

***KiwiGrow*TM: a community and environmental health framework for sustainable development**

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Abstract

An easily understood community and environmental health framework was devised to provide the basis for a comprehensive assessment of the water and sanitary services for Waitakere City Council, Auckland, New Zealand. The framework, now known as *KiwiGrow*TM consists of a matrix obtained by considering seven key qualities of healthy ecosystems separately in social, economic, environmental and cultural contexts. A healthy ecosystem is supposed to be *nurturing, supportive, stable, contributing, responsive, directed, and adaptive*. Each of these terms takes on consistent but slightly different meanings within each of the four major contexts, providing an easily communicated and holistic framework for sustainable development. If adopted as a “mantra” within the community, it could have far reaching applications to the management of entities ranging from pocket wetlands and neighbourhoods to entire regions. *KiwiGrow*TM can also underpin a new generation of easily understood, high impact “quadruple bottom line” sustainability reporting.

Keywords: ecosystem health, sustainable development, quadruple bottom line reporting.

1 Introduction

In 2002, New Zealand enacted new local government legislation that was based on principles of sustainable development (Local Government Act, 2002). In the Act, the purpose of local government was firstly to enable democratic local decision-making, but was also to promote the social, economic, environmental, and cultural well-being of current and future communities. To underpin the focus on sustainable development, the Act included provisions to improve strategic planning. Local authorities were required to identify and report regularly on the



achievement of desired community outcomes, and prepare, on a three yearly basis, Long Term Council Community Plans covering at least a ten year period, and from which annual plans would be derived. In addition, Councils were required to prepare an Assessment of Water and Sanitary Services, taking a long term view of demand and the effects of alternatives.

By July 2005, Councils were required to have prepared the first of these Assessments of Water and Sanitary Services. Waitakere City Council, already committed to being an “Eco-City”, saw the Assessments as an opportunity to bring a fresh, integrated perspective on these services, and a context within which to further explore ideas about quadruple bottom line (QBL) sustainability reporting. No system had yet been devised that would provide the framework for a QBL assessment of water and sanitary services.

In the absence of such a framework, and taking account of the Council’s desire for the Assessment to be easily understood and presented to the community via multimedia, an interim framework was developed. This framework, now known as *KiwiGrow*TM, shows promise as a general framework for sustainable development. This paper describes the framework and its origins, examines it more closely in light of the literature, and reaffirms that potential for more general use is very real.

2 Development of the assessment framework

2.1 Needs

As an organisation committed to sustainable development, Waitakere City Council has an urgent need to develop operational QBL systems that can give effect to legislative requirements for advancing social, economic, environmental and cultural well-being. While it is possible to structure an evaluation system around a council’s strategic framework, there is a compelling need for integrated planning for development within the Auckland region and elsewhere. The Water and Sanitary Services Assessment (WASSA) project provided a platform for determining whether an assessment framework could be devised that looked beyond local strategies and outcome areas, and presented the assessment in terms that could be used elsewhere in the region.

2.2 Foundations

The concept of ecosystem health has been promoted as a basis for a diagnostic and problem-solving approach to achieving sustainable development, in terms of maintaining and restoring the health of critical natural ecosystems [3]. However no consensus has emerged on a detailed framework that can be widely applied in sustainability assessments, especially for urban systems. Despite this, environmental and health professionals have increasingly seen community health and environmental health as most effectively approached synergistically [1, 16]. However, while the concept of ecosystem health had been adopted by the United States Environmental Protection Agency, an agreed definition was not evident as



recently as 1999, when Costanza and Mageau [5] proposed that a healthy ecosystem is one that “is sustainable – that is, it has the ability to maintain its structure (organisation) and function (vigour) over time in the face of external stress (resilience).”

Urban areas can be viewed as ecosystems either literally or metaphorically [17]. However, while urban ecosystem research is still in its infancy, there is a significant literature on the health of agroecosystems. Based on this, Okey [15] suggested there were seven system properties that lent themselves to a health interpretation:

- *Stability* - the capacity to maintain some form of equilibrium in the presence of perturbations; constancy of production under a given set of environmental, economic and management conditions;
- *Resilience* - the ability to maintain or re-establish structure and behaviour when disturbed; maintaining productivity under stress or disturbance;
- *Sustainability* - long term stability; maintaining production over long term frames despite major ecological and socio-economic perturbations and stresses;
- *Self-organisation* - the ecosystem’s ability to maintain itself through mutually reinforcing interactions or cybernetic feedbacks; related to autonomy and self-sufficiency;
- *Diversity/complexity* - the number of species; biotic “richness” or structural and functional variability of an ecosystem;
- *Efficiency* (or *productivity*) - the output per unit of input; related to the conversion of food resources to biomass;
- *Equitability* (or *equity*) - a socio-economic property representing the evenness of both product distribution and access to agricultural inputs within an agroecosystem.

