevance earthworms have the capacity to produce one inch of top soil in five year's, where under natural processes would take 500—1000 years (Oliver, 2009). With global topsoil under severe threat the earthworm has the potential to rebuild what we have lost.

Containing a rich nutrient base worm castings boast an abundance of beneficial minerals, nutrients and microorganisms essential for healthy plant growth and disease suppression and supply a necessary source of humus. According to research conducted by the Connecticut Agricultural University worm castings contain 50% more humus, five times more nitrogen, seven times the soluble phosphate, and 11 times more potassium than the average topsoil (Bikle and Montgomery, 2015).

Table 1. Benefits of Worm Castings

Direct Use	The only fresh manure not to scorch plants. Seeds can be sown direct in 100% worm castings.
Healthy Plant Development	Calciferous glands of the earthworm excrete calcium carbonate in worm castings, essential for the development of strong cell walls and for the absorption of nitrogen.
Slow Release	Concentrated nutrient base that slow releases as and when required by the plant.
Moisture Retention	Holds up to 50% moisture, building resilience against drought and heavy rainfall as a result of climate change.
Optimal Growth	Contains auxins and cytokinins, growth hormones promoting fibrous roots and healthy plant development.
Disease Control	Contain beneficial fungus eating nematodes.
Pest Control	Contains high levels of chitinase, a natural insect repellent.

Highly Concentrated	Teeming with beneficial soluble minerals.
Improves soil structure	Cylindrical shaped worm castings prevent compaction, aiding drainage and root development. Worm castings create aggregates that protect against soil erosion. Reduces acidity, neutralises PH.

There is a growing area of research and interest in the application of earthworms in the remediation of contaminated agricultural land. Bacteria found in the gut of an earthworm detoxifies pollutants, and secreted coelomic fluids destroys pathogens. The process referred to as vermiremediation has successfully shown to reduce contaminates of heavy metals, DDT's and PCB's (Bharambe et al, 2008).

Organic Waste Management

The Tiger worms ability to consume up to half its body weight a day whilst reducing the volume by 50—90% presents vast solutions for the sustainable management of a wide number of organic wastes. From dog excrement to food waste the Tiger worm can culture and adapt to a range of sources of organic material, notably some are more favourable than others requiring no pre-processing.

Addressing food waste, both within the home and within industry is vital when addressing issues surrounding

climate change. Food waste emits the green house gases GHG methane and nitrous oxide being 31 and 310 times stronger than carbon dioxide. Vermicomposting has the potential to reduce GHG emissions by significantly reducing the volume of food waste directed to landfill, which consecutively alleviates the necessity for fossil fuel driven vehicles.

The odourless mesophyllic (below 30°) process of vermicomposting can be practiced on a very small indoor scale, making desirable for the urban, densely populated environment. The size and level of sophistication of available vermicomposting systems varies greatly from domestic to industrial however one can be established on a very low budget.

On farm vermicomposting using animal manures as feedstock reduces the risk of run off and leaching into groundwater.

Table 2. Advantages & disadvantages of different organic materials for worm food

Organic Material	Advantages	Disadvantages
Cattle Manure	Excellent, easily cultured by worms for maximum reproduction and a high quality end product.	Pre-composting necessary to eliminate weed seeds.

Horse Manure	Excellent with a rich source of carbon.	Moisture needs to be monitored, can dry out due to high straw content. Pre-composting for 1—2 weeks necessary to eliminate weed seeds.
Sheep Manure	Good nutrition	Pre-composting required necessary to eliminate weed seeds.
Poultry Manure	High Nitrogen content, good nutrition and a high quality end product	Rich in ammonia, pre-composting required
Pig Manure	Excellent worm feed, considered the best manure for culturing worms with an excellent quality end product. No pre-composting required.	Foul odour.
Rabbit Manure	Ideal worm feed, high nitrogen and a balanced mix of vitamins and minerals.	Can over heat if fed in large quantities.

Food Waste	Excellent nutrition and moisture content. Can manage pre and post consumer food waste.	Strict food sorting required. Food with high fat content can cause anaerobic conditions and large volumes of acidic food (onion, citrus) needs to be restricted. Waste needs to be processed into smaller pieces when being practised on a large scale for efficient waste management.
Dog Waste	Reduces pathogens.	Takes the second generation of worms to fully adapt to the food source. Due to risk on contamination can only be used to fertilise non edible plants.

