MEASURING SUSTAINABILITY – PRACTICAL TECHNIQUES FOR ORGANIC ENTERPRISES

Brookman, Graham
The Food Forest, PO Box 859 Gawler, South Australia, 5118
brookman@bigpond.com

Introduction
Organic Agriculture prides itself on the responsibility it shows toward the environment and claims more 'sustainability' than conventional systems. The certifier of our farm even calls itself the National Association for Sustainable Agriculture, Australia, yet how many of us know just how sustainable our enterprises are. Do organic farmers use more diesel than their herbicide spraying neighbours? Could it really be environmentally sustainable to export lettuces?

During 2004 our certified organic permaculture property was required to establish its sustainability credentials and I drew heavily on the work of the prolific American researcher and writer David Pimentel. Another major reference was 'Triple Bottom Line Reporting" (Dept Environment and Heritage, Australia, 2003), a paper written for the Australian Government, which subsumes the international 'Global Reporting Initiative' protocols for the assessment of sustainability and aligns with the Environmental Management System Standard ISO 14001; this document suggests arithmetical methods for calculating many specific sub indicators: download from http://www.deh.gov.au/settlements/industry/finance/publications/indicators/#download

I propose a number of approaches to the calculation of sustainability, both physical (positivist) and economic (normative) (Milon W, 1995) that will enable managers to quantify the sustainability of their various enterprises beyond the (already stringent) requirements of organic certification.
Key indicators of sustainability are proposed and are supported by a number of sub-indicators from the Global Reporting Initiative. None of the indicators are perfect measurements of sustainability but most can be calculated reasonably easily and are expressed in units that we relate-to: weight, volume, energy and money.
Operators of organically certified enterprises collect most of the information required for the calculations as a normal part of their record-keeping processes for tax and for certification.

Key Indicators
1. Product energy/input energy ratio
2. Income/cost of non-renewable inputs ratio
3. Soil nutrient, pH, organic carbon levels and trends
4. Percentage of area given-over to effective biodiversity plantings and reserves
5. Income per kilolitre of water expended

The figures collected and analysed are of most use to the manager of the business in tracking trends in each enterprise as management and inputs change. They also enable benchmarking against other farms and food businesses.

Indicator 1. Product energy/input energy ratio
This is an excellent figure for comparing the raw physical efficiency of farms and is a key measurement if one assumes that the Greenhouse Effect or a future shortage of oil or gas may be something we should be concerned about. The figure is imperfect as a planning tool in that it does not address food quality or prices; those issues are better dealt with by some of the other indicators. Reducing the energy values of food, electric power, fuel etc to a common measure requires the use of several simple formulae. As Pimentel and his co-workers (Pimentel D, 1980) have mainly used the kilocalorie in their extensive work I adopted it as the unit of energy in my calculations but other units would work equally well as it is the **ratio** that tells us the energy efficiency of a system.
Some units 1 Kcal = 4.187Kjoules, 1 Kw = 1 Kjoule per sec, 3600 secs = 1hr, 1KWhr = 863 Kcal

Some common agricultural inputs (not all organic!) and their approximate energy costs
(Pimentel D, 1984)

Common insecticides per kilo	87000 Kcal
Common herbicides per kilo	100000 Kcal
Glyphosate per kilo	110000 Kcal
Fungicide per kilo	65000 Kcal

Winter-oil per litre	60000 Kcal
Petrol per litre	10000 Kcal
Diesel per litre	11430 Kcal
Gas per litre	7705 Kcal
Wood per kilo	4600 Kcal
Nitrogen per kilo	14700 Kcal
Phosphorus per kilo	3000 Kcal
Potassium per kilo	1600 Kcal
Guano per kilo	1000 Kcal
Rock phosphate per kilo	1100 Kcal
Electricity per Kwhr	860 Kcal
Compost per kilo	815 Kcal -my estimate
Embodied energy per kilo	
Tractors	3500 Kcal
Harvesters	3100 Kcal
Tillage equipment & seeders	2000 Kcal
Sprayers, manure spreaders, mowers	1760 Kcal
Forage equipment	1400 Kcal
Pumping 1cm ha (40m head)	20 Kwhr: ie 100Kl water = 17200Kcal
Dehydration (fast)	150 Kwhr or higher (at 20% moisture) per tonne corn = 129000Kcal and higher
Wheat per kilo	3300 Kcal
Maize per kilo	3570 Kcal
Straw per kilo	1000 Kcal – my estimate

As an example, below is a tabulation of the input energy costs and the energy yields of a pistachio plantation managed as part of a permaculture design at The Food Forest, Gawler, South Australia. As can be seen the plantation produces 1.27 times more food energy than is applied as inputs. A benchmark conventionally-managed nut farm has a Ratio of product to input energy of 0.51, meaning that about twice as much energy went into the production of the crop as was harvested. Thus the way one chooses to farm is critical to energetic performance and sustainability. Organically managed farms often have better ratios than conventionally managed ones even though yields on conventional farms tend to be higher.

