Introduction

Recently, a number of scientists have offered new strategies that promote agroforestry as a means of improving local livelihoods while conserving important species and environmental functions. Brosilus and Russell (2003) have even proposed to “reinvent” community-based conservation by suggesting the principle of “building assets across generations”; assets that can include natural, social, and economic. Leakey and Tchoundjeu (2001); Tchoundjeu et al (1999), have also made first rate progress in the domestication and marketing science for indigenous fruit trees in the humid tropics of West and Central Africa, thus supporting conservation in agroforestry landscape mosaics through use. Schroth and colleagues (2004) recently authored a synthesis of the benefits that agroforestry can offer biodiversity conservation in tropical landscapes. They identified three hypotheses around how agroforestry can contribute to conservation: protect nature by reducing pressure to deforest land, provide habitat for native plant and animal species, and serve as a benign matrix land use for fragmented landscapes. However, they also state that integrating and managing agroforestry with conservation is a major policy, institutional and technical challenge.

This recognition of the multifunctional nature of especially forested landscapes has thus recently being consolidated in the realization that, approaches to manage for integrated conservation and human development would require the identification and management of ‘flows’ of ecosystem functions (like food chains, gene flows, water flows, pollination, seed dissemination, soil formation, disease regulation, nutrient assimilation) across extensive inter-connected geographic and economic contexts. Thus from the parochial notion of managing biodiversity in ‘parks’ as a
strategy for environmental conservation this paradigm shift from parks to landscapes, has ushered in an even more urgent need to more fully define, articulate and co-ordinate our understanding of the interconnectivity of processes within multi-functional landscapes. One way in which we are improving our understanding of multifunctional landscapes in order to better craft management actions is to view them in the light of complex systems theory.

Complex systems theory amongst other things help us view landscape management as requiring a shift in approaches; from managing for pre-set outcomes on the assumption that ecosystem processes are linear and their outcomes, predictable; to managing for more adaptive ones. Therefore, in our current efforts we consider how best to link this 'scaling-up' of the management domain, from parks to landscapes, how it fits into complex systems theory and thereafter, what opportunities and challenges exist around which management actions can be built.

Among the realizations that come with understanding management needs for landscapes is the truism that, with our shift from parks to landscapes, it is becoming relatively less important how we physically manage individual anthropogenic and non-anthropogenic components, and more so, how we generate, manage, communicate and especially integrate the analyses of the information about their individual dynamics because, complex systems theory teaches us that, it is the whole that determines the parts. Even as important, are the ethical issues which surround the collection, analyses and use of such information.

Therefore, while in this paper we will attempt to present and explain the shifts in management paradigms in multifunctional landscapes, as a necessary step towards improving our understanding of the different dimensions of landscapes our eventual focus remains the recognition that, human communities have strong socio-ecological relationships with these multifunctional bio-physical, social and economic domains. Thus communities should represent the focal points for information generation and management. In order to then test our hypothesis that bio-physical, social and economic information management can constitute the cornerstone in successful landscape management, we will further examine how some emerging anthropogenic and ethical issues, like deliberative democracy, critical and institutional trust, that often govern the functionality of the human societies in landscapes, can influence the very effectiveness in the generation and use of information under innovative processes like Participatory Geographic Information Systems (PGIS).

From Parks to Landscapes: the paradigm shift

From the demise of Integrated and conservation projects (ICDPs) of the late 80s (West & Brechin, 1991), there have been, more recently (CARPE, 2000), strong shifts from managing biodiversity within designated blocks of supposedly 'pristine' parks, to that of managing flows of ecosystem functions within multifunctional landscapes. This departure has been prompted by the results of several studies that have largely concluded that, the 'pristine parks' model is yielding disappointing results (Hakizumwami, 2000; Musters et al. 2000; Byers, 1999; Hart et al. 1998). Some studies have even questioned whether the traditional Parks model of managing biological diversity, are effective, practical or even ethical. There is thus a growing school of thought for the dismantling of that mental model for managing biological diversity (Musters et al. 2000; Sayer, 2000; Mbiile et al, 2005) largely because, traditional parks are
both, too small to represent the full range of interdependent bio-physical processes that sustain continued ecosystems functions and secondly because, the social, economic and policy scales of parks do not appear to facilitate a coordinated understanding of the full scale of interdependent processes that occur in landscapes.