Aquaculture and Poultry Farming

Earthworms contain high volumes of protein (60—70%), amino acids, niacin, lysine, methionine, phenylanine, vitamins and B12. These qualities are desirable for feed stock within the aquaculture and poultry farming industry. In the UK earthworms are largely bred for bait for retail within the fishing

community however the application of vermicomposting for the production of feed for livestock creates opportunities that empower a sustainable food system. The growth of enterprise in aquaponics, where systems are utilising fish waste to fertilise plants provides a suitable avenue for the introduction of a vermicomposting system to compliment the sustainability of the process.

2. Lessons from the USA

Sharing a similar cultural climate to the UK, the USA provided the foundations for the transfer and replication of appropriate vermicomposting programmes that tackled the diversion of food waste from landfill sites. In the USA 1/3 of food is wasted every year, equating to 1.3 billion tons, costing the economy $3 trillion. In comparison, despite being a considerably smaller country the UK discards over 1/3 of food waste annually. Not exclusive to the management of onsite food waste, lessons from the USA included solutions for animal waste and the potential opportunities for enterprise in vermicomposting. Five case studies have been selected here.

Monroe Correctional Facility, Monroe, Washington

Feeding the worm beds, Monroe Correctional Facility, Washington, 2016

As part of the Sustainability in Prisons Project the Worm Farm at Monroe Correctional Facility is working beyond onsite organic waste management. The Worm Farm has not only become an educational hub for institutional vermicomposting, it has reached commercial capacity, distributing worms and wormeries to other correctional facilities, organisations and schools throughout the US, free of charge.

Initiated as a means to reduce tipping fees the programme is currently diverting 10 tons of food waste every month equating to savings of $100,000 since its inception in 2010. The indoor vermicomposting facility houses wormeries made from reclaimed materials covering an area of 13,000 ft2. The programme was established on a minimal budget starting with 200 worms, which has now grown to 9 million.

Nick H, The Worm Farm, Monroe Correctional Facility, Washington, 2016

The success of the project can be attributed to the engagement of inmates, namely Nick H otherwise known as the 'Worm Dude' who runs the facility full time. Nick demonstrated the passion and desire to spread awareness about climate change and topsoil depletion and recognised the importance of potential enterprising opportunities for inmates after release. Nicks passion was inspiring and the success of the programme can be attributed to his commitment and to the support of members of staff.

Whilst vermicomposting is successfully managing a significant proportion of prison food waste worms cannot easily handle meat, dairy or large quantities of bread. Through research and experimentation Monroe has introduced

composting using 'Black Soldier Fly larvae, an incredibly efficient organic waste management process, the flies consumed the bones of a rat and a chicken over the course of two days. Whilst this process has little public appeal the larvae provide a great source of protein and are favoured by reptiles and birds, Monroe are now supplying Seattle Zoo with a steady supply. Although the waste from the flies is not as superior as worm castings due to the high ammonia content, it is fed back to the worms produce a high value fertiliser. In addition to vermicomposting and Black Soldier Fly Monroe are also experimenting with bokashi composting.

Team work. Worm farmers Mark Purser from The Worm Farm with Dave Royal from the Earthworm Soil Factory, Chico, California, USA, 2016

The Worm Farm offers a blue print for other correctional facilities to follow as the programme provides vast social, economic and environmental benefits for the wider community. In addition to relieving prison tipping fee expenses the Worm Farm is supplying 5000 gallons of worm casting tea every month to Monroe County Government for use in public spaces, eliminating the need for synthetic fertiliser. Inmates are also growing plants using worm castings for hanging baskets, offering further savings for local government whilst greening public urban areas.

Portland Community College, Portland, Oregon

Every year Portland Community College offers students the opportunity to pitch for up to $20,000 from The Green Initiative Fund, allocated from a proportion of tuition fees. On request of the students the faculty invested in a food macerator and a 5ft×8ft flow through vermicomposting system designed and manufactured by Sustainable Agricultural Technologies Ltd. In 2016 13,615 lbs of food waste was processed onsite and applied as a nutritional soil amendment within the 3.4 acre Portland Community College Learning Garden (PCCLG).

