Towards Creating a Vision of Global Sustainability

A Theoretical Treatment of Resource Utilisation, Population and Power

A heuristic model is proposed which attempts to define the relationships between the use of resources, a mechanism for the control and management of resources, population, power and the conditions which regulate and define various levels of sustainability of resources. The ultimate aim is to identify key contributions to achieving sustainability and to highlight research areas which may form the scientific basis of a global vision of sustainability. A new economic paradigm is proposed based upon sustainable utilisation of resources.

SECTION 1

Resource Definition

In this discussion a resource is a defined as a finite system or finite body which provides levels of access to users. Most material finite systems are heterogeneous such as a river which consists of a variety of elements including water, fish, plants, micro-organisms, etc. and which supports an entire ecosystem. Homogeneous systems on the other hand consist of a single element such as the 'gold reserve'. Resources may occur naturally or may be man made and may be material or virtual. A virtual resource may be knowledge or flow of knowledge, information or the flow of information, money or the flow of money, etc. The type of resource configuration may be distributed or non-distributed.

The nature of the relationship between a finite system and its users governs how and the extent to which the resource is utilised. Levels of utilisation may vary extensively – from the critical level where utilisation is vital to both the existence of users and/or to the lifetime of the resource – to the case where utilisation is minimal or zero. Resources may be classified as passive or active depending on the mode of utilisation. When the mode of utilisation maintains a clear distinction between the resource and its users, the resource is passive. When the mode of utilisation fails to maintain a distinction between the resource and its users, the resource is active.

The following treatment is limited primarily to the relatively simple case of passive independent resources. A brief discussion of extending the theory of resource utilisation to include multiple resources, resource coupling and cross resource sharing is briefly considered.

Single Resource Utilisation

<u>Conservation Balance:</u>

Initially we examine how a finite resource fluctuates when subject to several users as a function of time. Let Q be the single total resource available. Each user (i) depletes the resource at a given rate and may replenish the resource at a given rate. A first order process is assumed for each user(i). The rates of depletion and replenishment of total resource Q are assumed to be the sum of the individual rates of depletion and replenishment associated with each user(i). The individual rates are further assumed to be proportional to the partial quantity q_i of resource Q accessed by each user(i). The respective rate constants of each user(i) for depletion and replenishment are k_i^d, k_i^r . The following equations clarify the construct for n users (i = 1, 2, …n):

$$Q = \Sigma\, q_i \qquad (1)$$

$$- dQ/dt = - d/dt \{\Sigma\, q_i \} = - \Sigma\{dq_i /dt \} \qquad (2)$$

$$- dq_i /dt = [k_i^d - k_i^r]q_i \qquad (3)$$

Substituting equation (3) into equation (2) gives

$$- dQ/dt = \Sigma\, [k_i^d - k_i^r]q_i \qquad (4)$$

Equation (4) expresses the 'conservation of resource' Q in terms of a balance between depletion and replenishment for all users accessing the resource.

Dividing equation (4) by Q we obtain

$$- d\ln Q/dt = \Sigma\, [k_i^d - k_i^r]\chi_i \qquad (5)$$

where the fractional resource χ_i available to each user(i) is defined as

$$\chi_i = q_i /Q \text{ and } \Sigma\chi_i = 1 \qquad (6)$$

For the particular case when each user(i) has the same the identical resource value q_i and the same value of rate constants [$k_i^d - k_i^r$], then equation (4) reduces to the equation of that for a single user of resource Q as is required for self consistency:

$$- dQ/dt = [k_i^d - k_i^r]Q \qquad (7)$$

Resource Control and Management:

Gates:

The notion of control and management of resource Q may be introduced by 'gates' which govern the access of each user (i) to resource Q by regulating both depletion and replenishment rates for each user. This may be expressed through the rate constants as follows:

$$k_i^d = g_i^d\, k_i^{*d} \qquad (8)$$

$$k_i^r = g_i^r\, k_i^{*r} \qquad (9)$$

where g_i^d and g_i^r are the gates which control access to resource R for the depletion and replenishment respectively and take the values:

$$0 \leq g_i^d \leq 1 \qquad (10)$$

$$0 \leq g_i^r \leq 1 \qquad (11)$$

where 0 indicates no access and 1 indicates full access to resource R. The respective rate constants k_i^{*d}, k_i^{*r} marked with the asterisk indicate full access when gates $g_i^d = 1$ and $g_i^r = 1$.

The application of a 'gate' mechanism depends on the extent of gate coupling which may be distinguished as two types: 'internal' and 'external' coupling. Internal coupling occurs when the gates g_i^d and g_i^r of a particular user(i) are not independent but are interdependent – the value of one affecting the other. External coupling occurs when the gates g_i^d and g_i^r of more than one user(i) are linked in a dependent fashion. The most general and complex case occurs when both internal and external gate coupling is operative. A precondition for resource sharing is active external gate coupling.