To deepen our understanding of landscapes, natural resources management scientists, including this one, are drawing parallels between the functioning of landscapes and the concept of complex systems, amongst many reasons, to illuminate the former, and guide the development of management approaches for multifunctional landscapes.

**Landscapes as Complex Systems**

Landscapes refer literally to huge expanses of land-based natural and or man-made resources within which, under normal conditions, linked social, economic and ecological processes and or functions can operate optimally.

Although equally applicable at economic and social scales, the concept of landscapes considered within the context of complex systems has grown from the need to develop understanding of the spatial and functional interdependence between man and nature (Raskin et al. 2002; Kasperson and Kasperson, 2001b). The landscape concept also considers linkages in life-supporting ecosystem functions like food chains, gene flows, water flows, pollination, seed dissemination, soil formation, disease regulation, nutrient assimilation etc (Baskin, 1997, Daily, 1997) over huge geographic scales. Complex systems thinking is thus used to bridge social and biophysical sciences to understand phenomena like climate history and human actions (McIntosh et al, 2000), in assessment of regions at risk (Kasperson et al, 1995), and how to link social and ecological systems for better and integrative environmental management and livelihoods (Gunderson and Holling, 2002; Berkes et al. 2002).

In landscapes therefore, two main forces are at play; anthropogenic and non-anthropogenic forces. According to Barry Commoner (1979) living things accumulate a complex organization of compatible parts; those possible arrangements that are not compatible with the whole are screened out over the long course of evolution. Thus, the organization of a current natural ecosystem is likely to be 'best' in the sense that, it has been so heavily screened for disadvantageous components that a new addition is likely to be worse than the previous one. This assertion by Commoner is likely to be truer for non-anthropogenic forces, than it is for anthropogenic ones involving the actions of economic man. For such reasons, managing landscapes thus require the awareness that, human communities can have strong and non-static relationships with ecological processes, from farm to ecosystem scale.

Extensive evidence exists for instance, that show local people's knowledge and experience of natural processes in landscapes to embed deep lessons on how to adaptively adjust to ecosystem shifts and how to manage biological diversity (Gadgil et al.1993; Berkes and Folke, 2002).The complex nature of these socio-ecological relationships requires therefore that, we revise the misconception of a global steady-state and mind-set, that, the effects of human actions on ecosystems are linear, predictable and can be controlled. Because these functions can neither be predicted nor controlled, managing landscapes thus requires a people-focused system of information
generation, management and communication which supports precautionary planning and perhaps increase our ability to mitigate system vulnerability.\(^2\)

**Participatory Geographic Information Systems (PGIS): unifying landscape functions and promoting participation**

Therefore, from a purely anthropogenic perspective, managing change in landscapes requires of us, among other things, to facilitate a social context with flexible and open decision-making institutions\(^3\) that allow for dynamic learning and actions through information generation, communication and feedback about their interactions with the ecosystem. It is by mastering such knowledge and information generation and flows that different parts of a landscape can communicate with each other, so to speak. And it is by using such systematic information generation and analyses that disorderly Man in his/her incessant search for betterment can begin to cope with how to manage landscapes for reduced vulnerability.

One such emerging discipline which can bring together systematic information generation, analyses and communication capable of unifying the needs for information management in landscapes is Participatory Geographic Information Systems.

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**Box 1: Participatory geographic Information Systems (PGIS) (Giacomo et al, 2004)**

PGIS is the result of a spontaneous merger of Participatory Learning and Action (PLA) methods with Geographic Information Technologies & Systems (GIT&S). Participatory Geographic Information Systems (PGIS) practice is based on using geo-spatial information management tools ranging from sketch maps, Participatory 3D Models (P3DM), aerial photographs, satellite imagery, Global Positioning Systems (GPS) and Geographic Information Systems (GIS) to compose peoples’ spatial knowledge in the forms of virtual or physical, 2 or 3 dimensional maps used as interactive vehicles for public deliberation: discussion, information exchange, analysis and as support in advocacy and decision making.

