LANDSCAPE ECOLOGICAL PATTERN OF TROPICAL AGRO-FORESTRY EFFORTS AT EDUCATIONAL FOREST LANDSCAPE OF MOUNT WALAT, SUKABUMI

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ABSTRACT

The process of urbanization has changed the face of the landscape, not only in urban environments, but it also has expanded the areas around it. The changes in land use are increasing not only occurs in areas formerly categorized a semi-intensive, such as agricultural lands, but also in extensive and protection areas. However, in some periphery still characterizes the function of a good environment; especially in rural areas the changes that occurred were limited to their own needs (subsistence), as in Mount Walat, Sukabumi. This study aims to identify and analyze the tropical agro-forestry efforts and to provide landscape ecological pattern in order to preserve the environment and social culture. The method used in this study was a site survey method with focusing on the biophysical condition of the site and analysis of reports or other sources regarding the management processes undertaken. Mount Walat ± 359 Ha area of forest is guided by land use pattern that is divided into four characters, i.e., forest ecosystem, opened forest, ownership land, and countrified. Its area of ± 70 Ha was managed as agro-forestry land. The form of tropical agro-forestry in the country side around the site consists of yard and mixture garden, while in the arable land is a mixture garden. In order to prevent of destruction, then the manager invites Hegarmanah villagers to cooperate in maintaining its sustainability by allowing land to cultivated in Mount Walat agro-forestry, with the terms agreed by both parties, without damaging the forest ecosystem. The study was suggested that the community structures and developmental pathways which arised across a gradient of disturbance frequencies can provide models for alternative agro-forestry solutions. Addressing multiple objectives and sustainability in a complex biophysical and socioeconomic system ought to be a challenging and exciting enterprises.

Key words: Change, land use, tropical agro-forestry, landscape ecology, pattern, sustainability.

ABSTRAK

Proses urbanisasi telah mengubah wajah lansekap, tidak hanya di lingkungan perkotaan, tetapi telah meluas ke daerah sekitarnya. Perubahan dalam tata guna lahan terus meningkat tidak hanya terjadi di daerah-daerah yang sebelumnya semi-intensif, seperti lahan pertanian, tetapi juga di daerah-daerah ekstensif dan perlindungan. Namun, di beberapa pinggiran masih mencirikan fungsi lingkungan yang baik, terutama di daerah pedesaan perubahan-perubahan yang terjadi sebatas pada kebutuhan mereka sendiri (subsisten), seperti di Gunung Walat, Sukabumi. Penelitian ini bertujuan untuk mengidentifikasi dan menganalisis usaha agroforestri tropis dan memberikan pola ekologi lansekap dalam rangka untuk melestarikan lingkungan dan sosial budaya. Metode yang digunakan dalam penelitian ini adalah metode survei tapak dengan berfokus pada kondisi biofisik tapak serta menganalisis laporan atau sumber-sumber lain mengenai proses manajemen yang dilakukan. Gunung Walat seluas ± 359 Ha kawasan hutan terdiri atas pola tata guna lahan yang terbagi menjadi empat karakter, yaitu ekosistem hutan, hutan bukaan, tanah milik, dan perkampungan. Seluas ± 70 Ha telah dikelola sebagai lahan agroforestri. Bentuk agroforestri tropis di perkampungan sekitar lokasi terdiri atas pekarangan dan kebun campuran, sedangkan pada lahan subur adalah kebun campuran. Dalam rangka untuk mencegah kerusakan, maka pengelola mengundang penduduk desa Hegarmanah untuk bekerja sama dalam menjaga kelestariannya, dengan memungkinkan lahan untuk budidaya di agroforestri Gunung Walat, dengan syarat yang disetujui oleh kedua belah pihak, tanpa merusak ekosistem hutan. Studi ini mengusulkan struktur masyarakat dan jalur perkembangan yang muncul di gradien frekuensi gangguan dapat dijadikan model bagi solusi agroforestri alternatif. Membahas berbagai tujuan dan keberlanjutan dalam sebuah kompleks biofisik dan sistem sosial-ekonomi yang seharusnya, dan, yang menantang dan menggairahkan perusahaan.

Kata Kunci: Perubahan, tata guna lahan, agroforestri tropis, ekologi lansekap, pola, keberlanjutan.