Elaine Cole, Sustainability Coordinator, Portland Community College, Portland, Oregon, 2016

Last year the garden produced 1200 lbs of fresh fruit and vegetables supplying the college canteen and sold to the college community at a weekly farmers market from April–October. As part of a Work for Food programme volunteers in the PCCLG can exchange one hours work for $5 to spend at the campus farmers market, food stamps can also be exchanged.

The success of the vermicomposting programme and PCCLG is attributed to the college's investment in sustainability, employing a Sustainability Coordinator, Learning Garden Coordinator, two Student Sustainability Leaders and two

Learning Garden Educators recruited through Americorp. The programme engages the wider community and has recently begun working with K12 elementary school children. Due to a high turnover of students at community colleges consistent education and training is key, which is driven by the commitment of the Sustainability Coordinator Elaine Cole.

Learning Garden Educator Blair Borax harvesting vegetables for the college, Portland Community College, Portland, Oregon, 2016

Woodland Park Zoo, Seattle, Washington

In addition to saving $100,000 in tipping fees every year Woodland Park Zoo is operating a commercially successful enterprise through the sale of 'Zoo Doo', a highly sought after artisan compost produced from the manures of 24 non primate herbivores. Due to the popularity of 'Zoo Doo' the zoo have had to introduce an 'Endangered Faeces' online lottery system, distributing the 270 tons to individual customers limited to 100 gallons at a cost of $40.

Although the zoo have been producing 'Zoo Doo' since 1985 the introduction of vermicomposting is relatively new with sales of 'Worm Doo' only launching last year. Vermicomposting

is practised using home made systems utilising old plastic containers, without the need for any financial investment. The programme has proven to be a great contribution to the zoo's horticultural activities, in particular in the production of wheat grass grown to feed the animals, completely eliminating the use of synthetic fertilisers. Interestingly the application of worm casting tea, also used as a liquid fertiliser is successfully being used to eliminate foul odours from the feline enclosures.

Dan Dorum, aka Dr Doo, Woodland Park Zoo, Seattle, Washington, 2016

Worm Power, Rochester, New York

The largest vermicomposting operation in the world, Worm Power is successfully processing the manure from 8,000 cows a day, equivalent to the municipal solid waste produced from a city of 40,000 residents. Founded in 2003 by Tom Hurley, a consulting engineer in waste management Worm Power offers a blueprint solution for industrial manure management. demonstrating the potential for two agricultural enterprises to work in symbiosis. Coyne Farm and Worm Power are situated adjacently, modelling the potential for two agricultural enterprises to work in symbiosis.

Manure from Coyne Farm is processed through a screw press, diverting liquid to their 1 million gallon lagoon and used to fertilise cornfields producing grain for cattle feed, with solid waste managed by Worm Power.

Industrial mechanised vermicomposting beds, Worm Power, Rochester, New York, 2016

Worm Power is a heated indoor mechanised operation of 18 vermicomposting beds measuring 160ft×8ft×2ft housed in three separate buildings producing 450,000 lbs of worm castings annually. To maintain consistent efficiency buildings are heated at 17 degrees—23 degrees and each bed is fed 2000 lbs a week. Due to OMRI certification manure is pre-composted before being fed to the worms and must reach over 145 degrees over a minimum of three days to kill any trace pathogens.

Worm Power received significant government funding for research and development as a response to the grave environmental degradation caused by industrial dairy and cattle farming. Methane emissions from cow manure is 31 times stronger than carbon dioxide and run off leaches into ground water, contaminating rivers, destroying aquatic life and polluting fresh water supplies. Transforming a waste product into wealth Worm Power are supplying the high value horticultural market with worm casting tea and worm castings, including the turf, hops, tomatoes, berries and medical marijuana industry.

Vermicompost sacks ready for brewing vermicompost tea, Ted Miller, Technical and Marketing Manager, Worm Power, 2016

The Worm Farm, Durham, California

A family run operation The Worm Farm is a highly successful enterprise supplying worms and worm castings throughout the world. In contrast to the high mechanisation of Worm Power The Worm Farm adopts the simple and cost effective out door method of windrows, operating with 12×300ft and 4×125 ft long rows covering an area of 5 acres. Each windrows is fed 450 lbs each every two weeks with cattle manure collected from a dairy farm 20 miles away.