Geo-referencing and visualizing ‘indigenous spatial knowledge’ (ISK) help communities to engage in peer-to-peer dialogue and promotes their issues and concerns vis-à-vis higher level authorities and economic forces. The integrated and multifaceted process of which PGIS is a component, gives communities confidence in interacting with outsiders and adds authority to local knowledge.

PGIS practice has to be embedded into long-lasting interventions in the position to support stakeholders in jointly pursuing multiple objectives and to eventually deal with differences in opinion resulting from new realities which may emerge from the process (e.g. delineating a static, linear boundary defining access to resources in a context of overlapping / seasonal pastoralist / farming land uses).…..

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\(^2\) Vulnerability here refers to an ecosystem losing its ability to adjust to stresses and shocks

\(^3\) Decision making institutions here can range from individual household heads, through local management committees to government departments
By the sheer scale at biophysical and socio-economic levels of landscapes, a first step in management requires approaches to decentralize and devolve governance structures for management decisions-making. A growing literature (McGinnis, 1999; 2000) is demonstrating that, dynamic efficiency in management is often thwarted by centralized management frameworks and enhanced by systems of governance existing at various levels of autonomy complemented by modest overlap of authority and competence.

To thus increase our ability to manage complex multifunctional landscapes, two main axes of understanding need to be developed; first there is the need to identify existing, and generate new technical knowledge of resources, processes and interactions. Secondly, there is need to develop deliberative spaces, i.e., non episodic, real and virtual spaces where meaningful dialogue and debate can occur (Parkins & Mitchell, 2005), to ensure and sustain public participation in the generation, use, analyses and management of especially natural resources information.

Public participation in landscape management may either involve bringing people together physically (in workshops, meetings, seminars, etc), or virtually by using communications technologies and other media. Both methods involve costs and benefits; each depending on the usefulness of the process towards attaining the eventual objectives of natural resources management. For instance, when local actors are 'up-rooted' from their more familiar natural contexts or environment and brought into a discussion forum, their contributions can become static, conditioned by the nature of the meeting and largely based on their memory and or facilitation (manipulation) method. If in addition, virtual interactions evolve where these local actors are encouraged to continue making their contributions towards landscape management, but are able to remain physically present and 'active’ in their natural environments, carrying out their usual activities, their participation will tend to depend more on the usefulness of the process to them; relevance and compatibility with other livelihood strategies, and effectiveness of the data/information capture, encryption and communications technologies used. Here additional benefits may accrue to the overall management process in terms of local ownership. As participation in landscape management becomes a pre-occupation rather than an event in the local actor or facilitator’s life, this, according to Chambers (2005) leads to self-mobilization and transformative actions. Thus, PGIS in landscape management becomes a spatially explicit methodology that ensures continuous and dynamic involvement of local people in natural resources management based on the representativeness and pertinence of their locations and activities within the landscape, tied to the overall management requirement of ecosystem functions in the landscape and does not depend on their availability or willingness to inform, work for, or collaborate, which according to Chambers’ participation ladder (2005) falls within the extractive, inducement or consultative categories, respectively. In practice however, raising the quality of participation in Landscape PGIS is less straightforward and thus is requiring even greater efforts in ensuring better governance.

**Landscape PGIS: a thesis from experience**

Our experiences of PGIS implementation are drawn from the DJA-Minkebe-Odzala Landscape straddling Cameroon, Congo and Gabon, where the results of pilot PGIS work are already being integrated and communicated to
stakeholders using new information and communications technologies\(^4\) (NICTs) and in the Democratic Republic of Congo where it is being suggested as a management support option for the Salonga-Lukende-Sankuru landscape. The experiences have enabled us realize that, improved governance in facilitating frank, deliberative and democratic dialogue within real\(^5\) and virtual spaces remains vastly more important than the technological considerations required for their communication via NICT media. To preclude the ‘garbage in, garbage out’ phenomenon in the PRM process there must be a strong local perception of respect for procedural norms as well as both critical (inter-personal) and institutional trust. Local knowledge is not just central to PGIS practice but local confidence about its use and protection is crucial. We can thus argue that, Landscape PGIS imposes on itself a pre-requisite for deliberative, democratic governance that can be enhanced by both critical and institutional trust. Without these elements the purpose of PGIS – a decentralized system of knowledge valorization, fair use and effective communication, for action and advocacy, are impossible. To highlight the importance of deliberative, democratic considerations in building critical and institutional trust, elements required for generating high quality information in the context of landscape PGIS, an analysis of what these concepts in their generic form, mean to landscape PGIS is hereby called for.