3 A health vocabulary for human-dominated systems

3.1 Development

Okey’s work [15] provided the starting point for developing a vocabulary for describing health of human-dominated, urban ecosystems. However, in order to move forward, it was necessary to clarify the particular requirements of a model for urban ecosystem health.

Complex systems can be conceptualised as entirely different systems in terms of their components, organisation, purpose and performance measures [2]. Thus an urban ecosystem can be viewed variously as a social system, an economic system, a cultural system, or an environmental/ecological system. Each of these four systems represents a living, changing, evolving system, and consequently ecosystem health concepts should be relevant to each in turn. If a vocabulary can be found that applies equally well to these four systems, then it is likely to endure as a robust basis for assessment. The vocabulary also needs to be concise and easily understood, and to lend itself to presenting issues in terms of risk. It



also needs to focus on symptoms of healthy behaviour, rather than fundamental determinants or predictors, which can subsequently be the focus of ongoing research.

Thus we started by evaluating Okey's [15] vocabulary against these criteria. Okey had suggested five of the seven properties listed were useful in defining ecosystem health: stability, resilience, diversity/complexity, efficiency, and equitability. These were examined in turn.

Each system clearly needed to be stable, and instability in any one of the four areas would increase tendencies toward instability in the others. The link between social and economic stability is one of the main lessons from history, and cultural stability also depends on stability in the physical and social environments [6].

Resilience was clearly an important property. However, Moran [13] has suggested, from an ecological anthropology perspective, that human adaptability provides the key to understanding long term interactions of social and natural systems. Whether response to external change is viewed in terms of stability, resilience, or adaptation would depend on the degree of change that may occur within the system while maintaining its essential nature, and on the expected lifespan of the ecosystem [4]. For *KiwiGrow*TM, with its focus on long term issues, we preferred the requirement that healthy urban ecosystems be "adaptive".

While there was evidence of their role in determining health, Okey's diversity and complexity properties were not considered sufficiently symptomatic of healthy behaviour. They also did not lend themselves easily to connotations of risk. Okey's concern was actually for connections and structures that would be indicated by properties such as diversity. For *KiwiGrow*TM the term "supportive" was preferred: a supportive community would support and benefit from diversity. Okey's equitability property became redundant as a supportive community should also be an equitable one.

The efficiency property was also insufficiently symptomatic of urban ecosystem health, carried only weak risk connotations, and could not be applied equally well across the four systems. We considered that the way a community or ecosystem interacted with its environment through products and services was more fundamental: an ecosystem depends for its sustainability on the role or function that it plays within the hierarchy of ecosystems that make up the landscape mosaic. A key aspect of ecosystem health was that the ecosystem should be "contributing" positively.

Thus, consideration of Okey's five definitive properties of healthy agroecosystems produced four qualities – stable, supportive, contributing, and adaptive – describing urban ecosystem health. These by themselves are insufficient, however, and Okey's two other properties, self-organisation and sustainability, were therefore re-examined.

Okey's sustainability property was adequately captured in our "stable" quality, while the self-organisation property provided the key to the next quality, which linked to ideas about the ability to be self-sustaining. For human-dominated systems, this property relates to qualities such as community spirit,



inner resources, and leadership: healthy urban ecosystems should be “directed” in some way, just as natural systems show organisation and direction in their development. Directedness not only captures the sense of being energetic, purposeful, confident, inspired, and organised, but also the extent to which there is coordinated, integrated action, and leadership matched by followings that achieve action. As urban ecosystems are themselves composed of multiple nested component ecosystems, health is obviously improved by some alignment of these directions.

A fundamental characteristic of living organisms is their ability to respond to changes in their environment. Similarly, urban ecosystems, as collections of people and other living organisms, should be “responsive” to threats and challenges. A responsive system is reactive and resourceful, and opportunities and threats are met with timely and substantial responses from a system that has a sound capital base. Ideas regarding social, natural capital and cultural capital [8, 9, 19] are entirely consistent with this interpretation.