The temperate climate of California in comparison to up state New York affords less inputs in maintaining the temperature for the maximum cultivation of worms. Notably it was The Worm Farm who supplied Worm Power with 2750 lbs of worms in 2005 to establish the operation. The Worm Farm now ships 120 lbs of worms a week, reaching 500 lbs a week during the spring commanding a market price of $28.50 per lb. In addition to worm sales on average the farm ships 13 trucks holding 40 yards of worm castings each per week retailing at $200 a yard.

The Worm Farm's success has earned owners Mark and Arlita Purser significant media attention, featuring on Blue Collar Millionaire and True, Weird and Freaky. This publicity led to great public interest in establishing a worm farm and now Mark runs one-day commercial farming workshops at a cost of $1000. There are now 11 worm farmers within a radius of 50 miles of Durham, 8 of those are within 20 miles. The demand for worm castings is high within California in particular for the medical marijuana industry since the passing of Proposition 215 in 2004.

Vermicomposting windrows, The Worm Farm, Durham, California, 2016

The Worm Farm is not only a successful enterprise it is a family community in itself with 10 homes surrounding the farm, including one employee living onsite. The philosophy of community is revealed by Marks establishment of The Worm Farm Learning Foundation, a not for profit entity hosting up to three schools a month free of charge. Schools travel up to 100 miles for a visit, typically from towns without gardens providing children with an invaluable learning experience.

Reflections from the USA

The integration of vermicomposting into mainstream agriculture and organic waste management provides an exemplarily case for replication in the UK. Albeit research was condensed to the West Coast and New York, throughout the USA there is a growing movement of awareness and consciousness for the need to find an ecological alternative to fossil fuel dependent agriculture and organic waste management.

Resource scarcity is evidently a driver for the growth of vermicomposting, reflected in California's thriving worm farming culture. A state suffering with 98% drought and 44% in exceptional drought, as a response Californian governance in 2014 introduced mandatory composting for businesses and institutions under legislation AB1826. The 5th largest producer of food in the world and supplier of 43% of the nations food, drought in California presents a serious threat to global food security. Hearing stories of small-scale organic farmers in Santa Barbara forced to abandon farming due to the high expense of water highlights not only the fragility of our food and farming system but the injustice in the disparity of wealth for those most vulnerable to resource scarcity and climate change. Whilst the rich and famous of Santa Barbara continue to maintain their mansions and swimming pools, scarce natural resources are consumed by the elite few, mirrored throughout the world.

Governance of the USA transgressed whilst undertaking this research, with the newly appointed leadership from Donald Trump raising grave concern for ecological advocacy and the acceleration of climate change, undermining global food security. Trump's denial of drought in California does little to address the severity of the situation, however there is a shift in conventional farming occurring.

Bruce Elliott, owner of Sustainable Agricultural Technologies Ltd designs and manufactures industrial vermicomposting and vermicompost tea brewing systems supplying conventional farmers throughout the world. Learning of conventional farmers converting to the use of vermicompost and vermicompost tea in pursuit of a more cost effective, safe and resource efficient alternative to synthetic agrochemicals provides the foundations for a true shift in agriculture, and organic waste management.

Selected case studies from the USA illustrate the vast spectrum of benefits vermicomposting serves from thriving opportunities in enterprise to institutional savings. Beyond finances vermicomposting provides a means to renew connection with the earth, fostering respect and value for the soil, in particular within urban societies. Introducing vermicomposting into mainstream waste management provides education on mass into all areas of society, not restricted to the organic movement, making way for a shift in thought and consciousness regarding the value of natural resources.

2. Lessons from Cuba

Cuba is often heralded as a nation that survived peak oil, and by necessity has come to be known as a global leader in the organic movement, for which vermicomposting played a key role. The collapse of the Soviet Union in 1989 suddenly left Cuba without 80% of its imports in synthetic fertilisers, 50% of its oil and 53% of its food imports (Mayling & Roach, 2008). This time referred to as the "Special Period in Peacetime" inflicted war like rations upon the country seeing the average Cuban loosing 20lbs (Sinclair and Thompson, 2001). Prior to the collapse industrial sugarcane farming took precedence over food production and agrochemicals were being applied in quantities double to that was being used in the USA. These practices resulted in soil erosion, compaction, salinization, water logging, pest resistance and environmental contamination (Rosset & Benjamin, 1994).