INTRODUCTION

A much broader range of impacts of land-use change on ecosystem goods and services were further identified. Of primary concern are impacts on biotic diversity worldwide (Sala et al., 2000), soil degradation (Trimble & Crosson, 2000), and the ability of biological systems to support human needs (Vitousek et al., 1997). Land-use changes also determine, in part, the vulnerability of places and people to climatic, economic, or sociopolitical perturbations (Kasperson et al., 2005). When aggregated globally, land-use changes significantly affect central aspects of Earth System functioning (Cassman et al., 2005). Land use has been defined as the purposes for which humans exploit the land cover. It involves both the manner in which biophysical attributes of the land are manipulated and the intent underlying that manipulation, i.e., the purpose for which the land is used (Lambin & Geist, 2006).

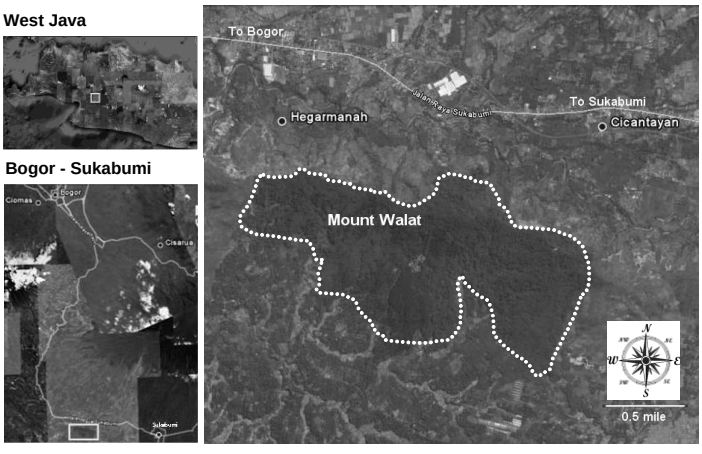
The unprecedented rate of forest clearing in the tropics and the increasing importance of secondary forests calls for an evaluation of the effects that human activities have on forest recovery. The effects of former land uses, particularly agriculture, on ecosystems may be long-lived (Dupouey et al., 2002); (Uriarte et al., 2004). In Indonesia, changes in land use over time increasingly felt in the suburban areas (periphery), as a result of the space requirement is very high in urban areas. The changes evident are changes in land use are increasing, not only occur in areas formerly a semi-intensive, such as agricultural lands, but also occur in extensive areas and protection, such as forests, mounts, and mountains. Bogor, Tangerang, Bekasi are the suburbs of Jakarta, very clearly visible changes in land use. Even the expansion does not only occur in those areas, but has expanded to more distant regions such as Cianjur, Karawang, Serang, and Sukabumi. However, in some periphery still found some areas which characterize the function of a good environment especially in rural areas, the changes that occurred were limited to their own needs (subsistence). These can be seen in the land use of the community yards, mixture gardens, orchards, and forests.

The example is the agro-forestry efforts in Mount Walat for the width of ± 70 Ha which is located in Sukabumi, West Java. Agro-forestry is recognizes the use of trees and shrubs on farms to support agricultural production, protect soil and water resources, enhance biodiversity, sequester carbon, and improve landscape values (Nuberg et al., 2009). In Mount Walat, the forest area is guided by land use pattern that is divided into 4 characters, i.e., the forest ecosystem, opened forest, ownership land, and countrified. The form of agro-forestry in the countrified around the site consists of yard and mixture garden. The form of agro-forestry in the arable land is a mixture of garden. Since 1970's, Mount Walat was start managed by Institut Pertanian Bogor (IPB) and established as educational forest. Along with time and weakened of economic condition caused by monetary crisis in 1998's, so the community around the forest begin to cut down the forest to fulfill their needs. In order to prevent a larger damages, in early 2000's Forest Faculty of IPB and the community around the forest, especially Hegarmanah villagers, make a cooperative program to manage Mount Walat by allowing land to cultivation without damaging the forest ecosystem. Until now, these agro-forestry efforts are sufficient for bridging between community needs and the sustainability of natural resources. Nevertheless, these activities have to be monitored and controlled to ensure the ecological sustainability, not only to the site but also the impacts to the environment.