Finally, healthy urban ecosystems must consistently meet first-tier requirements for safety and regeneration, and care of the young and vulnerable. They therefore needed to be “nurturing”, a term equally relevant in economic, social, cultural and environmental contexts.

3.2 *KiwiGrow*TM quadruple bottom line assessment model

Table 1 summarises the seven *KiwiGrow*TM qualities of healthy urban ecosystems, and the underlying themes that provide the basis for their application in social, economic, environmental and cultural contexts.

Having settled on the seven qualities of Table 1, we devised working definitions for each within the four contexts, for use in the WASSA project (Table 2). Different definitions, but equally based on the seven qualities, may be required for different applications. Wider application of the framework would provide a body of experience from which guidelines could be established for catchments, neighbourhoods, small settlements, businesses, schools, and other systems.

Concepts presented in Table 2 suggest a vast array of measures would be required to fully assess and communicate urban ecosystem health. However, the framework can also be used qualitatively, to structure dialogue, and identify issues and collections of goals that together can make up a compelling vision. Research is needed to explore interactions and identify the system properties that fundamentally determine the QBL matrix scores, and can become the focus for management. These more fundamental qualities are likely to reflect more closely the vocabulary that is emerging from ongoing scientific research into ecosystem health, and include such concepts as biodiversity and resource use efficiency.

As part of the WASSA project, we assessed how current water and sanitary services impacted on each of the 28 performance areas in the *KiwiGrow*TM framework, and identified 28 sets of issues. We then created contrasting year 2050 visions centred on each of these issues. In parallel, an overarching management action plan was developed by Council staff to address key issues.



Table 1: The seven system qualities of *KiwiGrow*TM, and one graphic reporting format (where shading indicates the score, or level of risk).

<i>System quality</i>	<i>Underlying themes</i>
<i>Nurturing</i>	Regenerating, safe, caring
<i>Supportive</i>	Respectful of roles of components, non-inhibiting, fulfilling, maximising potential, equitable
<i>Stable</i>	Strong, not fragile, continuing, protective, respectful / honouring of traditions, not capricious
<i>Contributing</i>	Providing goods and services, not wasteful or draining, or a source of harmful constituents or activities
<i>Responsive</i>	Reactive and resourceful, having a strong capital base
<i>Directed</i>	Energetic, inspired, motivated, self-sustaining, confident, purposeful, self-organising
<i>Adaptive</i>	Resilient to change, accommodates change, innovative

	<i>Social</i>	<i>Economic</i>	<i>Environmental</i>	<i>Cultural</i>
Nurturing				
Supportive				
Stable				
Contributing				
Responsive				
Directed				
Adaptive				
<i>Overall</i>				

4 General applicability of *KiwiGrow*TM

4.1 Robustness of the ecosystem health concept

The validity of the ecosystem health concept has been discussed by Okey [15] and Lackey [10]. One concern has been that it is inappropriate to compare an ecosystem to an organism, for which the idea of health is valid. Some have argued that even if it is valid for an ecosystem as a concept, the lack of scientific data limits its use in practice.



Table 2: Customised *KiwiGrow*TM health definitions used for Waitakere City's Assessment of Water and Sanitary Services, 2005.

<i>Nurturing</i>	
<i>Social:</i>	Safe communities, caring attitudes towards people and especially children. Providing essential needs for families.
<i>Economic:</i>	The economic environment supports new business establishment and relocation through availability of workforce, land, financial and other resources and support services.
<i>Environment:</i>	The environment provides for natural regeneration, and spawning and other breeding grounds are protected or being restored. Exotic predators are controlled.
<i>Cultural:</i>	The community supports cultural regeneration and rejuvenation.
<i>Supportive</i>	
<i>Social:</i>	Communities are respectful rights of citizens, including minorities. They provide equal opportunities for advancement and individual fulfillment and value fairness.
<i>Economic:</i>	Businesses are supported through appropriate networks and services, possibly via "ecosystems" of businesses related via inputs and outputs. Tax and rating environment is favourable.
<i>Environmental:</i>	The environment is biologically diverse, and the number of threatened species is minimised. A wide variety of habitats support diversity at the micro and macro levels. Pests and weeds are minimised.
<i>Cultural:</i>	The community respects and supports cultural diversity. Individuals are able to live fulfilling lives without abandoning cultural heritage.
<i>Contributing</i>	
<i>Social:</i>	People within the community are contributing positively to society through paid and unpaid activities. Unemployment and waste of human resources is low. Negative contributions including crime are minimised.
<i>Economic:</i>	Businesses contribute positively to the economy and community welfare in the broadest sense. Businesses are resource efficient, and produce minimal pollution and waste that is not recycled.
<i>Environmental:</i>	The environment provides a variety of "ecosystem services" such as clean water, water storage, and amenity, which benefit communities directly or indirectly. Emissions of pollution and harmful biological materials such as weeds and pests are minimised.
<i>Cultural:</i>	Cultural diversity provides benefits to the community. Cultural groups contribute positively to society.