A rapid shift in agricultural practices, implemented through government led initiatives and education programmes resulted in 172 vermicomposting programmes being established by 1994. The advent of vermicompost realised a highly efficient method of agriculture where 4 tons of vermicompost replaced the need for 40 tons of cattle manure per hectare.

Urban agriculture provided the foundations for food security for city residents, without readily available fossil fuel for transportation from the countryside urban spaces, including redundant car parks were transformed into Organicoponicos; intensive urban farms. In Havana alone 7,718 hectares of land is under agricultural production, with 90,000 urban residents involved in some form of agriculture.

Irrespective of the cultural and political differences the UK shares Cuba's island demographic, highlighting the fragilities of dependence on food imports and synthetic

fertilisers. Cuba models the potential for conversion from industrial energy intensive agriculture to a low input organic model. Three projects have been selected as case studies demonstrating the capacity for vermicomposting to play a significant role in food security and resilience.

Vivero Alamar Organoponico, Havana, Cuba

The second largest Organicoponico in Cuba, 15km east of Havana UBPC Vivero Alamar covers an area of 26 acres, 7 of which are under food production, supplying urban residents, schools and hotels with 625 tons of fresh fruit and vegetables every year.

Polytunnels, Vivero Alamar Organicoponico, Havana, Cuba

The onsite vermicomposting system utilises the simple windrow method and sheltered from the sun with a canopy. Six windows measuring 15 metres × 3 metres with a depth of 60cm, hosts 200,000 worms every metre squared produces 300 tons of worm castings annually. Worms are fed using the manure from 7 horses and 13 bulls located onsite. Fresh manure is added every 15 days in 10 cm layers, intensively producing worm castings for harvest every 60 days. Approximately 5 tons of worm castings are sold to the local community every year for domestic use at a cost of 10 Cuban Pesos per kilo.

Vermicomposting beds, Vivero Alamar Organicoponico, Havana, Cuba, 2016

Prior to the collapse of the Soviet Union synthetic fertiliser was purchased at a cost of $40 a ton, today 1 ton of organic fertiliser costs $0.55 to produce. Conversion to organic agriculture has been calculated to have saved Cuba $39.5.

Finca de Casimiro, Sancti Spiritus, Cuba

Established in 1993 Finca de Casimiro was the first permaculture farm in Cuba, founded upon the principles of cooperation, community and respect for the land. Today the farm thrives and continues to sustain a family of four generations on a 24 acre site, completely self sufficient in energy, food, water, soap, alcohol, and transportation. Self-grazing cattle provide the foundations for the farms success supplying the family with milk, meat, energy and organic fertiliser. Producing 120 lbs of manure a day cattle play a key role in the self-sufficiency of the family community, in particular as a source of renewable energy by fuelling a bio-digesting system, designed by Jose Casimiro.

Serving multiple uses the nitrogen rich spent manure from the bio-digester is mixed 1:4 parts with water and fed back to the land using a channelling system in preparation for planting. This process has played a significant contribution to

the remediation of the land through the action of earthworms. Prior to the adoption of sustainable farming practices the land was heavily contaminated with agrochemicals from intensive tobacco production. Continually feeding the earthworm population in the ground has served as a successful remediation technique.

Vermicomposting system, Finca de Casimiro, Sancti Spiritus, Cuba 2016

Vermicomposting system, Finca de Casimiro, Sancti Spiritus, Cuba 2016

For ease of management and maintaining permaculture principles cattle are housed at night under a shelter located in close proximity to the bio-digester and vermicomposting system measuring 7 × metres × 1.5 metres × 1.5 metres. Since being gifted 9 tiger worms in 2001 the population

has grown to over 500,000. Worm castings are applied directly to the land and used for starting off seeds.

Despite there being over 2000 bio-digesters in use in Cuba only 2% of the agricultural community are farming by sustainable permaculture principles. Since the collapse GM has been introduced in Cuba placing the country in a fragile place of dependency, and whilst chemicals are prohibited for use within the city rural areas are returning to conventional farming practices. Jose Casimiro continues to advocate for small scale farming as a solution for food security and social economic development.