This study aims to identify and analyze the ecological agro-forestry activities in this landscape in order to preserve the biophysical and social culture environment; to identify major changes and evaluate the impacts; to identify of the existing management and evaluate the future alternative management plans.

RESEARCH METHODS

The study was conducted in 2006, with the object of observation on educational forest of Mount Walat, Sukabumi, West Java. Geographically, it is located at 106°48'27" EL until 106°50'29" EL and 6°54'23" SL until 6°55'35" SL. Administratively, educational forest of Mount Walat includes in Cicantayan district area of the Sukabumi Regency. It is located between the village borders of Cicantayan and Hegarmanah (*see* Fig. 1). The entire width of forest area ± 359 Ha, consists of three blocks, which are the Eastern block (Cikatomang) covering ± 120 Ha, Western block (Cimenyan) covering ± 125 Ha, and the Central block (Tangkalak) covering ± 114 Ha.



Source: Google Earth

Fig. 1. The location of Mount Walat, Sukabumi, West Java.

Materials were used of this study such as land use and land cover map, topographic and slope level map, geologic and soil condition, climatic, and demographic and visitors. The equipments were used such as stationery, global positioning system (GPS), and digital camera. The method that used in this study was a site survey method with focusing on activities:

1. Observations on the biophysical condition of the site, to determine such as: the condition of landscape elements, the existing site conditions, land use, level of maintenance, control, and ongoing management. In this case examined the impact that may result from environmental changes that occurred.
2. Conducting interviews, analysis of reports, or other sources regarding the management processes undertaken. In this case will be reviewed on an alternative management plan that can be done on the site.

RESULTS AND DISCUSSION

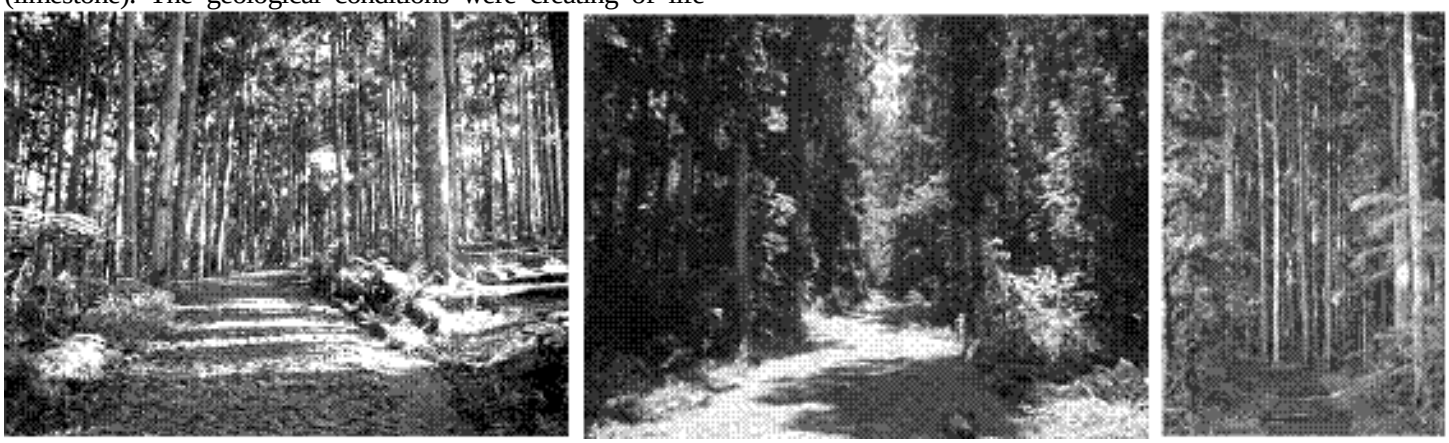
Abiotic: Topographic, Geologic, Soils, and Microclimates

Educational forest of Mount Walat is located at an altitude between 500-726 m above sea level with a 2 point triangulation 676 m and 726 m above sea level. Mount Walat especially in the north, marked by a ridge that extends from the east end to west end. The topography of the area is mountainous with large areas ± 98 ha (56%), hilly ± 42 ha (24%), corrugated ± 23 ha (13%), corrugated ± 9 ha (5%), whereas the relatively flat ± 4 ha (2%). In the middle of the ridge on Gadung hill rather have stakes triangulation with 676 meters altitude above sea level. While in the eastern part precisely on the top of the Batu Bilik hill there room stakes triangulation with 726 meters altitude above sea level, which is the highest place in Mount Walat, so the natural landscape view (agricultural landscapes, rural landscapes, and the landscape of Mount Walat) which runs to the east, south, and west can be enjoyed.