Table 2: Continued.

<i>Responsive</i>	
<i>Social:</i>	The community and individuals within it respond to challenges such as crises, and areas of need. The skill base is high and people have the tools and technologies to be effective.
<i>Economic:</i>	Businesses have resources to respond to increases in demand, or to downturns.
<i>Environmental:</i>	The environment responds positively to demands placed on it. Ecosystems are inhospitable to exotic biosecurity threats. Systems recover diversity after disturbances such as floods or erosion.
<i>Cultural:</i>	Cultural groups respond to challenges and opportunities and have key skills and other human capital that enable them to flourish.
<i>Stable</i>	
<i>Social:</i>	The community is strong, has a sense of its own past, and respects traditions. Leaders ensure it is not vulnerable to rapid change to its disadvantage.
<i>Economic:</i>	The local economy is strong and not vulnerable to major cyclicity. Many businesses are well established and provide community economic leadership.
<i>Environmental:</i>	Ecosystems and populations are stable, and not being irreversibly degraded. The abiotic environment is maintained within healthy limits.
<i>Cultural:</i>	Cultures are strong and not dying out. People maintain and respect their traditions and heritage.
<i>Adaptive</i>	
<i>Social:</i>	The community acknowledges need for change, learns from experience, and has robust learning institutions that serve its needs.
<i>Economic:</i>	The economy responds to change in economic fortune without major layoffs. Entrepreneurs maximise benefit from new opportunities.
<i>Environmental:</i>	Biological systems reach new stable equilibria following change in environmental circumstances, while maintaining nutrient and other cyclic processes.
<i>Cultural:</i>	Cultures adapt to or accommodate social, economic and environmental change. All cultures have access to research and learning systems



Table 2: Continued.

<i>Directed</i>	
<i>Social:</i>	The community has a sense of its own future, and major projects are well coordinated to achieve shared goals. Leaders have vision.
<i>Economic:</i>	The economy is sustainable, and not founded on a resource base or market that is short-lived. Businesses and leaders have a sense of direction and progress.
<i>Environmental:</i>	Biological systems are generally self sustaining and require minimal inputs from outside the community. Human inputs are local.
<i>Cultural:</i>	Cultural groups have a sense of vision and purpose. Leaders are strong and visionary.

Lackey recognised ecosystem health was a dynamic and normative concept, and that, to be useful, public involvement was essential in its definition. Okey found that proponents of the ecosystem health concept argued that the health metaphor was simply a model that did not require that ecosystems behaved as organisms, health itself was not a static concept, and the ecosystem health approach was a pragmatic approach justified by the limited mechanistic understandings. Lackey [10] considered the ecosystem health concept did not help policymakers with the critical task of identifying tradeoffs. However *KiwiGrow*TM provides a rich array of 28 management areas which must be prioritised in any practical application.

4.2 *KiwiGrow*TM as an operational framework for sustainable development

Operationalising sustainable development requires measurement [20]. The OECD [19] considered that indicators should illustrate linkages to policy questions and the related tradeoffs, the long term implications of policy, and provide a means of measuring progress via baselines and trends. Measures should be simple and easily-understood without compromising the underlying inherent complexity. While resource and environmental accounting frameworks provided information on interactions and a basis for evaluating efficiency, they could be complex and impenetrable. They were also limited to the economic and environmental dimensions, whereas it was essential that social dimensions of sustainable development were also accommodated within the framework. OECD guidelines [14] further state that decisions should be based on both locally-accepted and global values, and reflect risk and uncertainty. Sustainability measures should essentially address five questions: (1) how well is the ecosystem in question, (2) how are the people affecting the ecosystem, (3) how well are the people (including current and future generations), (4) is their well-being fairly shared, and (5) how are these questions connected.



Frameworks for measuring progress towards sustainable development need to reflect means (processes) as well as ends (outcomes). Mog [12] suggested measurement should capture process factors such as the nature of participation, capacity-building efforts, creative thinking, and processes to accommodate diversity and change. Lee [11] likened the level of integration and focus to achieve sustainable development to that required for a major war effort.