The simplest mode of a gate mechanism occurs when there is no internal or external gate coupling and the function governing the gate mechanism may be characterised by a simple change of state such as an 'open/closed' tap:

$$g_i^d = [0 \text{ or } 1] \text{ and } g_i^r = [0 \text{ or } 1] \qquad (12)$$

Here the value 0 indicates the tap is closed resulting in no access to resource Q and the value 1 indicates the tap is open resulting in full access to resource Q. This may be modelled using a form of the Dirac Delta or 'boxcar' mathematical function.

Resource Sharing:

In contrast, a continuous function may be selected which governs the gate mechanism assuming active external gate coupling. Ideal sharing occurs when resource users utilise resource Q according to their relative need. A resource sharing function may be defined by the extent of sharing of each user(i) of resource Q which in turns regulates the depletion and replenishment rates of resource Q for each user(i) as:

$$g_i^d = 1/\exp[1/s_i^d] \text{ and } g_i^r = 1/\exp[1/s_i^r] \qquad (13)$$

where s_i^d and s_i^r represent the fractional extent that resource Q is shared by user(i) for depletion and replenishment rates respectively. In this scenario, the extent of sharing determines resource utilisation of each user by regulating their gate access. The asymptotic limits for sharing are as follows:

When sharing $s_i^d \rightarrow 0$, then $g_i^d \rightarrow 0$. Similarly, as $s_i^r \rightarrow 0$, then $g_i^r \rightarrow 0$
In this case access to resource Q approaches 0.

When sharing $s_i^d \rightarrow \infty$, then $g_i^d \rightarrow 1$. Similarly, as $s_i^r \rightarrow \infty$, then $g_i^r \rightarrow 1$
In this case access to resource Q approaches 1.

If the extent of resource sharing is established according to relative need for each resource user, then sustainable gate access results. By '*according to relative need*' we mean that the values of the rate constants k_i^{*d}, k_i^{*r} are the 'natural' rate constant values required for sustainable survival.

If there is no resource sharing or the extent of resource sharing imposed is not in accordance with relative need, then non-sustainable gate access results which may create resource destabilisation arising from competition or conflict between users.

Conditional Levels of Resource Utilisation:
In order to define conditional levels of resource utilisation, we substitute equations (8) and (9) into equation (4) and obtain the general equation:

$$- dQ/dt = \Sigma [g_i^d k_i^{*d} q_i] - \Sigma [g_i^r k_i^{*r} q_i] \qquad (i = 1, 2, \ldots n) \qquad (14)$$

Equation(14) defines the rate of resource utilisation in terms of the quantity of resource Q accessed by each user, the rate constants for resource depletion/replenishment and resource accessibility governed by the gates.

Referring to equation (14) it is possible to define a set of useful conditions which may lead to distinct levels of resource utilisation.

Case: - dQ/dt > 0

Resource Extinction:
The overall extent of depletion exceeds the overall extent of replenishment over a period of time

$$\{\Sigma [g_i^d k_i^{*d} q_i] - \Sigma [g_i^r k_i^{*r} q_i]\} > 0 \text{ or } \{\Sigma [g_i^d k_i^{*d} q_i]\} > \{\Sigma [g_i^r k_i^{*r} q_i]\} \qquad (15)$$

Catastrophic Resource Extinction:
This is a sub set of equation (15) when the overall extent of replenishment is zero, thus depletion occurs in the shortest time

$$\{\Sigma [g_i^d k_i^{*d} q_i]\} > 0 \text{ and } \{\Sigma [g_i^r k_i^{*r} q_i]\} = 0 \qquad (16)$$

Case: - dQ/dt < 0

Resource Replenishment:
The overall extent of replenishment exceeds the overall extent of depletion over a period of time

$$\{\Sigma [g_i^d k_i^{*d} q_i] - \Sigma [g_i^r k_i^{*r} q_i]\} < 0 \text{ or } \{\Sigma [g_i^r k_i^{*r} q_i]\} > \{\Sigma [g_i^d k_i^{*d} q_i]\} \qquad (17)$$

Enhanced Resource Replenishment:
This is a sub set of equation (17) when the overall extent of depletion is zero, thus the overall extent of replenishment occurs in the shortest time

$$\{\Sigma [g_i^r k_i^{*r} q_i]\} > 0 \text{ and } \{\Sigma [g_i^d k_i^{*d} q_i]\} = 0 \qquad (18)$$

Case: $- dQ/dt = 0$

Resource Preservation:
This condition occurs when total user access to the resource Q is denied. The gates for both depletion and replenishment for all users(i) are closed

$$g_i^d = g_i^r = 0 \qquad (i = 1, 2, \ldots n) \tag{19}$$

Resource Equilibrium:
This condition occurs when overall extent of depletion exactly balances the overall extent of replenishment

$$\{\Sigma\, [g_i^d\, k_i^{*d}\, q_i]\} = \{\Sigma\, [g_i^r\, k_i^{*r}\, q_i\,]\} \tag{20}$$

Case: $- dQ/dt = - \lambda$

Resource Sustainability:
The overall extent of replenishment exceeds the overall extent of depletion by a constant amount λ. In this case, equation (14) becomes

$$\{\Sigma\, [g_i^r\, k_i^{*r}\, q_i\,]\} - \{\Sigma\, [g_i^d\, k_i^{*d}\, q_i]\} = \lambda \quad \text{where } \lambda > 0 \tag{21}$$

In practice the value of λ is adjusted to be large enough to compensate projected fluctuations in gate access and variations in rate constants over time. A reasonable excess of resource above the initial value of Q is kept in readiness to accommodate unforeseen challenges.