Mount Walat was created in tertiary age. Mains rock of this area consists of two components which are sedimentary rock and volcanic rock with component of quartz rock (limestone). The geological conditions were creating of life quartz cave because forest cover is relatively undisturbed. Mount Walat region in the classification of Schmidt and Fergusson including climate type B (the value of Q = 14.3% - 33%). The average temperature around 25.4 ^{O}C with a minimum temperature of about 20.6 ^{O}C and a maximum temperature of about 30.3 ^{O}C. Air humidity averages of 81.8% with 1987.6 mm rainfall per year, the sun shines approximately 41.3%.

Biotic: Vegetations and Animals

Educational forest of Mount Walat vegetations composition comprising plants trees, shrubs, and ground covers and now there are agricultural crops on the sidelines of the plant stands (*see* Fig. 2). Vegetation types that dominate the site for the tree such as: Akasia (*Acasia mangium*), Damar (*Agathis loranthifolia*), Jengkol (*Pithecellobium umbellatum*), Jeunjing/Sengon (*Paraserianthes falcataria*), Krei payung (*Filicium decipiens*), Mahoni (*Swietenia macrophylla*), Puspa (*Schima wallichii*), Saga (*Adananthera pavonina*), Salam (*Eugenia operculata*), Pinus/Tusam (*Pinus merkusii*), and Waru-waruan (*Gosyphium* sp.). Some shrubs and herbs such as: Acung (*Dracontium* sp.), Alang-alang (*Imperata cylindrica*), Areuy hutan (*Cissus discolor*), Babadotan (*Ageratum connyzoides*), Balakacida (*Eupatorium odoratum*), Harendong (*Melastroma malabathricum*), Lempuyang (*Zingiber papuanum*), Saliara/Lantana (*Lantana camara*), and Soka (*Ixora javanica*). Types of grass and ground cover plants include Antanan (*Viola odorata*), Akar wangi (*Polygala paniculta*), Calincing (*Oxalis berrelieri*), Jampang (*Phartopus compressus*), Jukut kipait (*Paspalum conjugatum*), Jukut hideung (*Arthraxon pilipes*), Letah hayam (*Hemidioda ocimofolia*), Pungpurutan (*Urena lobata*), and Teki (*Kyllinga monochepala*). And agricultural crops are cultivated such Kapolaga (*Ammomum* sp.), Kopi (*Coffea* sp.), Padi ladang (*Oryza sativa*), Pisang (*Mimusa* sp.), Salak (*Salacca zalaca*), Singkong (*Manihot esculentum*), Talas (*Colocacia esculentum*), and Ubi jalar (*Manihot* sp.).



Source: Private collection and http://www.gunungwalat.net/

Fig. 2. The vegetations structures and configurations of Mount Walat landscape.

There are many different types of wildlife that Mount Walat inhabitant, including birds, such as Ayam hutan (*Gallus varius*), Bincuing (*Cacomantis sonneratii*), Burung hantu (*Bubo* sp.), Elang (*Haliastur indus*), Kutilang (*Pycnonotus golavier*), Perkutut (*Geopelia striata*), Piit (*Lonchura leucogostroides*), Tekukur (*Streptopelia chinensis*), and Srigunting (*Dicurus leucophaeus*). Types of mammals and reptiles, such as Babi hutan (*Sus scrofa*), Bajing (*Callociurus notatus*), Kera (*Macaca sp.*), Musang (*Martes flarigul*), Tikus (*Rattus exulans*), Biawak (*Varanus salvator*), Bangkong (*Bufo melanosticus*), Kadal (*Mabuya multifasciata*), snakes, and fishes. These animals have a habitat that spread in the forest area. Some founds in individuals, and some founds in groups. The dynamics of this biotic aspect may represent indicators of environmental conditions of Mount Walat.