Daughter and Father, Leidy and Jose Casimiro after the rice harvest, Sancti Spiritus, Cuba, 2016

Granjita Feliz, Guanacoboa, Cuba

Modelling the potential for small-scale urban farming Darious and Elizabeth Frometa's 24 metre squared indoor farm is producing 1 ton of rabbit meat, 600 quails eggs and 8 litres of Melopina honey each year.

Vermicomposting is playing a significant role in this system by efficiently managing the waste of 50 rabbits, as maintaining a hygienic environment is essential as the

farm is attached to Darious and Elizabeth's apartment. The worms are additionally supporting the system by providing a source of protein for the quails and worm castings are used for growing food on the small rooftop garden. Granjita Feliz donate rabbit meat, quail eggs and honey to the charity United Por Ti, empowering the food security of the wider community. Although Granjita Feliz generates an income from the sale of produce it also operates using a trade economy by exchange with other farmers.

Darious Frometa, Granjita Feliz, Guanacoboa, Cuba, 2016

Passionate about promoting vermicomposting and educating on the benefits of rabbit farming as a component of food security within their community Darious and Elizabeth established the charity United Por Ti (United For You). United Por Ti teaches children with autism how to grow food, live independently and contribute to society. The charity has developed a network of 100 small-scale farmers and individuals growing food for donation to 120 children with cancer and autism, each child receiving 100 lbs of organic produce every month. This collective action and sense of community is empowering the food security of vulnerable members of society.

Elizabeth Frometa holding worm castings, Granjita Feliz, Guanacoboa, Cuba, 2016

Reflections on Cuba

Humanitarianism is ingrained within Cuban society, and despite their own hardships imposed by the US embargo and the collapse of the Soviet Union there exists a deep culture of community. Without this culture it would be difficult to realise a peaceful transition to a resource scarce society. Socialist governance evidently played a key role in assisting this transition through education, access to communal land for food production and by importing over a million bicycles from China. Fortunately for Cuba vermicomposting was introduced in 1989, shortly before the collapse and now is understood as a recognised component of mainstream food production, and was promoted as such in government guidance manuals. For a nation to thrive in adversity there must be in place governance that acts upon the best interest of the people, not purely in the interest of economic growth.

For the past ten years there has been however a shift in agriculture in Cuba with a return to the use of agrochemicals and the introduction of Genetically Modified (GM) seeds in 2008, raising concern over future food security and food sovereignty. As a socialist government in control of the majority of the islands land if political forces advocate for fossil fuel dependent, high

input farming practices it leaves little room for negotiation. Fears of the cross contamination of seed undermines diversity and resilience, leading towards monoculture and the monopolisation of the food supply.

Despite the concerning shift in government supported agricultural practice in Cuba, reminding us of humanities bad habit for forgetting easily the mistakes of our history, there remains a strong organic grass roots movement. The experience of Cuba teaches us that a reorientation to sustainable agriculture is achievable, with political will to support and mobilise citizens. Adopting integrated agriculture techniques with livestock and crop production is key, and ultimately harnessing the vermicomposting process to convert valuable animal waste into a superior fertiliser and compost. In the city urban agriculture continues to thrive, not only empowering urban food security, it builds community, and surviving in a resource scarce world requires united action.

4. Actions for the UK

Vermicomposting in the United Kingdom is comparatively underdeveloped to that of the USA and Cuba. Despite being pioneered by Dr Clive Edwards in the 1980's there remains a distinct lack of awareness or understanding of the power or potential of vermicomposting within both agriculture and organic waste management.

Responding to the impact of global natural resource depletion and climate change should be priority for policy makers and recognised as presenting serious threats undermining national food security.

Greater independence as a result of leaving the EU requires greater management of resources, within both agriculture and organic waste management. A reorientation towards sustainable organic agricultural practice that utilises the vermicomposting process can provide a cost effective alternative to synthetic agrochemicals. Closing the loop must be on the policy agenda in order for societies to thrive in the face of future resource scarcity.

Learning from the USA and Cuba has been vast and there exists great opportunity to integrate these lessons for the betterment of British society. Raising the profile of vermicomspoting by integrating the process into mainstream waste management and promotion as best practice can be achieved by further scientific research and governance in agriculture and organic waste management both locally and nationally.