A more general formulation of equation (14) or (21) may be applied where $\lambda = \lambda(\omega t)$ to account for cyclic dependence of resource variation where ω is the frequency and t is time.

The results in this section are summarised in Table 1

Table1: Conditional Levels of Resource Utilisation for a Single Resource

Conditional Resource Utilisation	**- dQ/dt**	Rate Constants & Gates
General	$- dQ/dt$	$\Sigma\, [g_i^d\, k_i^{*d}\, q_i] - \Sigma\, [g_i^r\, k_i^{*r}\, q_i\,]$
Resource Extinction	$- dQ/dt > 0$	$\Sigma\, [g_i^d\, k_i^{*d}\, q_i] > \Sigma\, [g_i^r\, k_i^{*r}\, q_i\,]$
Catastrophic Resource Extinction	$- dQ/dt > 0$	$\Sigma\, [g_i^d\, k_i^{*d}\, q_i] > 0$ and $\Sigma\, [g_i^r\, k_i^{*r}\, q_i] = 0$
Resource Replenishment	$- dQ/dt < 0$	$\Sigma\, [g_i^r\, k_i^{*r} q_i] > \Sigma\, [g_i^d\, k_i^{*d}\, q_i]$
Enhanced Resource Replenishment	$- dQ/dt < 0$	$\Sigma\, [g_i^r\, k_i^{*r} q_i] > 0$ and $\Sigma\, [g_i^d\, k_i^{*d}\, q_i] = 0$
Resource Preservation	$- dQ/dt = 0$	$g_i^d = g_i^r = 0$ for all users
Resource Equilibrium	$- dQ/dt = 0$	$\Sigma\, [g_i^d\, k_i^{*d}\, q_i] = \Sigma\, [g_i^r\, k_i^{*r}\, q_i\,]$
Resource Sustainability	$- dQ/dt = - \lambda$	$\Sigma\, [g_i^r\, k_i^{*r} q_i] - \Sigma\, [g_i^d\, k_i^{*d}\, q_i] = \lambda$ where $\lambda > 0$

Multiple Resource Utilisation, Resource Coupling and Resource Sharing:

The next stage in the development of theory is the extension of the treatment to include multiple resource utilisation with resource coupling and sharing across multiple resources. The nature of coupling is defined in terms of how the rate of utilisation of a single resource specifically affects the resource utilisation of other resources to which it is connected. The coupling between resources ultimately results in a network of resources such that variations in the resource utilisation of one resource by one user may in principle affect the entire resource network. Resonance behaviour may then develop within a network and/or between linked networks. For this purpose, the coupling between resources introduces a level of complexity not dissimilar to the many body problem in physics. What is apparent, even at this elementary stage of the theory based on single resource utilisation, is that the stability of multiple coupled resource systems is optimised when resource utilisation for each resource in the network is in the steady state thus leading to long term sustainability. The coupling of several resources may constitute a utility which may function as new resource entity capable of substituting for lost resources or providing additional flexibility in resource utilisation.

It may be possible to employ the relatively simple analysis given above for a single resource utilisation as basis set for building the theory to include multiple coupled resource utilisation with user sharing across many resources and larger resource networks. In this regard, studies on linked networks and the mathematical Hession Matrix construct may be helpful.

Hession Matrix Analogy:

The Hession matrix is used in Hückel Molecular Orbital quantum mechanical calculations as an approximation to simplifying the many body problem in estimating molecular orbital energies of linear molecules such as conjugated hydrocarbons. Knowing the topology of the basic chemical unit (say, $H_2C{=}CH$-) allows the calculation to be extended to higher chain configurations as long as the linear topology is maintained. For such linear conjugated systems, the electron field binding the individual C atoms is de-localised and shared throughout the molecule. This mathematical construct has the possibility to be applied in a more general approach to describe the extent of shared resources by defining a unit topology applicable to a basis set of critical resources and number of users. Typically this would include establishing the criteria for the critical resources to support about 200 human beings in a self sustaining community environment. This single topology may be multiplied by links between similar topologies which give rise to an ownership delocalisation of specific topological resources by analogy with the delocalised electron field discussed above. The extent of delocalisation would then correspond to a measure of shared resources accessed by all linked topologies. The benefit of linked human topologies would add diversity to overall survival strength. Such an analysis would ideally reveal how the extent of shared resources impacts the sustainability for a single and linked topologies. The results of such calculations may also shed light on the rate constants governing the depletion and replenishment of resources. Other formulations also need consideration.