**Box 2a & b: A PGIS-Based Information System for the DJA Landscape, Cameroon**

The Concept of a PGIS in landscape management is underway in the DJA landscape in Cameroon, led by the World Agroforestry Center (ICRAF). The system has been designed to be a community-accessible one. It comprises of geographically explicit socio-economic and ethno-ecological data collection and analyses mediated by participatory resources mapping processes and using tools like global positioning systems (GPS), the storage and management of that data within a local geographic information system (GIS) and the eventual communication of that data via a wireless internet system to collaborators (including markets) hundredths even thousands of kilometers away.

The process so far has commenced with the systematic sampling of sites across the landscape to represent watersheds, critical floral and faunal habitats, buffer zones, mining areas, purely agricultural zones, timber concessions and an ongoing selection of niches of specific concern for environmental management, commercial interests or local livelihoods. In site selection, emphasis has been on evidence of interconnectivity between sites, thus functions.

The variables to be simultaneously monitored include (i) Agroforests in watersheds; and in them, tree species, numbers, densities, productivity, markets, layout of trees; (ii) Habitats: and in them, sightings of droppings, live animals, regeneration etc; (iii) Buffer zones; and in them farming practices, size of farms, length of fallows; (iv) Mining: and in them, type of mining activities, hydrology, spatial extent of activity, etc; (v) Agricultural activity; and in these soil quality, farming systems; (vi) Concessions/community forests: species extracted, extent of activity, level of soil disturbance, access roads created, settlements, etc.

Only one site is so far active since 2004 due to limited resources. Data collected here has covered productivity of trees, logging, farm expansion, and timber exploitation. A wireless communications system was established in 2005 by a local NGO network, which can serve at least 25% of the landscape. An evaluation of this information system has just been completed and findings on the opportunities and constraints will soon be published. Furthermore, research on the economic potential and logging of *Balanionella toxasperma*, and their potential effect on some social development indicators in two communities have just been completed and results will be published soon. A PhD thesis is being prepared on the Total Economic Valuation of *Balanionella toxasperma*. The single point data collected so far is hardly sufficient for any useful generalizations to be made yet.

**Box 2b: Options for landscape PGIS for the Salonga Landscape, DRC.**

This Landscape presents yet another challenge for management. With its multifunctional nature, a systematic sampling of sites around its two national parks and the development of socio-economic data collection parameters have been a first step completed in 2004 with assistance from the World Agroforestry Center. Here again the idea of a PGIS being to ensure systematic collection of spatially explicit socio-economic and ethno-ecological data from a representative portion of the landscape through the use of a mosaic of participatory resource maps of the sampled sites, and the integrative analyses of these data within a GIS by the managing agency (WWF-RDC) in collaboration with ICRAF to ensure effective monitoring and evaluation. Additional resources are required for this to be continued.
PGIS and Democratic theory

A discussion of PGIS and democratic theory is not possible without prior analyses of the generic meaning of 'democracy' as it would mean in the context of landscape management. According to George Graham, US Senator for South Carolina (2005) "democracy is not voting, it is the rule of law supported by public participation.". PGIS is about participation so we will focus of the former – 'rule of law' as the next essential element in this 'democratization of the landscape'. Although the expression 'rule of law' referred to in this quote by a consummate politician may not necessarily refer to a natural resources landscape context, the nuance in 'rule of law' remains highly pertinent to us.

Rule of law, can be seen in three ways. Firstly, according to Dicey, (1982) rule of law is "the absolute supremacy or predominance of regular law (a nation's guidelines for governance) as opposed to the influence of arbitrary power, or even discretionary authority on the part of a constituted government". The emphasis here is on 'law content' or the substantive quality of policy guidelines as a way of shaping public behaviour, in our case, towards the use, management and disposition of resources in a landscape; natural, human, knowledge, material.