Academia

Academic research in food security and waste management should focus on developing a robust scientific framework and understanding of the role and potential of vermicomposting. Research topics should include:

- The role of composting worms in the remediation of contaminated agricultural land, known as vermiremediation.
- Vermiremediation techniques investigating sustainable canine waste management.
- Measuring the nutrient content of vermicomposts produced from a variety of different livestock and food waste.
- Measuring the nutrient content of food produced using vermicompost.
- Horticultural trials in plant development and disease suppression using vermicompost and vermicompost tea.
- The application of earthworms for aquaponic feed.
- The use of vermicompost as fertiliser for hydroponic systems.

Agriculture

Dependency on energy intensive and increasingly costly synthetic agrochemicals for the production of food places the UK in a fragile financial scenario, in particular in the wake of uncertainty surrounding Brexit negotiations where farmers face fears of loosing subsidies from the European Union. Finding a cost effective alternative to high inputs can potentially provide relief for the British farmer and calls for partnership building between livestock and crop producers solving agricultural waste management issues. Farmers should be informed and supported by the:

- Production of national resources with guidance for onsite vermicomposting for livestock farmers under the Nutrient Management Plan.
- Releasing start up funding for livestock farmers to establish appropriate onsite vermicomposting systems.
- Promotion of vermicompost as a cost effective fertiliser.
- Develop networks for diversification of livestock farmers to enter the vermicomposting market.
- Develop networks between crop producers and livestock farmers initiating partnerships for the management and use of animal waste for vermicomposting.
- Promoted as a key component of urban agriculture.

Diversion of Food Waste

Reducing the volume of food waste in the UK destined for landfill demands attention. In the UK 10 million tons of food is wasted every year from the household to the wholesale sector, accounting for 20 million tonnes of greenhouse gas (GHG) emissions (WRAP, 2015). Whilst this waste can be potentially vermicomposted there is unnecessary waste occurring throughout production from farm to plate, and this is by nature a consequence of industrial agriculture and food production, costing the UK economy £2.3 billion a year (WRAP, 2015). However, raising the profile of vermicomposting and reducing compostable organic waste destined for landfill should be addressed by:

- Introducing legislation for businesses and institutions that requires all organic waste to be composted or vermicomposted, either onsite or by collection service.

- Produce vermicomposting guidelines and resources for businesses and institutions.

- Inform and educate citizens through local council publicity and marketing campaigns promoting the value and importance of vermicomposting.

- Integrate vermicomposting into schools as a core component of the national curriculum, developing maths and science whilst fostering an understanding of the importance of healthy soil and composting.

- Funding Free DIY wormery workshops for citizens, in particular within the urban environment where space is scarce.

- Support communities, institutions and businesses to work together sharing resources, for example modelling the system

within Monroe Correctional Facility where the local council utilised the worm castings produced by inmates.

- Providing grant start up funding and support to develop onsite vermicomposting systems for businesses and institutions.

References & Further Reading

Bharambe, G. et al. (2008) *Converting wasteland into wonderland in wonderland by earthworms — a low cost nature's technology for soil remediation: a case study of vermiremediation of PAHS contaminated soil.* The Environmentalist. 28 (4), 466—475

Bikle, A and Montgomery, D (2015) *The Hidden Half of Nature: The Microbial Roots of Life and Health*. New York: W.W. Norton & Company

Brown, L., (2011) *World on the Edge: How to Prevent Environmental and Economic Collapse*. Washington: Earthscan

Chan, M. and Roach, E. (2012) *Unfinished Puzzle Cuban Agriculture: The Challenges, Lessons and Opportunities.* California: Food First Books

Cordell, D. Drangert, J. and White, S. (2009) 'The Story of Phosphorus: Global Food Security and Food for Thought', *Global Environmental Change*, Volume 19 (Issue 2), p.292—305

Crawford, J. (2012) *What if the worlds soils run out ?* Time [online] Available at http://world.time.com/2012/12/14/what-if-the-worlds-soil-runs-out/

Darwin, C.(1945). *The Formation of Vegetable Mould Through the Action of Worms With Observations on their Habits.* London: Faber and Faber

Howard, A. (2006) *The Soil and Health: A Study of Organic* Agriculture. Kentucky: The University Press of Kentucky