SECTION 2

Population & Resource Utilisation

In this section we list at the outset a number of postulates which form the basis for the sustainable utilisation of critical resources which support a given population density ensuring continuous survival. We then develop the idea of a ‘gauge pressure’ to explore the relationship between a given population density and its critical resource utilisation in an attempt to establish some justification for the initial postulates.

Postulates:

1. A given population density requires a critical number J of renewable resources for sustainable survival

   $J = \Sigma(Q)_j \qquad (j = 1, 2, \ldots J)$ (22)

2. Optimum long term survival is favoured when the rates of resource utilisation v_j of each of the j critical resources required for survival satisfy the resource sustainability criterion given equation (21) with $(\lambda)_j$ constant for each resource j

   $\Sigma(v)_j = \Sigma(dQ/dt)_j = \Sigma(\lambda)_j$ (23)

3. The rate of growth of the population must be in steady state balance with the critical resources which sustain it.
4. Globally each specific population must meet these criteria.
5. Each economic system competing for resources must maintain and regulate the critical resource utilisation so that the overall steady balance is maintained locally and globally – we call this ‘the law of micro-sustainability’.
6. The role of global economic systems is to maintain the global steady balance of resources for each specific population. This means that such systems act in harmony as part of nature as stewardship, not the overseer of nature.
7. Long term survival is optimised by shared resources distributed according to need.

The Gauge Pressure: Π

To examine the relationship between a given population and the critical resource utilisation upon which the population depends for its continuous survival, we define a gauge pressure Π. Π may be described in terms of a given population density ρ and the rate v at which j critical resources Q_j are utilised to sustain survival of the population. Here:

$$\Pi = d/dt\,\{\rho v\} = \rho(dv/dt) + v(d\rho/dt) \qquad (24)$$

where in general ρ and v are both functions of time with

$$v = \Sigma(dQ/dt)_j \qquad (25)$$

Substituting equation (25) into equation (24) gives

$$\Pi = \rho\{\Sigma(d^2Q/dt^2)_j\} + \{\Sigma(dQ/dt)_j\}(d\rho/dt) \qquad (26)$$

In this form equation (26) states that the gauge pressure consists of two terms. The 1st term is a product of the population density and the acceleration of critical resource utilisation. The 2nd term is a product of the rate of critical resource utilisation and the rate of change in population density.

When $\Pi = 0$, variations in population density are balanced by variations in the rate of resource utilisation resulting in sustained long term survival of the population and the critical resources which support it.

General Ideal Case: $\Pi = 0$
For gauge pressure $\Pi = 0$, the optimum balance between variation of the rate of resource utilisation and the variation of population density with time is obtained favouring long term survival. Equation (24) becomes:

$$\rho(dv/dt) = - v(d\rho/dt) \qquad (27)$$

$$dv/v = - d\rho/\rho \qquad (28)$$

integrating and collecting terms

$$\rho v = \exp(\alpha) \qquad (29)$$

where α is the integration constant.

Equation (29) states that the variation in the population density ρ is compensated by variation in rate v at which critical resources Q are used so as to maintain the constant value $\exp(\alpha)$. If ρ increases with time, v decreases with time so as maintain the product (ρv) constant and vice versa.

Specific Ideal Cases: ($\Pi = 0$ and $d\rho/dt = 0$) or ($\Pi = 0$ and $dv/dt = 0$)

$\Pi = 0$ and $d\rho/dt = 0$
If we further impose the steady restriction of population density such that $d\rho/dt = 0$, then equation (27) demands that also $dv/dt = 0$ and v is constant thus satisfying the sustainability criterion $\Sigma(dQ/dt)_j = \Sigma(\lambda)_j$ given in equation (23).

$\Pi = 0$ and $dv/dt = 0$
Similarly, if the resource sustainability criterion is imposed such that $dv/dt = 0$, then equation (27) demands that $d\rho/dt = 0$ and the population density ρ is a constant.

In essence, sustainable resource utilisation supporting a population requires that the population density remains constant and vice versa. If resources are finite, population regulation is imperative to maintain balance and long term survival.

Gauge Pressure, Rate Constants and Gates

The relationship between the gauge pressure and specific resource utilisation variables associated with each resource is readily derived.

