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TransLinks and the Millennium Villages

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The Environment in the Millennium Development Goals and the Millennium Villages

Achieving the Millennium Development Goals (Figure 1) set forth by the United Nations will require balancing use of ecological resources with negative feedbacks resulting from resource use pressure (Millennium Ecosystem Assessment 2005a). The Millennium Villages Project (MVP), which currently involves 500,000 people across 14 sites in sub-Saharan Africa, seeks to achieve the eight MDGs in all sites within 5-10 years. The implication is that if research-based development interventions are able to achieve success at the village level, these same interventions can be scaled up to regional and ultimately national scales. Since the inception of the first Millennium Village in Sauri Kenya in 2003, agricultural development has played a central role in the project (Sanchez et al. 2007).

Goal 1: Eradicate Extreme Hunger and Poverty
Goal 2: Achieve Universal Primary Education
Goal 3: Promote Gender Equality and Empower women
Goal 4: Reduce Child Mortality
Goal 5: Improve Maternal Health
Goal 6: Combat HIV/AIDS, Malaria and other diseases
Goal 7: Ensure Environmental Sustainability
Goal 8: Develop a Global Partnership for Development

Figure 1 Millennium Development Goals (MDGs)

Millennium Villages Project sustainability and scaling literature identifies agriculture as the “lead sector” for overall growth (Annual report, 2008). However, most of the agricultural sustainability components addressed in the 2008 Annual Report are economic issues relating to market access, financial and human capital, and improved agricultural inputs and increased yields. While this evidently ties into Goal 1, 3, 4, 5, and 6, largely absent from this discussion is an extended focus on environmental sustainability (ie. biodiversity, ecosystem health, land use). In this sense, while MVP literature identifies agricultural sustainability as a key component of the project, its emphasis on inputs, infrastructure, and market conditions suggests that conservation goals and environmental issues, while important, are secondary to economic prerogatives in scaling models and applied interventions. MVP identifies sustainable development as “ecological, social, and economic interdependence,” but environmental considerations are absent from the “findings” and “recommendations” sections of the 2008 synthesis report (Annual Report, 2008). Often in rural and poor areas, agriculture is the primary means of development, and this is why it has been such a strong focus in the MVP.

2009

At the 2009 Annual General Meeting in Addis Ababa, this lack of emphasis on the environmental sector to date was highlighted and acknowledged by the science lead Dr. Cheryl Palm and the director of the entire project, Dr. Pedro Sanchez. In part, the difficulty in integrating environmental goals into the MVP is related to the metrics for goal 7, "ensuring environmental sustainability". The targets are as follows:

> **Target 7a:** Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources
> **Target 7b:** Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss
> **Target 7c:** Reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation
> **Target 7d:** Achieve significant improvement in lives of at least 100 million slum dwellers, by 2020

Target 7a and 7d are not relevant on a village scale, and while important, 7c and its indicators do not specifically refer to the role of natural resource management in achieving this target, but are more to do with infrastructure and access to resources rather than sustainable resource management. Target 7d is important, but in regions that have already had much of their biodiversity depleted, this is difficult to interpret. The indicators outlined (figure 2) by the assessment are for the most part not instructive for incorporating more ecologically sustainable practices into development, be it agricultural development or otherwise. For example, how would one identify suitable and sustainable "proportions" for indicators, 7.1, 7.4, 7.5, 7.6 and 7.7?

7.1 Proportion of land area covered by forest
7.2 CO_2 emissions, total, per capita and per $1 GDP (PPP)
7.3 Consumption of ozone-depleting substances
7.4 Proportion of fish stocks within safe biological limits
7.5 Proportion of total water resources used
7.6 Proportion of terrestrial and marine areas protected
7.7 Proportion of species threatened with extinction

Figure 2: Indicators for MDG 7b: Reduce Biodiversity loss, achieving significant reduction in the rate by loss by 2010

The primary ways the MVs are endeavoring to better incorporate the environmental sector are as follows:

(i) Systemically planning and drastically increasing the types of tree seedlings and number of seedlings in nurseries or seeds and distributed and planted (minimum of 200,000 per village of 5,000 people) to the communities;
(ii) Promoting and expanding integrated soil fertility management practices to half of the cropped area in the village;
(iii) Conducting participatory environmental assessments in all sites;

(iv) Developing plans for natural resource management (land rehabilitation, conservation areas, tree planting, erosion control, removal of invasive species) made based on the participatory assessments; and

(v) Organizing better erosion control through terracing (biological or stones) in sites with slopes of 30 percent or more.

All of the above interventions (tree planting, integrated soil management, and terracing) address preservation or restoration of critical **ecosystem services**. In the case of both treeplanting and terracing, the primary services provided are erosion control, and improved water infiltration to soils. Integrated soil management includes a number of techniques to increase soil carbon, improve agricultural yields naturally, and reduce the spread of pests and disease, among others. These are important actions that will benefit the agricultural sector, but there is room for a more holistic view of ecosystem services and how they are integrally involved in an overarching sustainable development agenda.

With support from the TransLinks Leader with Associate's Award, the Earth Insitute/E3B of Columbia University is working with staff of the MVP andthe Millennium Villages to develop materials and tools that will help enhance biodiversity and improve the provisioning of multiple ecosystem services in the Millennium Villages. Of course, the materials being developed are designed to be beneficial to personnel from other organizations and institutions beyond the project. For those unfamiliar with ecosystem services, a first step might be to review the Earth Instiute/E3B **Ecosystem Services Primer**. Herein, a case is made for the importance of more explicitly incorporating ecosystem services into the MVPs, and specifically how examining interactions among services at multiple scales can be instructive to appreciate not only the monetary value of ecosystem services, but their role in both environmental and economic sustainability.