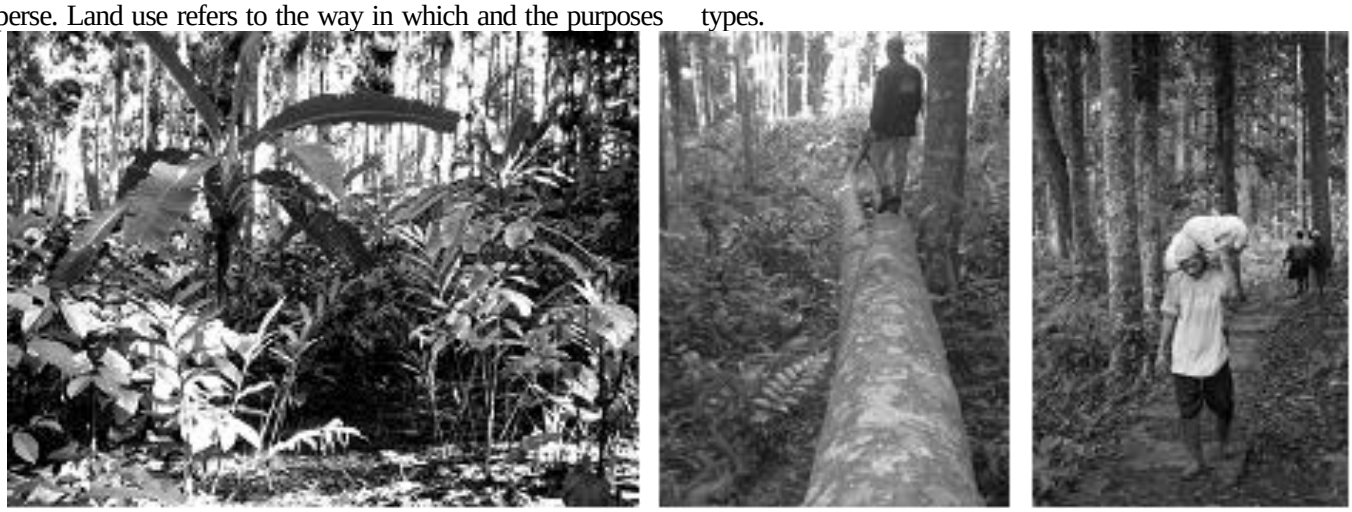
Socio-culture, Land Use, and Agro-forestry

The number of people in Cicantayan district until September 2001 for 45,316 inhabitants with men numbered 23,011 (50.78%) and women numbered 22,305 (45.22%). Livelihoods in Cicantayan rely on agriculture so that farmers are the most dominating job with the number of 7,780 people (43.2%), this is supported by a rural area, either as cultivators, agricultural laborers, or farmers' property. Communities around the site are Sundanese culture, which is reflected in the pattern of stage house and typically of courtyard house. Stage house has walled of bamboo woven and has a pit stall used for livestock of ducks and chickens. The courtyard house was planted a variety of crops that give benefits for its owner and also cultivating of fishes, and so livestock. The landscapes of agricultural Sundanese was reflected by broadly of rice field.

Land use patterns in educational forest of Mount Walat were divided into four characters, i.e., the forest ecosystem, opened forest, ownership land, and countrified. Patterns of land use can alter both the rate and direction of natural processes, and land-use patterns interact with the abiotic template to create the environment in which organisms must live, reproduce, and disperse. Land use refers to the way in which and the purposes for which humans employ the land and its resources (Meyer, 1995). In Mount Walat, forest ecosystems were dominated by Damar (*Agathis loranthifolia*), Puspa (*Schima wallichii*), and Pinus/Tusam (*Pinus merkusii*). Condition under the trees still thick with shrubs, herbs, and ground cover plants, and so it is suitable for wildlife habitat.