*KiwiGrow*TM appears to address all of these concerns. It is simple, yet asks searching questions about the health of our economic, social, environmental and cultural systems. It is values-based, and entirely consistent with concerns of international agencies such as the OECD who could extract information for their international comparisons. It addresses processes as well as outcomes, and can reflect priorities and preferences of society, while being guided by fundamental concepts of ecosystem health. It also readily lends itself to risk-based approaches, as deficient performance in any of the 28 performance areas carries risk.

4.3 Completeness

A number of concepts exist that tend to appear in debates about sustainable development, but are not explicit within the *KiwiGrow*TM vocabulary. Among the concepts of health listed by Costanza et al. [3] was the concept of balance between ecosystem components. In *KiwiGrow*TM balance is arguably an aspect of the ‘supportive’ quality: a system in balance will support coexisting components in ways that are mutually beneficial or beneficial to the system as a whole. The framework also captures the notion of tradeoff, as managers are required to achieve some sort of balance among the 28 performance areas. Graham and Wiener [7] discussed this in terms of tradeoff between risks: managers should, in adopting a “whole patient” culture, aim to reduce overall risk, through managing a risk portfolio. *KiwiGrow*TM provides a coherent framework for a comprehensive risk portfolio.

Vigour is a longstanding ecosystem health concept. Costanza and Mageau [5] saw this as indicated by primary productivity. In *KiwiGrow*TM vigour is captured primarily through the “contributing” quality, but also through the “responsive”, and “directed” qualities.

Within *KiwiGrow*TM, growth is viewed as development and improvement rather than augmentation. Augmentive growth is a measure of performance to the extent that it affects the degree that the system is supportive, nurturing, responsive, contributing, etc. Ecological limits may be communicated through the “supportive”, “nurturing” and “responsive” qualities, with the latter being capable of capturing perceived threats to ecosystem viability as well as the associated response. Measures related to participation and other aspects of the democratic process would necessarily be captured under the “socially-supportive” quality.

Frameworks can fail totally if they are not well-aligned culturally. Compatibility of *KiwiGrow*TM with contrasting world views and cultures is indicated at two levels. The first is that the nature of the framework suggests that cultures can coexist to their mutual benefit, so long as they adapt and evolve.



Some cultures may be more widely represented and require other cultures to adapt. However a community is expected to be culturally nurturing and supportive and to retain or acquire diversity. At a more fundamental level, cultural acceptability of the *KiwiGrow*TM framework is assisted by its biological basis, as well as by the appeal to pragmatism and the inevitable need for real world tradeoffs.

4.4 Underpinning an ecosystem approach

The ecosystem approach to integrated planning and development [18, 21] is one approach that could conceivably deliver sustainable development in New Zealand. Following [21], an ecosystem approach would have the following elements:

- Defining the boundaries of the area of concern, clarifying the agendas of the principal participants, and high level issues to be addressed
- Gathering information on the historical ecosystem and the present economic, environmental, and social conditions and trends, and building understanding
- Identifying stakeholders and associated perspectives on the situation, including their conflicting aims
- Identifying issues, assembling information on possible solutions, and creating alternative visions for the future, from the perspective of various stakeholder groups, firstly qualitatively with stakeholders, then increasingly quantitatively drawing on resources available for research and modelling, with clarity on tradeoffs
- Debating the alternative futures, and producing a common vision, and designing an implementation plan including provision for collaborative learning
- Implementing the plan, including resolving priorities and responsibilities, and establishing institutional arrangements and policies
- Monitoring and evaluating implementation and associated outcomes, including selecting indicators and resolving responsibilities for measurement, information management, interpretation and subsequent action and adaptive responses.

Implementing the ecosystem approach faithfully will always be difficult where there are multiple political jurisdictions, short time frames dictated by electoral and planning cycles, and other economic and infrastructure imperatives. Particularly when large areas and populations are involved, the complexity of the interacting issues is usually so great that single issue, unsustainable responses are always liable to emerge. Establishing a sustainability value-base within the community would ease planning processes, but this has always been hindered by difficulties in explaining what sustainability actually means. However *KiwiGrow*TM is simple enough to be championed politically within the community as a “common sustainability language”. This can then underpin debates about outcomes, processes, and tradeoffs, help to transcend debilitating



expertise and policy “silos”, promote values convergence, and support self-sustaining sustainability initiatives throughout the community.