"Secondly, as F. A. Hayek (1994) puts it, rule of law "means that a government in all its actions is bound by rules fixed and announced beforehand – rules which make it possible to foresee with fairness and certainty how the authority will use its coercive powers in given circumstances, and to plan one's individual or group affairs on the basis of this knowledge". In landscape PGIS, indigenous knowledge is shared freely and resources are expended both by local people and managing agencies. It is thus crucial for confidence to reign regarding how contributions are to be valued, benefits distributed and rights protected. Here also, there is the indication of process and the term 'fair' has appeared as a way of qualifying the substantive element of management guidelines (policies). Suggesting though mildly that policies need to possess a service value, not just a substantive one, and serving a just, societal purpose.

Finally, according to Shen (2000) rule of law refers to formal or procedural justice. And this denotes the method of achieving fairness in decision-making by consistently applying rules and procedures that shape the institutional order of the system*. Formal or procedural justice consists of a number of principles. Firstly, the system of laws must have a complete set of decisions and procedural rules that are fair. Secondly, the fair rules of decision and procedure must also be pre-fixed, pre-announced and seen to be done transparently and consistently. Here Shen (2000) brings in the essential element of process- deliberation and dialogue, in evaluating the effectiveness of policy as well as in evaluating if policies are providing the services as intended. Note in this latter notion that, justice is more concerned with process and procedure than it is with substance, or the end result. And as Selznick (1969) had earlier stated, "legitimacy has to do mainly with how policies and rules are made and applied rather than with their contents. Note again, the emphasis on process and participation? What needs balancing here in understanding 'rule of law' is

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*Note that government in this discussion and as applied to forest landscapes could be local or regional management authorities, management committees or even the village authority structure.
both substantive (content) justice as described by Dicey (1982) and procedural forms (Shen, 2000; Schauer, 1988) that, without fair and just procedures and processes, there is no guarantee that the end result will be just (i.e., attaining substantive justice). As such, procedural justice (transparent and fair processes) is seen as a necessary condition for achieving a substantive outcome.

Therefore, like in managing complex systems, in information generation and management we may not focus on the end product alone, i.e., the information we may need for a report, an evaluation or an article. If the norms of transparency, process and fair-play are not observed in the information generation and management process we are likely to feed garbage into the system, and at landscape scale this could be enormous garbage indeed! It is thus impossible to acquire accurate, reliable and useful data and achieve participation if the PGIS is seen to be top-down, extractive, exclusive, manipulative or exploitative. Therefore, democratic governance in Landscape PGIS becomes the transparent and consistent articulation of fair decisions, respect for local perceptions, capacities, procedures and rules, while in collaborative enquires with local communities.

However, knowing that procedural justice is required for democratic governance is fine. Nevertheless, for this to be sustained it has been shown in the case of the DJA landscape in Cameroon that, an additional ingredient in Landscape PGIS is mutual confidence, attainable through the building of both critical and institutional trust between and amongst stakeholders.

**Confidence building in PGIS practice: the DJA experience again**

Democratic dialogue in landscape management has to do with capturing knowledge systems (both local and scientific) and linking these to management needs. Two crucial variables in PGIS practice are time and space. The unique contribution that PGIS brings to this effort is found in how it progressively records and synthesizes spatial and temporal information, facilitating communication and contact, and builds capacity and confidence in stakeholders.

In the DJA PGIS-mediated learning situation, willing actors have been able to revise spatially explicit preferences for tree species, comparative interests in timber, non-timber products, hunting and agricultural development, expectations and beliefs, progressively (across time and space)—the key aspect being that unlike activity reports and traditional socio-economic surveys, which are episodic and non-evolutionary, landscape PGIS as a management tool becomes a systematic, knowledge-based, spatially explicit ‘diary’ of the results of public participation, permitting dynamic and comparative analyses. This facilitates regular and transformative contact between the different stakeholders, government agents, researchers, NGOs other villages, etc. Several authors (Wondolleck and Yaffee, 1994; Moore, 1994) have reached similar conclusions about the important role of relationship building in participatory processes leading to frank and commonly owned outcomes (Lachapelle, Mcool and Patterson, 2003;).