Opened forest is a forest area which was opened for agro-forestry activities. This opened forest areas were cultivated by farmers in the Hegarmanah village have permission to work from Mount Walat management. Agro-forestry is one of the sustainable approaches to land-use management where both agriculture and forestry combine into an integrated production system to get maximum benefits (Nair, 1998). In order for agro-forestry activities going well then made an agreement of cooperation between the Forest Faculty of IPB with cultivators of Hegarmanah village. There were five blocks of tenants groups, which were Cipeureu block, Sindang block, Citalahap block, Sampay block, and Nanggerang block. To find out the progress and constraints in agro-forestry activities, then conducted meetings held every certain period of time between the groups, which was facilitated by the escort from Forest Faculty of IPB. In generally, agro-forestry land in the site has a fairly steep slope, so then when the land processing, the farmers to make terraces to avoid erosion of soil and water. This land processing is usually started in the rainy season, because the soil is more easily treated with hoes and right for planting.

In this area many agricultural crops that are planted by communities such as: Singkong (*Manihot esculentum*), Kapolaga (*Ammomum* sp.), Pisang (*Musa* sp.), Talas (*Colocacia esculentum*), Kopi (*Coffea* sp.), and other crops plant. The form of agro-forestry in the countrified around the site consists of yard and mixture garden, while the form of agro-forestry in the arable land is a mixture of garden. Mixture of agricultural and forestry crops are generally at random pattern, which is in one land unit spacing between the trees may vary (*see* Fig. 3). Agricultural crops are planted on the sidelines of the tree tend not to notice plant spacing, especially if the crops are planted more than two types.



Source: Private collection and http://www.gunungwalat.net/

Fig. 3. Some types of agro-forestry activities in Mount Walat.

The agro-forestry systems have many benefits were often taken for granted based on a superficial comparison of monocultures to natural ecosystems. However, frequently, yields in agro-forestry systems reduced instead of increased (Sanchez, 1995). Even if increased productivity is not the main objective, interaction research on (crop) productivity remains necessary, because trees influence crop production anyway and a reduced production is in general not acceptable to farmers (Kho, 2008). Although design of these integrated tree–crop and/or tree–crop–livestock systems can be flexible in order to meet the different objectives or constraints of farmers or landowners, there are many obstacles, in both ecological and economic terms, to overcome to make them attractive to landowners. The acceptability of agro-forestry systems by landowners would be improved if interactions that exist between trees, crops, and/or livestock remain largely beneficial so that productivity per unit area of land is increased while reducing environmental risks associated with mono-cultural systems (Jose & Gordon, 2008).

Agro-forestry and Ecological Landscape

As a system of land use, agro-forestry has become an increasingly attractive land-use option in temperate and tropical regions as countryside policy objectives have been broadened in response to concerns for the environment, demographic movements, changes in rural economies, and shifts in land use (Doyle & Waterhouse, 2008). In particular, agro-forestry is often regarded as being easier to ‘‘sell’’ to farmers than conventional forestry, which has had limited adoption (Doyle & Thomas, 2000). Nevertheless, crop planting techniques in agro-forestry land of Mount Walat still simple (traditional). There is no special treatment in the planting, and same case happened in plants maintenance, the farmers do not much care for the land. Activities frequent maintenance is cleaning the grass and watering plants obtained from the rain. And so prevention of pests and crop diseases are not carried out specifically. Most farmers do not care if the plant disease due to lack of fees. For pest control and plant diseases, farmers usually remove the affected plants or cut it down. Even if agro-forestry can be unequivocally demonstrated to be more profitable than conventional agriculture, it is not a foregone conclusion that farmers will embrace it. Although farmers may state that they want to improve profits, it is a mistaken assumption that this means that they will adopt any new land use that is shown to be more profitable. A farmer will not suddenly switch to farm forestry to improve his income. Instead, his reaction will be to look at ways of modifying existing enterprises to secure an increase in profitability (Newman & Gordon, 1997).