5 Conclusion

*KiwiGrow*TM is a community and environmental health assessment framework initially developed to assist with and communicate Waitakere City Council’s 2005 Assessment of Water and Sanitary Services. It seems clear that it has significant potential as a general operational framework for sustainable development. It can form the basis of an array of tools to assist education, monitoring and reporting, issue identification, visioning, and decision-making, including identifying and making tradeoffs. Promoting *KiwiGrow*TM and a “common sustainability language” within any community that genuinely aspires to sustainable development has the potential to precipitate a wave of collaborative innovation centred simultaneously on systems such as pocket wetlands, ecological restoration projects, neighbourhoods and small settlements, catchments, cities, regions, households, businesses, public agencies, schools, and governments.

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References

- [1] Burke, T.A., Litt, J.S., & Fox, M.A. Linking public health and the health of Chesapeake Bay. *Environmental Research Section A* (82) 143-149, 2000.
- [2] Checkland, P. *Systems Thinking, Systems Practice*. Wiley & Sons, Chichester, 330 pp, 1981.
- [3] Costanza, R., Norton, B.G., & Haskell, B.D. *Ecosystem Health – New Goals for Environmental Management*. Island Press, Washington D.C. 269 pp, 1992.
- [4] Costanza, R., & Patten, B.C. Defining and predicting sustainability. *Ecological Economics* (15) 193-196, 1995.
- [5] Costanza, R. & Mageau, M. What is a healthy ecosystem? *Aquatic Ecology* (33) 105-115, 1999.
- [6] Elmer, D.M., Christensen, H.H. & Donoghue, E.M. Understanding the links between ecosystem health and social system well-being: An annotated bibliography. *USDA. Forest Service, General Technical Report PNW-GTR 559*. 47 pp, 2002.
- [7] Graham, J.D. & Wiener, J.B. *Risk versus Risk. Tradeoffs in protecting health and the environment*. Harvard University Press, 1995.



- [8] Hawken, P., Lovins, A. & Lovins, L.H. *Natural Capitalism: Creating the Next Industrial Revolution*. Rocky Mountain Institute. 1999.
- [9] Holling, C.S., Berkes, F. & Folke, C. Science, sustainability and resource management. In F. Berkes, and C. Folke. (eds.) *Linking social and ecological systems – management practices and social mechanisms for building resilience*. Cambridge University Press, 342-362, 1998.
- [10] Lackey, R.T. Values, policy, and ecosystem health. *BioScience* **51** (6) 437-443, 2001.
- [11] Lee, K. *Compass and Gyroscope: Integrating Science and Politics for the Environment*. Island Press, Washington D.C., 243 pp, 1993.
- [12] Mog, J.M. Struggling with sustainability – a comparative framework for evaluating sustainable development programs. *World Development* **32** (12) 2139-2160, 2004.
- [13] Moran, E.F. *Human adaptability, an introduction to ecological anthropology*. Second edition, Westview Press, Boulder, CO. 446 pp. 2000.
- [14] OECD. *Sustainable development strategies. A resource book*. OECD, Paris and United Nations Development Programme, New York. 2002.
- [15] Okey, B.W. Systems approaches and properties, and agroecosystem health. *Jl Environmental Management* (48) 187-199, 1996.
- [16] Parkes, M., Panelli, R. & Weinstein, P. Converging paradigms for environmental health theory and practice. *Environmental Health Perspectives* **111** (5) 669-675, 2003.
- [17] Pickett, S.T.A., & Cadenasso, M.L. The ecosystem as a multidimensional concept: meaning, model, and metaphor. *Ecosystems* **5** (1) 1-10, 2002.
- [18] Slocombe, D.S. Environmental planning, ecosystem science, and ecosystem approaches for integrating environment and development. *Environmental Management* **17** (3) 289-303. 1993.
- [19] Stevens, C. Measuring sustainable development. *OECD Statistics Brief* No. 10. September 2005. 8 pp, 2005.
- [20] UNCED. Agenda 21 & the UNCED Proceedings. N.A. Robinson, editor. *United Nations Conference on Environment and Development, Rio de Janeiro, Brazil*. New York: Oceana Publications. 1992.
- [21] Waltner-Toews, D. & Kay, J. 2005. The evolution of an ecosystem approach: the diamond schematic and an adaptive methodology for ecosystem sustainability and health. *Ecology and Society* **10** (1) 38 Online. www.ecologyandsociety.org/vol10/iss1/art38/.