Inputs	**Quantity/ha**	**Kcal/ha**
Labour	198 hours	Not allowed for
Light machinery	20 kg	340200
Fuel/oil	15.5 litres	141360
Elect/irrig (notional)	6cm	100000
Phosphorus + Nitrogen etc – composted byproducts	224 kg	182560
Potassium - ash	100kg	byproduct
Insecticides – winter oil	10 kg	600000
Fungicides - Cuprous oxide	0.5kg	50000
Herbicides	-	-
Electricity (drying)	116 kWhr	126133
Total inputs		**1,223762 Kcal inputs**
Total yield	**250kg pistachio nuts**	**1,548250 Kcal (food energy)**
Product Energy / Input Energy Ratio		**1.27**

Pistachios (Organic) at The Food Forest, *Product Energy / Input Energy* per annum

Inputs	Quantity/ha	Kcal/ha
Labour	198 hours	Not allowed for
Machinery	30kg	540000
Fuel/oil	155 litres	1413600
Elect/ Irrig	301cm	9025000
Nitrogen	224kg	3115000
Phosphorus		
Potassium		
Insecticides	12.2 kg	492800
Fungicides	11.2kg	246400
Herbicides	4.5kg	255400
Gas	37 litres	2331500
Transport	3361kg	373900
Total		**21,150000**
Total yield	**1792 kg almonds**	**10,719000**
Product Energy / Input Energy Ratio		**0.51**

Almonds (Conventional, America) Benchmark *Product Energy/Input Energy* per annum (Pimentel D, 1984)

Whilst the figures above are from different environments and nut crops I believe that they demonstrate a significant difference in energy efficiency of the production system. Most importantly, they demonstrate the use of the calculation process for comparative purposes.
Assuming that the difference in *Product Energy / Input Energy Ratio* is significant, here are some likely reasons for the relatively higher energy efficiency and low greenhouse impact of the permaculture-designed orchard at The Food Forest, South Australia compared with the benchmark conventionally farmed property.

- Fuel use is low due to under-tree grazing rather than herbicides or mowing
- Biocide use is low as part of the biodiverse, organic system
- Irrigation is low due to the choice of well-adapted species and a desire for optimisation rather than maximisation in the system. The benchmark almond property mentioned above uses 50 times as much water, achieving more than 7 times the yield, but not 50 times. The average Australian orchardist would use 10-25 times the water.
- Income per kilolitre of water used is about $5 compared with the benchmark property's 36 cents. (This incorporates a 100% organic premium for certified nuts)
- Fertilizer use is low as legumes and animals provide nutrients and yields are accepted as low compared with conventional production
- Drying is efficient due to dehydrator design
- Geese can exploit inter-row space in the orchard in spring and early summer. They are a gourmet food and are weeders and 'fertilizers' as well as being profitable, low maintenance animals. They provide an extra crop from the orchard area.