Substituting (25) into (24) gives

$$\Pi = \rho\{d/dt[\Sigma(dQ/dt)_j]\} + (d\rho/dt)[\Sigma(dQ/dt)_j] \qquad (30)$$

Substituting equation (14) into equation (25) gives v as a double sum expressed in terms of the individual rate constants and gates regulating the specific utilisation of each critical resource j accessed by each user i.

$$v = \Sigma(dQ/dt)_j = \Sigma\{\Sigma\,[g_i^{r}\,k_i^{*r}\,q_i\,] - \Sigma\,[g_i^{d}\,k_i^{*d}\,q_i]\}_j \qquad (31)$$

Substituting equation (31) into (30) yields the gauge pressure expressed in terms of the population density and resource utilisation variables k_i^{*r}, k_i^{*d}, g_i^{d} ,g_i^{r} which regulate the resource gate accessibility (g_i^{d} ,g_i^{r}) and resource utilisation rate constants (k_i^{*r}, k_i^{*d}) for each user(i) using resource quantity q_i for each critical resource j

$$\Pi = \rho\{d/dt[\Sigma\{\Sigma\,[g_i^{r}\,k_i^{*r}\,q_i] - \Sigma\,[g_i^{d}\,k_i^{*d}\,q_i]\}_j]\}$$

$$+ (d\rho/dt)\{\Sigma\{\Sigma\,[g_i^{r}\,k_i^{*r}\,q_i\,] - \Sigma\,[g_i^{d}\,k_i^{*d}\,q_i]\}_j\} \qquad (32\ )$$

If resource sharing is established within each critical resource $(Q)_j$ and across critical resources according to relative need for each resource user, then sustainable gate access results.

If the extent of resource sharing is imposed not in accordance with relative need, then non-sustainable gate access results which in turn may generate user conflict for resource utilisation. Consequences may result in resource destabilisation leading to resource extinction.

SECTION 3

Power Definition

The notion of power in the control of resources is key to understanding survival strategies and creating a sustainable world. In what follows is a speculative attempt to examine some aspects of power in order to arrive at a working definition within the context of resource utilisation and control.

Power is instinctual as seen in lower order primates. Pecking order is a precursor for managing dominance and survival of species. The pre-condition in humans and some primates permits the exchange of goods or services for mutual benefit. The socialisation in humans allows for the partial control of instinctual dominance and the eventual recognition that survival of the 'other' is a necessary pre-condition of the survival of the self, the environment, sustainability and so forth – underpinning the interdependence of everything.

Where the mechanism for socialisation fails due to natural disasters, lack of infrastructure, missing genes or other genetic flaws, disease, cultural hazards etc, then unbridled dominance of instinctual development proceeds without limit or balance which in turn results in catastrophic abuse of individuals and/or resources. We may define two modes of power: rational power as instinct modulated by socialisation; and irrational power as instinct free from socialisation – unbridled without constraints. Both these modes are discussed below. Clearly a spectrum of behaviour may be drawn.

Underpinning any treatment of the notion of power requires the determination of a given value system which results in the definition of a relative value function. A behavioural scale of survival values of an individual in a given group or society may be described. At one end of the scale, only the survival of the individual self matters – this is the basic instinctual level. At higher levels of socialisation, the individual survival of self is connected to the survival of others in the group and at the far end of the scale is the individual or group whose survival of self is of no consequence and whose behaviour is dedicated only to the survival of others.

Rational Power: Instinct Modulated by Socialisation

For simplicity we restrict this analysis to a set of users dependent on a single resource Q. The ownership of resource Q is arguably the most important component contributing to the control, utilisation and regulation of resource Q. A measure of power P associated with resource ownership Ψ may be defined as:

$$P = E\Psi \tag{33}$$

where E is the extent of resource Q defined in terms of size and relative scarcity; Ψ is the ownership function. Variables E and Ψ are in general time dependent and each variable is discussed below.

Power of Resource Extent: E

The power associated with resource extent E depends on the resource size σ, and the 'scarcity' distribution function $S(\check{r},t)$ of resource Q. $S(\check{r},t)$ is both spatially ($\check{r}$) and time dependent. Thus

$$E = \sigma\, S(\check{r},t) \qquad 0 \le S(\check{r},t) \le 1 \tag{34}$$

$S(\check{r},t)$ has the property that when $S(\check{r},t)=0$, the resource Q is distributed everywhere and is assumed freely available to potential users; when $S(\check{r},t)=1$ the resource exists at only one location and is non-distributed.

Resource Ownership Function: Ψ

Indeed the 'gates' to power reside in resource ownership, resource access control and regulation of resource utilisation. The resource ownership attributed to an individual or group enables a resource owner to control the total number of resource users n and resource utilisation of each user. The mechanism whereby resource utilisation is controlled by an owner is through the control of user gate access to the resource and regulation of the utilisation rate constants for each resource user. For a single resource Q owned by a single owner, the resource ownership function Ψ may be constructed as:

$$\Psi = n\sum v_i\varphi_i \qquad (35)$$

In equation (35) n is the total number of resource users, v_i is the resource utilisation rate of each user(i) accessing resource Q, φ_i is the **ownership** psychometric value function associated with each user(i). Each of the terms in equation (35) is now discussed in detail.