Koont, S. (2011) *Sustainable Agriculture in Cuba*. Florida: University Press of Florida

Oliver, G. (2009) *Friend Earthworm*. Milton Keynes: Review Press

Rosset, P. and Benjamin, M. (1994) *The Greening of the Revolution: Cuba's Experiment with Organic Agriculture*. Melbourne: Ocean Press

Schumacher, E.F. (1972) *Small is Beautiful: Economics as if People Mattered*. London: Vintage

Shewell-Cooper, W.E. (1944) *Soil Humus and Health*. London: The Garden Book Club

Shiva, V. ed., (2015) We Are Soil. In: *Dirt: a Love Story*. New England: Foreedge, p.173—178

Stewart, A.(2004) *The Earth Moved*. New York: Algonguin Books of Paper Hill

WRAP, (2015) *Estimates of Food and Packaging Waste in the UK Grocery Retail and Hospitality Supply Chains*. [online] Available at http://www.wrap.org.uk/sites/files/wrap/UK%20Estimates%20October%2015%20%28FINAL%29_0.pdf

Tomlinson, I. (2010). *A rock and a hard place — Peak phosphorus and the threat to our food security*. London: Soil Association

Itinerary

Location	Sites Visited	Date
San Diego, California, USA	The Worm Ranch, Richard J. Donovan Correctional Facility Point Loma Nazarene University	6—7 October 2016
Santa Monica, California, USA	Santa Monica Community College	10 October 2016
Santa Barbara, California, USA	The Open Alternative School	11 October 2016
Chico, California, USA	The Worm Farm The Soil Factory	13—14 October 2016
Cottage Grove, Oregon, USA	Sustainable Agricultural Technologies Inc.	15 October 2016
Portland, Oregon, USA	Portland Community College	17—19 October 2016
Seattle, Washington, USA	Woodland Park Zoo Monroe Correctional Facility	20—22 October 2016

Rochester, New York, USA	Worm Power Organix Inc	24—26 October 2016
Havana, Cuba	Granjita Feliz Finca de Luivar Finca de Melissa (ANAP) Finca de Alfred Gonzalez (ANAP) Purita Organic Agriculture Co-operative UBPC San Miguel Organicopomico UBPC Vivero Alamar Organicoponico	1—8 November 2016
Sancti Spiritus, Cuba	Finca de Casimiro	9—12 November 2016
Vinales, Pinar del Rio, Cuba	Finca de Paraiso	13—15 November 2016

ABOUT THE AUTHOR

In 2008, after graduating with a Bachelors degree in Photojournalism I had the opportunity to travel to Nepal as a volunteer photographer to work with the NGO Practical Action, established by the late Ernst Fritz Schumacher, pioneer of the green movement and author of Small is Beautiful: Economics as if People Mattered. Schumacher advocated for localised economies and small scale appropriate technology as a means to development. On return to the UK I received support from the Arts Council England and Practical Action to exhibit my photographs titled 'Small is Beautiful' raising awareness of the work of the NGO and the environmental challenges facing Nepal.

Inspired by my experience with Practical Action I returned to study with the objective of working in sustainable development undertaking a Masters degree in Human Security and Environmental Change, where I specialised in Urban Agriculture and Food Security. In 2013, shortly after graduation I was awarded as a winning finalist for Women in Social and Environmental Enterprise (WISEE) where I received initial start up support to establish what is now The Urban Worm CIC. The Urban Worm CIC promotes worm composting as a sustainable solution for organic waste management and organic horticulture, in particular within the urban

environment. As an enterprise we have manufactured components to convert domestic wheelie bins into worm farms for domestic and commercial use. The philosophy of The Urban Worm CIC is based upon the teaching of Ernst Fritz Schumacher, empowering communities to manage their own resources through the use of appropriate, small-scale technologies, laying the foundations for a sustainable, circular economy.

anna@theurbanworm.co.uk
+44 (0) 7971171525
www.theurbanworm.co.uk

Anna de la Vega with Leidy Casimiro, inspirational permaculture heroine next to the vermicomposting housing 1000's of worms. Sancti Spiritus, Cuba, 2016

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Pictures by Anna de la Vega.

The Urban Worm, May 2017

The Worm Farm,
Monroe Correctional Facility,
Washington, 2016