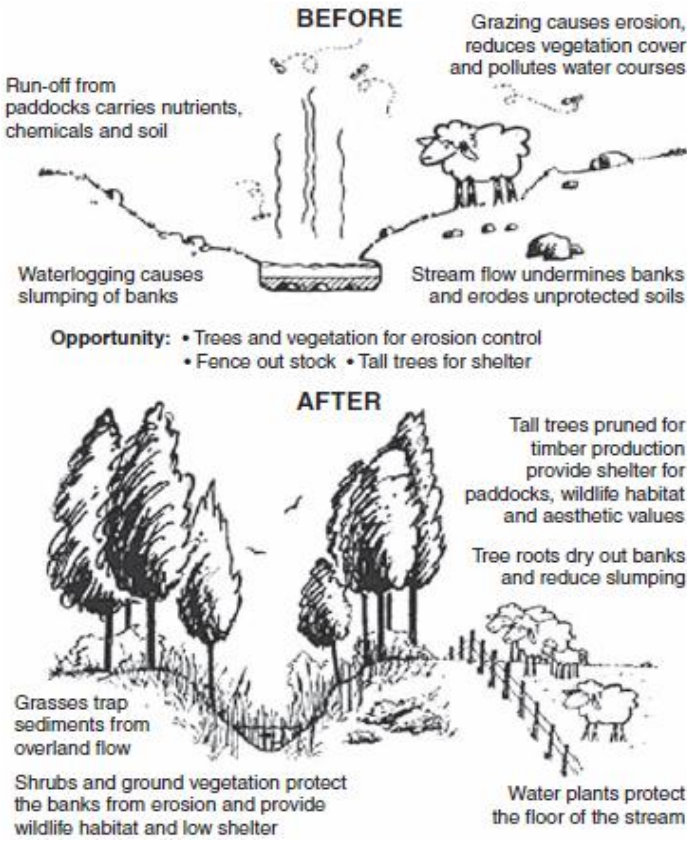
Forestry is the art (skill), practice, science, and business of managing forest ecosystems to sustain an ecologically possible and socially desirable balance of forest resources and other ecosystem services and values. This experience-based approach must be supplemented with an understanding of the ecological processes that underlie both the traditional systems and the new set of values. The design of future agro-forestry systems will have to be based as much or more on an understanding of the processes responsible for production and sustainability of multiple values and environmental services as it has on traditions and experience in the past (Kimmins et al., 2008). Ecological design is needed to predicate on the co-evolution of nature and culture. It is a kind of covenant between human communities and other living communities: Nothing in the design should violate the wider integrities of nature (Van der Ryn & Cowan, 2007).

Whether agro-forestry will play a significant role in the future of rural employment in Mount Walat regions will depend on three factors:

1. The willingness of farmers to plant tree;
2. The willingness of the government and institutions to subsidize farm forestry; and
3. Public attitudes to forestry in general and agro-forestry in particular.

The first of these will depend strongly on the perceived economic benefits of agro-forestry. The second factor, there are likely to depend on the perceived wider local and regional benefits arising from increased farm forestry in general and agro-forestry in particular. The governments and institutions have to introduce a variety of tree planting and management schemes to bring about policy objectives ranging from agricultural diversification through to habitat creation and enhancement of biodiversity. It is these nonmarket benefits connected with amenity, habitat, landscape, and animal welfare that will determine the third factor, namely public attitudes.

These observations of study indicate that farmers in the Hegarmanah village perception and attitudes to agro-forestry are likely to be central to its uptake. A high proportion of farmers regard agro-forestry as an ‘‘inappropriate’’ use of productive land and as ‘‘irrelevant’’ as an alternative source of income. There is a credibility problem over the relevance and practicality of such systems, compounded by a lack of knowledge and expertise among both farmers and their advisers about agro-forestry management. For these reasons, it is unlikely at the current point in time that farmers in Mount Walat will adopt such systems on a widespread basis without strong government encouragement in the form of grants for establishing the systems on farms and funding to support further research and extension activities. The need for land degradation control or stock shade and shelter may define where trees must be established on a particular property and the role they must play to be effective in the short term. Then, if the landholder has an interest in producing



Source: Abel et al., (1997).

Fig. 4. Appropriate agro-forestry design for multiple outcomes begins with an understanding of the problems and opportunities.

timber, they may consider how to adapt their design to incorporate commercial species and forest management options that keep alive the possibility of harvesting a commercial product in the future (*see* Figure 4).