Total number of resource users: n

$$n = \sum n_i \qquad (i = 1, 2, \ldots n) \qquad (36)$$

The resource owner controls the number users accessing the resource. As n increases, so Ψ increases.

Resource utilisation rate of each user(i): v_i

$$v_i = dq_i /dt = [k_i^{r} - k_i^{d}]q_i = [g_i^{r}\, k_i^{*r} - g_i^{d}\, k_i^{*d}]q_i \qquad (37)$$

where we have used equations (3), (8) and (9). We further define the owner controlled gate function governing user resource accessibility and user resource utilisation rate constants of each user as:

$$(G^{\delta})_i = [g_i^{r}\, k_i^{*r} - g_i^{d}\, k_i^{*d}] \qquad (38)$$

The superscript δ indicates the ownership type and accounts for the case that the resource owner is not a resource user (δ=ς) or the resource owner is also a resource user (δ=u).

By controlling the gate function $(G^{\delta})_i$, and partial quantity of resource q_i available to each resource user, the resource owner can totally set the resource utilisation rate of each user. Substituting equation (38) into equation (37) gives:

$$v_i = (G^{\delta})_i q_i \qquad (39)$$

In the steady state,

$$v_i = (G^{\delta})_i q_i = \lambda_i \qquad \lambda_i \text{ is constant} \qquad (40)$$

Ownership psychometric value function: φ_i

The ownership psychometric value function φ_i is a measure of the combined associated value of both the partial resource q_i and the resource utilisation of resource user (i) to the resource owner. The resource owner value function φ_i may be constructed in terms of *perceived survival importance* characterised by a psychometric existential variable (ε_i) attributed by the resource owner to the resource utilisation of each user (i). We assign the scaled value $\varepsilon_i = 1$ to represent the owner perception that the associated function $\varphi_i(\varepsilon_i)=1$ is fundamentally essential to *owner* survival. The value $\varepsilon_l = 0$ represents the owner perception that the associated resource function $\varphi_i(\varepsilon_i)=0$ is not essential to owner survival. Values of ε_i between 0 and 1 represent perceptions which result in intermediate vaules of $\varphi_i(\varepsilon_i)$. Thus:

$$\varphi_i = \varphi_i(\varepsilon_i) \qquad (0 \le \varphi_i(\varepsilon_i) \le 1) \qquad (i = 1, 2, \ldots n) \qquad (41)$$

The limits imposed $(0 \le \varphi_i(\varepsilon_i) \le 1)$ define a *rational* ownership psychometric profile if we further impose the condition that resource utilisation of each user(i) is *according to natural need*. By this is meant the objective quantifiable extent of resource utilisation to sustain survival of user(i). For example, if the single resource were a body of water, then resource utilisation to provide sustained survival a particular user(i) could require a set number of litres of water per day.

Discussion of Rational Power P:

Substituting equations (34) and (35) into equation (33) and using equation (39) gives the full expression for rational power:

$$P = \sigma\, S(\check{r},t)n\Sigma(G^{\delta})_i q_i \varphi_i(\varepsilon_i) \qquad (i = 1, 2, \ldots n) \qquad (42)$$

Subject to conditions:

$$0 \le S(\check{r},t) \le 1 \text{ and } (0 \le \varphi_i(\varepsilon_i) \le 1) \qquad (43)$$

To facilitate the discussion we assume that $S(\check{r},t) = 1$ so that the resource exists at one location and is unique. Equation (40) becomes:

$$P = \sigma\, n\Sigma(G^{\delta})_i q_i \varphi_i(\varepsilon_i) \qquad (i = 1, 2, \ldots n) \qquad (44)$$

For a single resource ownership characterised by the owner value function $\varphi_i(\varepsilon_i)$ restricted to the range $(0 \le \varphi_i(\varepsilon_i) \le 1)$, the variation in the value of P with time will follow variations in σ, n, and $(G^{\delta})_i q_i$. The value of σ will be its initial value prior to resource utilisation modulated by changes in the number of resource users n and associated changes in the total user resource utilisation rate Σv_i. Thus in general $\sigma = \sigma(n,\Sigma(G^{\delta})_i q_i)$. The value of v_i may be determined by any of the conditional resource utilisation conditions set out in Table 1 above for each resource user. Optimum sustained rational power is obtained for the steady state condition when v_i is constant for each user given by equation (40) for resource utilisation. Under this condition, equation (44) becomes:

$$P = \sigma n \sum \lambda_i \varphi_i(\varepsilon_i) \qquad (i = 1, 2, \ldots n) \qquad (45)$$

Ideal rational power sustainability occurs when resource access is governed by sustainable gates regulating user resource utilisation according to natural user need. Equation (45) provides the necessary prerequisite for the transformation of ownership rational power to the state of 'stewardship' governing sustainable resource utilisation. The change required in mind set from rational power to stewardship is both necessary and significant.

This treatment may be extended to include multiple resource owners, coupled gates, resource sharing and multiple resources.