State of Research on Ecosystem Service Management and Information Needs

The ecology & economics of ecosystem services

Ecological research has demonstrated scientifically that the magnitude of ecosystem services are a function of the combined influence of ecological regulatory, or state, factors (e.g. Daily 1997, Loreau et al. 2002, Kremen 2005, Balvanera et al. 2006, Diaz et al. 2007). Key state factors include environmental conditions and the diversity and composition of biotic communities (Amundson and Jenny 1997), and ecosystem dynamics link state factors to ecosystem services. However, ecological and environmental economics typically do not trace ecosystem service values (ESVs) back to ecosystem processes or state factors, except for a handful of high-value forest goods (e.g. fresh water provision; Kaiser and Roumasset 2002). Furthermore, both ecological and economic studies of ecosystem services delivery and valuation have typically focused on single services, at or above landscape spatial scales. Thus, the disciplinary specificity of ecological and economic work has prevented effective synthesis of cross-disciplinary knowledge that is required to resolve the dual social and biophysical nature of ecosystem service delivery, toward predictive understanding at the spatio-temporal scales at which land management is conducted.

Multifunctional agriculture and spatiotemporal scale

Ecosystem Services commonly interact with one another (Millennium Ecosystem Assessment 2005, Carpenter et al. 2009, Nelson et al. 2009), resulting in trade-offs and synergies between services. For example, trees intercropped with an annual crop may either compete with (trade-off) or benefit crop production (synergy) (Ong et al. 2002). In contrast, trees in fallow land have clear synergies with production of subsequent crops.

The scales over which ecological processes operate determine the nature and magnitude of ecosystem services. Different ecosystem services originate biophysically and accrue to beneficiaries at a variety of spatial, temporal, and social scales, from local ecosystems to the biosphere (Kremen 2005, Carpenter et al. 2009). Ecological theory predicts that important influences of biodiversity and ecosystem process complexity on overall ecosystem functioning and services should occur via spatial and temporal exchanges that may require large spatial extents, and multiple years (Loreau et al. 2003, Tscharntke et al. 2005). Ecological processes operating at greater spatial scales tend to be 'slower' variables, allowing space and time influences on ecosystem dynamics to be integrated conceptually along a spatiotemporal continuum. Trade-offs and synergies between ecosystem services should scale in conjunction with ecosystem processes across spatial and temporal dimensions. Thus, valuation of portfolios of several ecosystem services tend to exhibit emergent properties invisible to single-service valuation.

At coarse spatiotemporal scales (e.g. the biosphere, Hadley cells, biomes, ecoregions; and over years to millennia), ecological heterogeneity generates synergies between ecosystem services that are strong relative to trade-offs. Coarse-scale heterogeneity provides supporting and regulating ES that maintain and stabilize earth systems functioning, and moreover these benefits cannot be replaced with technological substitutes.

At finer scales over which management is conducted (e.g. from sub-meter to landscape scales; and over months to decades), it is commonly asserted that multifunctionality in land use can help reconcile trade-offs between ecosystem services (e.g., Jackson et al. 2007, Steffan-Dewenter et al. 2007). Scaling upward across spatiotemporal scales, the apparent strengths of synergies tend to decline in comparison to trade-offs. Some provisioning ecosystem services exhibit clear trade-offs at finer spatiotemporal scales, for example between production of wood and livestock, resulting in specialization of management and agroecosystem simplification to maximize immediate returns (Swift et al. 2004). This trend results in part from declining ability to technologically replace ecosystem services at greater spatiotemporal scales; even if farmers may maintain agricultural productivity at finer scales, landscape-scale ecosystem services may be compromised, and high cropping frequency of annual crops can impair future production capacity. The importance of ecological heterogeneity at finer scales remains debated. For example, ecological experiments demonstrate that the number of species required for near-saturating levels of ecosystem process rates increases with the number of processes considered (Hector and Bagchi 2007, Gamfeldt et al. 2008), although such mechanistic research is difficult at greater scales.

The strengths of synergies relative trade-offs between provisioning ecosystem services are scale-dependent, and often non-linear. Not only must research estimate how synergies and trade-offs change with spatiotemporal scales, the mechanisms in terms of ecological regulation must be elucidated, if this knowledge is to eventually benefit effective management. Valuation of provisioning ecosystem services should account for the extent to which different ecosystem state factors (e.g. functional traits, species composition, vegetation structure) and ecosystem processes influence delivery of multiple ecosystem services, as well as the contributions of identical state factors and processes to multiple ecosystem services. Because ecosystem services often differ in terms of underlying regulatory state factors and processes, maintaining a certain level (e.g. ½ the maximum rate) for each of several ecosystem services in a portfolio should require greater ecological complexity. Furthermore, a single state factor or ecosystem process can contribute simultaneously to more than one provisioning ecosystem services (e.g. plants producing goods during the fallow period also restore soil fertility, improving subsequent crop yields), increasing additively the value of state factors and processes that contribute to different ecosystem services in the portfolio. Valuation focused on single ecosystem services ignores these essential biophysical aspects of ecosystem services delivery, underestimating the value of individual state factors and processes.

Ongoing Research

The goal of the work in the Millennium Villages with the support of TransLinks is to use ecological and economical data generated from the MVP to understand how the structure, function, and management of ecosystems influences the aggregate ecological and economic value of the landscape. Within this context, a further aim is to assess the functional roles of indigenous plant biodiversity in ecosystem services production and economic productivity, and influences of different land management techniques on biodiversity. The work constitutes one step in the greater process of gauging the prospects and perils that residents of MVs may face in coming decades.

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