Ecological Landscape Design for Sustainable Management

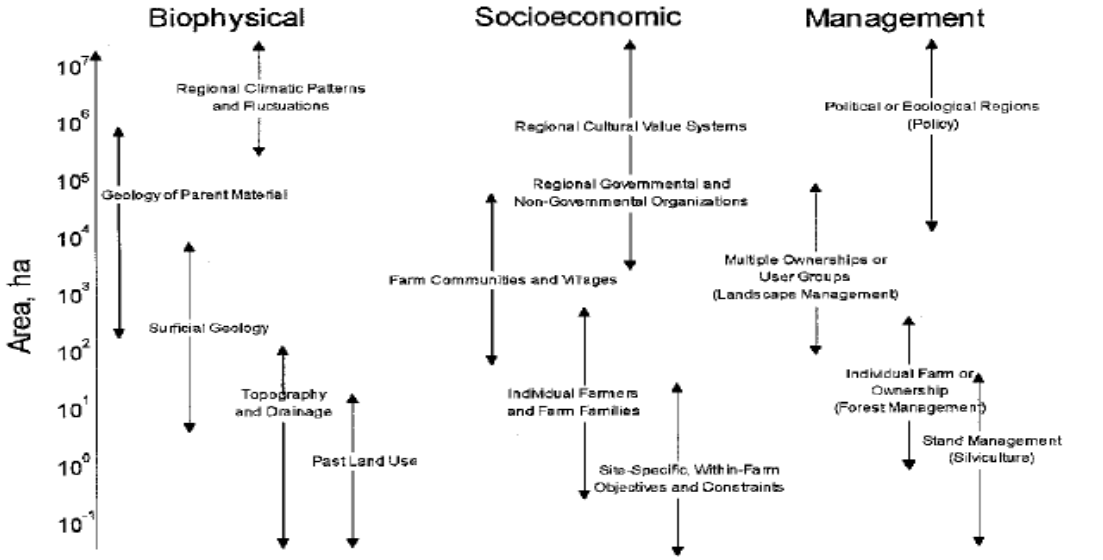
Many of the site assessment and classification techniques employed in traditional forestry applications fare poorly when confronted with the biophysical, ecological, and social complexity of the agro-forestry setting. When we confront agro-forestry problems at large scales, such as agro-forestry efforts in Mount Walat, we immediately encounter complexity. The dominant question at the scale of the individual field or stand, that of whether or not a specific approach is more or less productive than some other alternative, gives way to more subtle questions about how a particular approach meshes with broader physical, biological, and social systems. We are forced to contend with the spatial and temporal aspects of agro-forestry systems, and the ways in which multiple values can be balanced against each other. The systems approach is an emphasis on hierarchical structures in natural, social, and ecological phenomena (*see* Figure 5). It is absolutely essential to consider multiple scales and hierarchical levels simultaneously in any successful landscape management problem.

Classification at regional scales is often related to the objectives of research planning, as exemplified by the meso- and macro-scale methods of the diagnosis and design. An awareness of regional context is also important for decisions at a local scale, particularly when novel systems are to be designed or tested. Regional-scale information can offer important insights into opportunities currently being missed, or challenges that must be confronted, by local-scale solutions. We must consider the regional, social, and economic context for agro-forestry systems. In an agro-forestry context, local inhabitants must be considered not merely as beneficiaries of some outside design process, but as participants. The patterns of resource production, consumption, and transportation may suggest opportunities or limitations to agro-forestry systems.

The future management has to develop a framework for identifying possible agro-forestry communities surround Mount Walat, with particular reference to their structural characteristics, and the ways in which those characteristics change through time. The community structures and developmental pathways which arise across a gradient of disturbance frequencies can provide models for alternative agro-forestry solutions. The degree that these circumstances require us to change our analytical perspective, we should not expect those changes to come smoothly. Addressing multiple objectives and sustainability in a complex biophysical and socioeconomic system ought to be, and is, a challenging and exciting enterprise.

CONCLUSIONS

The agro-forestry in the Mount Walat as one effort to conserve the environment and welfare of surrounding communities that must be balanced with the appropriate management systems approach. Communities should be placed as the subject of development and participants of it activities. The attraction of productivity and the concept of managements must be able to be understood and translated by the government and institutions, so as to provide a better understanding to communities as the implementers. Through ecological design, the future management has to develop a framework for identifying possible agro-forestry communities surround Mount Walat, with particular reference to their structural characteristics, and the ways in which those characteristics change through time. The community structures and developmental pathways which arise across a gradient of disturbance frequencies can provide models for alternative agro-forestry solutions.



Source: Ducey et al., (2000).

Fig. 5. Parallel hierarchies of biophysical characteristics, socioeconomic characteristics, and management structures.

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