Irrational Power: Instinct Unhinged from Modulated Socialisation

Irrational Power Defined as Resultant of a Viral Operator: Ж

The idea here is that there exists an operator Ж which is viral in nature and operates on the elemental *rational* power function P. In the case of a single resource under single ownership, Ж transforms P to produce a new power function P*. Using equations (33) and (35), P* can be written as:

$$P^* = Ж(P) = Ж(E\Psi) = Ж(En\sum v_i\varphi_i) \qquad (46)$$

Initially we assume that Ж affects only the psychometric ownership function given be equation (41) such that the following transformation occurs

$$\varphi_i(\varepsilon_i) \rightarrow [\varphi_i(\varepsilon_i)]^* \qquad ([\varphi_i(\varepsilon_i)]^* > 1) \qquad (47)$$

The transformed psychometric ownership function $[\varphi_i(\varepsilon_i)]^*$ is no longer bounded by *rational* values $(0 \leq \varphi_i(\varepsilon_i) \leq 1)$ as in the case of *rational* power, but is now seen as *irrational* and takes transformed values $([\varphi_i(\varepsilon_i)]^* > 1)$. A value of $([\varphi_i(\varepsilon_i)]^* > 1)$ *exceeds* what is fundamentally essential to the perceived survival of the resource owner and indicates a psychometric profile unhinged from socialisation restrictions and manifests as extreme self interest. Hence (46) becomes:

$$P^* = Ж(En\sum v_i\varphi_i) = En\sum v_i[\varphi_i(\varepsilon_i)]^* \qquad ([\varphi_i(\varepsilon_i)]^* > 1) \qquad (48)$$

As a consequence of the transformation $\varphi_i(\varepsilon_i) \rightarrow [\varphi_i(\varepsilon_i)]^*$, the resource owner may then manipulate the variables E, n, v_i so as to maximise increased power. In most cases, this results in exploitation of users and resource destabilisation possibly leading to resource extinction in a relatively short period. The extent to which $([\varphi_i(\varepsilon_i)]^* > 1)$ indicates an amplification factor for power accumulation. Moreover, for $([\varphi_i(\varepsilon_i)]^* > 1)$, the steady state condition given by equation (40) for resource utilisation of each user cannot apply to all users if at all. In this scenario, sustainable *irrational* power is not achieved. The key to understanding the transformation $\varphi_i(\varepsilon_i) \rightarrow [\varphi_i(\varepsilon_i)]^*$, rests in the characteristics of the viral operator Ж.

A possible way to model the operator Ж is by a positive feedback loop amplifier mechanism where the input signal contains a perturbation which is amplified on output. The magnified perturbation then becomes the new input resulting in continued perturbation growth until the amplifier reaches saturation. For example, consider an amplifier restricted to the combined input values of two psychometric variables: insecurity (I) and the need to dominate (D). The input filter selects only positive values of (I) and (D) and the output amplifies the input values of (I) and (D). A selection filter could be constructed by using a restricted form of the covariance function cov(I,D) such that when (I) increases, (D) increases and vice versa. Only numerically positive values of (I) and (D) are accepted, other values are filtered out. Increased values in (I) and (D) generated by the viral operator transform the *rational* ownership psychometric function $\varphi_i(\varepsilon_i)$ to the *irrational* ownership psychometric function $[\varphi_i(\varepsilon_i)]^*$. In this scenario, the amplifier saturation value is a measure of the maximum multiplier value of $[\varphi_i(\varepsilon_i)]^*$. The positive feedback loop may have attributes analogous to continuous drug induced stimulation – each output/input cycle increasing insecurity and the need to dominate at any cost. The causes underlying the decoupling of instinctual behaviour from socialisation restraints may arise from various sources including possible genetic flaws in an individual owner, viral disease, severe social abuse, and natural disaster each of which amplify the perturbations in the relevant psychometric values.

SECTION 4

Economic Systems and Governance

From the previous sections we can envision a new economic paradigm – a single global dynamic economic system comprised of multiple economic systems operating at local, national and international levels. The new economic paradigm is constructed upon the law of micro-sustainability of resource utilisation and managed in accordance to resource stewardship. If each economic level conforms the law of micro-sustainability, then the single global economic system is also sustainable. What is clear is that such a global sustainable economic system must be based on steady state resource utilisation structured from the bottom up.

We may examine the global configuration in terms of network nodes where each economic system level joins levels above and below its position in the multi-network global economic structure. The global economic system operates as a quantum net in terms of information transfer. Perturbations in critical resources and resource utilisation at any node are immediately seen across the system. Communications are virtually instantaneous. Mechanical distribution instructions for resource re-distribution are then allocated to bring fluctuations in resource utilisation back into the steady state. The global communication multi-network must be standalone, separate from all other networks such as the global internet and be totally independent of commercial interests. All key control elements in the global economic structure must be under UN control with key contributions verified from all network nodes. UN funding must be provided by all nation states in proportion to their natural wealth to maintain a sustainable population calculated per individual. The assessment would involve a detailed knowledge of the number, type and distribution of critical resources readily available to the given population, its ability to utilise, develop and maintain these resources as well as the number, type and distribution of critical resources not immediately accessible to the population but required for survival. In addition, resource specificity to support cultural diversity must be identified and maintained.