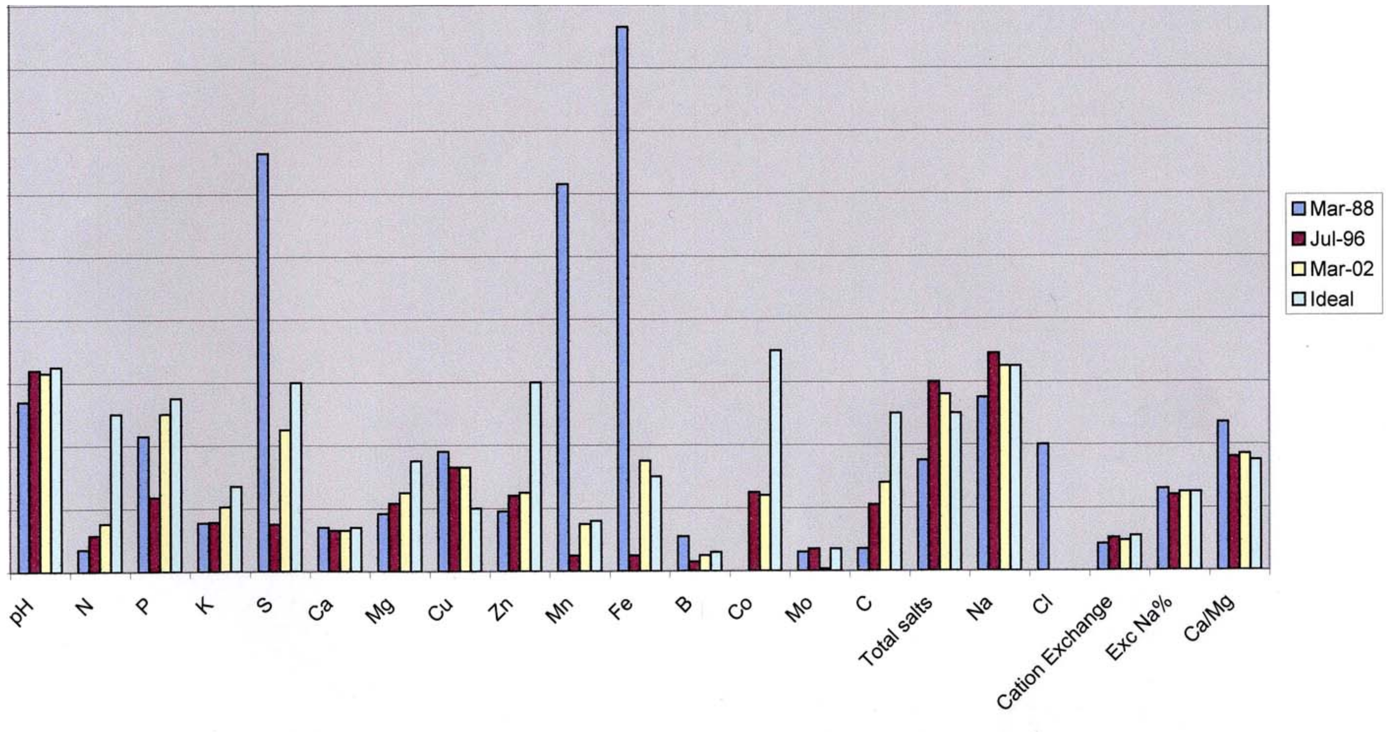
Crop choice

Whilst the way one chooses to grow a particular crop can make an enormous difference to the sustainability of what happens on a hectare of ground, one could choose to grow another crop on that piece of the planet. Some crops are intrinsically better physical converters of inputs into food energy.

Crops like lettuce which are eaten for pleasure, vitamins, minerals and fibre, typically have an unfavourable **product energy/input energy ratio** (0.18) (Pimentel D,1984) with over 5 times as much non-renewable energy going into production of the crop as food energy value produced. The same holds to an extent for all vegetables and fruits. Legume crops like lucerne hay (13.1**)** are the star performers because they are perennial and 'fix their own nitrogen'.

Indicator 2. Income/cost of non-renewable inputs ratio
This very simple-to-calculate indicator shows the environmental footprint of each dollar you earn. Water is dealt with separately as it is the most critical resource and is both renewable and damageable. Most other inputs that are not products or by-products of the production system on the property need to be costed. Examples: A wind turbine purchased for the farm is costed but the electricity produced by it is not. Waste organic material that would have gone to land-fill is not costed but its transport to the farm for composting is. Inputs can be amortised where required eg. gypsum may be applied in one year but lasts for five, so can be charged-for in 5 yearly instalments just as equipment would be depreciated.
The information for the calculation of the value of this indicator can be derived from your tax return.

Indicator 3. Soil nutrient, pH, organic carbon levels and trends
This indicator is to show that you are not 'mining' or in some other way degrading your land through your farming system and also to allow yourself to track credits which result from investments in nutrients through husbandry or import. Regular soil tests will provide all the data required. Results can also be indexed against recognised optimal values for growing a range of crops (obtainable from good soil testing labs) as below.



Nutrient levels at The Food Forest

Indicator 4. Percentage of area utilized for effective biodiversity plantings and reserves
It is generally regarded as appropriate to have at least 15% of a farm given over to plantings or remnant vegetation to enhance biodiversity, protect waterways and other fragile elements of the landscape and possibly to combat dryland salinity. The ideal percentage will depend on the particularities of the site and its surroundings. Local and international best practice should be referred to on a site-by-site basis.

Indicator 5. Income per kilolitre of water expended
Much water is wasted in growing inappropriate species such as rice in semi-desert environments. Primary processing of food on-farm is often undertaken using significant amounts of water but without cycling the water back into the production stream. This indicator is easy to derive from water

consumption records and tax returns and shows how well one is using water drawn from the environment. In deriving the figure one must first determine kilolitres of water applied per hectare and quantity of product per kilolitre of water – useful figures in themselves, but the final monetary figure reflects the value society places on the product. For organic producers this is significant as consumers are often prepared to pay a premium for certified organic produce.

Conclusion

Sustainability is becoming an increasingly important feature of organic production and its measurement will be required by government agencies as environmental challenges accelerate over the next decade. The five indicators proposed are in line with international conventions and provide a simple means for collecting data. An information sheet explaining the energy values of common inputs and products needs to be produced to facilitate this and could be placed on the websites of certifying organisations.

The indicators combine physical and monetary values that really mean something to a farmer. They will be useful for farm management in that they provide trend information and allow comparison with benchmarks.

References

Pimentel D, 1984, ‘Food and Energy Resources’
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Milon W, 1995, ‘Integrating Economic and Ecological Indicators’
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