Effective participation or ‘involvement’ according to Parkins & Mitchell (2005) is a function of mutual and incremental trust that builds-up between external collaborators and communities in the resource management process. And thus, as
Mcool and Gunthrie (2001) affirm, unless there is trust even between community members themselves, they would be even reluctant to share information such as say map and 'expose' the habitats of rare but important plants or incidence and breeding grounds of wildlife species or sacred sites during participatory GIS analyses in ethno-ecological studies, although such information may be crucial for the management of the resource. Landscape PGIS in the culturally diverse DJA landscape is facilitating both critical trust between Bantu and Pygmy communities over access and control of forest-based fruit trees (Baillonella toxisperma, Irvingia gabonensis) and rare medicines (Combretum mucronatum) as they have been obliged to work together and manage the data through local NGOs for a common purpose.

By physically engaging communities and external experts in spatially explicit deliberative dialogue over forest resources, PGIS has helped facilitate the understanding of spatial advantages in terms of for instance, which land use investment is likely to provide the most benefits and least cost for livelihood, a conclusion almost impossible to achieve, without a spatial analysis dimension. The exercise has also exposed comparative advantages in new knowledge generation roles. For instance, in ethno-ecological studies involving high-value trees, although community knowledge has remained the most cost effective way of tapping into this knowledge, the same communities, lacking in time and resources to explore and understand more complex interrelationships, which may be affecting their lives, have ultimately relied on expert opinion for guidance. For such a relationship to be built on trust, and thus result in communities accepting risks, and even increased vulnerability, and reposit even greater confidence in authorities and researchers, and vice versa, time and tangible interactions are required (Smith and McDonough, 2001; Freudenberg, 1993). PGIS products (resource maps and GIS) often provide proof of such interactions.

Conclusions

We can conclude confidently today, that the ongoing paradigm shift in environmental management, from the notion of pristine isolated parks to multiple-use landscapes is relentless and likely to continue. Whether it is Technical Operations Units or UTO (Unités Technique Opérationelle), Model Forests or Landscapes, the underlying commonality established by this paper is that, these entities all have important temporal and spatial characteristics that need careful study and monitoring, and can be understood within the context of complex systems theory. Therefore, these systems are all exposed to gradual and continuous shifts and their management requires that we not only generate knowledge for appropriate responses, but more so we should develop the capability to both plan for and be sensitive to these shifts.

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7 the French appellation and concept for managing huge natural resources areas for multiple objectives
8 A CIFOR facilitated Canadian sponsored concept for managing extensive natural resources areas as multiple use zones in Cameroon and elsewhere in the world
9 The USAID-led Model for managing ecosystems for multiple objectives
Thus, because human communities have strong and dynamic relationships with landscapes from farm to ecosystem scale, there is the need for continuous, multi-site research and analyses, to provide scientific and anthropogenic understanding of processes. Secondly, there is a need to develop, non episodic, linguistic, non-linguistic and spatially explicit forms of democratic dialogue in real and virtual spaces over the results of research with the sole aim of fostering dynamic and integrative understanding of processes.

To ensure continuous and frank participation, the process must be guided by the articulating of fair decisional and procedural rules, transparently and consistently supported and seen to be supported through public participation. Finally, because Participatory Geographic Information Systems (PGIS) is all about facilitating public participation in resource dialogue, it can serve as a unique platform for such deliberation and dialogue in a milieu such as landscapes, constantly faced with uncertain futures, complexity and surprise. PGIS will, in the coming years serve as a robust platform for integrating the results of empirical research with the dynamic relationships between communities and ecological processes. With PGIS essentially adopting a progressive character, mutual confidence between stakeholders is built as the open relationship re-enforces both critical and institutional trust. Stakeholders in such constant and interactive contact quickly become aware that they are in the same boat; that a pre-requisite for managing landscapes is one of compromise or consensus; consensus between environmental services, livelihoods and policies, not to produce pre-determined ‘solutions’, but to enhance human ability to plan and respond. Thus PGIS cannot only facilitate mediation but also the effective communication of spatially and temporally explicit information in a tangible, interactive, verifiable and simplified form to all interest groups; landscape managers, community and state parties.
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