The question we need to explore is the possibility of a self regulating dynamic global sustainable global economic network. If such a system were possible, then the next question is 'What conditions are pre-requisite for a single sustainable dynamic global economic system to be self-regulating?

Pre-requisite conditions:

1. The law of micro-sustainability applies at every economic level.
2. The critical number of resources and their properties are identified. For example: local accessibility and network node accessibility, natural life cycle of the critical resource, relative abundance, natural distribution, re-distribution capacity and time coefficient for supplying the global network nodes.
3. Rational power according to user natural need applies throughout all levels leading to the development of 'stewardship'.
4. Irrational power is not tolerated, isolated and minimised.
5. Maximum flexibility for resource utilisation is obtained by optimising resource coupling and sharing within and across critical resources.
6. Population levels remain essentially constant and remain in balance with the utilisation of resources that sustain each population level corresponding to a given economic level.
7. Objective monitors at each node in the multilevel economic network topology provide real time data in node resource utilisation. The data is subject to independent verification.

It is clear that such as global economic system would require immense computing resources, global political commitment and security. The system would have the capacity to be self regulating only in terms of information processing provided by the system. Verification of data input to the system, system monitoring and maintenance would necessarily be subject to checks and balances determined by the UN governing body. Safeguards would have to be built into the global system to permit on-going survival even in the case of catastrophic system failures. One such safeguard would be the determination of the default conditions of critical resource utilisation for each economic base level population. A back-up system acting as a 'stored facility' would be fully resourced at all times and come into play if and when required.

Although the elements discussed above in contributing to the creation of a global vision of sustainability may seem 'pie in sky' in the present state of the human condition, it is nevertheless essential to bring this idealistic notion into the realm of scientific debate and clarification if mankind and our fellow species are to survive the impacts of global environmental threats that we have helped create.

SECTION 5

Conclusions

From the treatment above, we infer the following conditional requirements are essential contributions to the formulation of a global vision of sustainability.

The central role of the steady state throughout this treatment is paramount to the achievement of sustainability in the utilisation of resources, population density and rational use of power.

The regulation of resource utilisation through the mechanism of controlled gate access to resources in the steady state optimises sustainability when resource gate accessibility for resource depletion and resource replenishment for each user remains open and is in accordance with each user's natural need.

Both internal and external gate coupling regulating resource utilisation within single and across multiple resources with resource sharing provides a more robust network capable of withstanding fluctuations in resource availability and utilisation. Under these conditions, sustainability is enhanced.

The long term stability of population density and multiple resource utilisation upon which population depends achieves optimum sustainability when the law of micro-sustainability applies. Each user within the population density accessing both local and global resources is subject to steady state resource utilisation. The ideal sustainable state requires that the population density remains constant which in turn demands that resource utilisation remains constant and vice versa. Economic systems acting within and across multiple resources both locally and globally must comply with the law of micro-sustainability if conflict and resource destabilisation is to be avoided.

The relationship between power and resource utilisation is governed by resource ownership. The notion of ownership is constructed as combination of objective components and subjective components based on psychometric values assigned to the resource owner. *Rational* power incorporates the possibility of steady state resource utilisation with ownership psychometric values limited to the range determined by the modulation of instinct by socialisation. With steady state resource utilisation throughout, resource sharing and resource access gates fully open in accordance with user natural need, sustainable power is achieved. It is this ideal sustainable state which may transform to 'stewardship' in the management of resource utilisation. *Irrational* power does not admit of possibility overall steady state resource utilisation with ownership psychometric values beyond the *rational* range and determined by the decoupling of instinct from social modulation. *Irrational* power is relatively short lived and leads to the destabilisation of resource utilisation and possible resource extinction. *Irrational* power is un-sustainable. What may be inferred from the treatment on power so far is that economic systems based on power accumulation are only sustainable under the constraints imposed by *rational* power.

A new paradigm for the development of a global economic system is suggested which is based on sustainable resource utilisation and stewardship. The pre-requisites and possibility of a self regulating system are discussed.

It is the intention of this treatment that the vision of global sustainability be established on a scientific basis subject to verification. It is hoped that some of the areas highlighted in this treatment will lead to further research and the development of models that can be tested against real systems.

Author's Notes

Since 2008 I have been doing some research concerning the possible formulation of a vision of global sustainability. I have done no background reading on the topic except for a recent paper by Professor Alan Knight (Reference 1) which provided the impetus to complete the 1st rough draft of my paper. The formulation in this manuscript is entirely original.

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