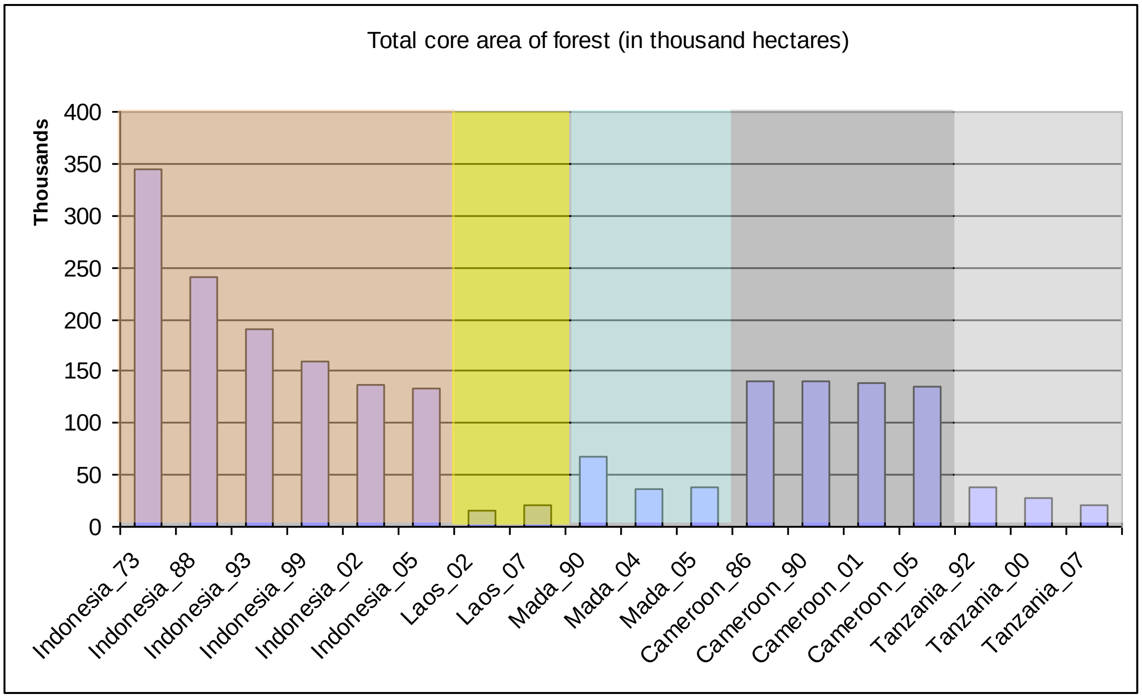


Figure 38. Total core area of forest in five sites over time

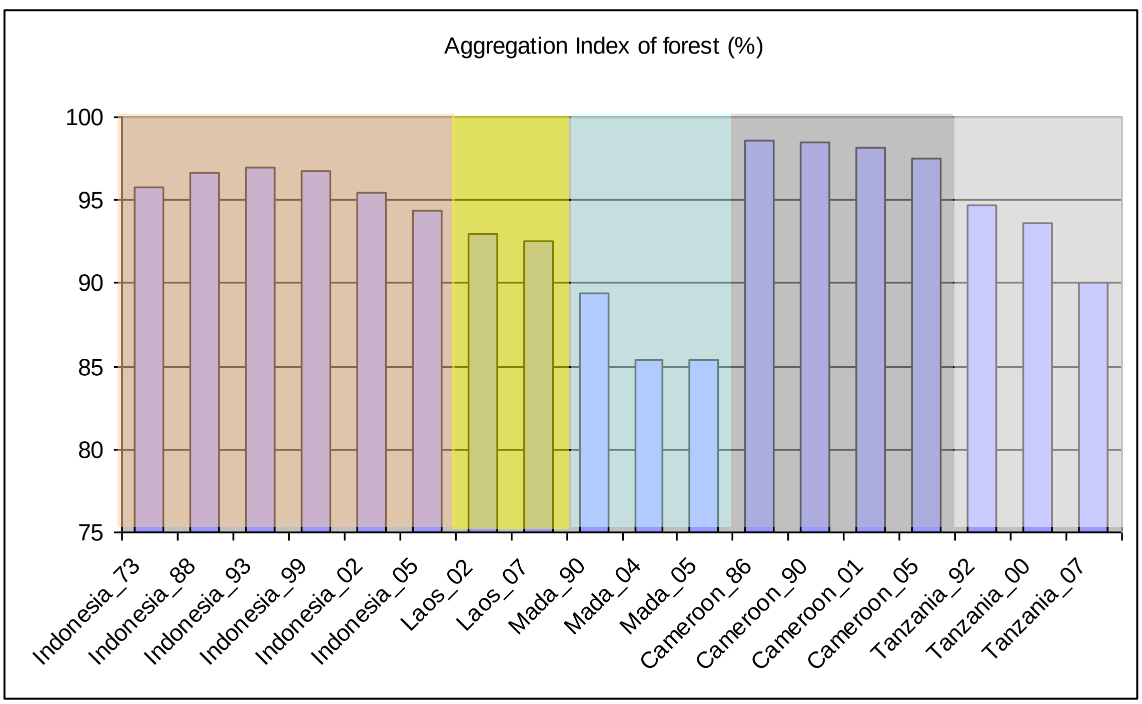


Figure 39. Aggregation index of forest in five sites over time

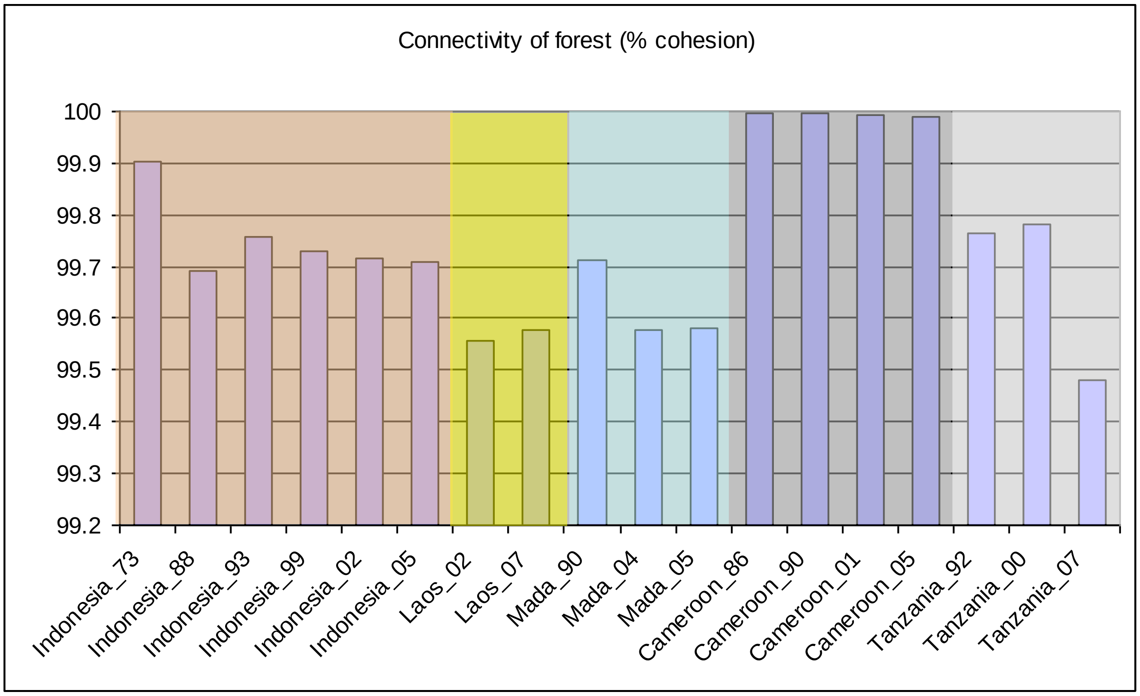


Figure 40. Aggregation index of forest in five sites over time

Landscape dynamics over space

This section will present visually the most current local (sub-landscape) configuration for each of the landscape. Each pixel represents the indices for the circular area of 1 km radius from it. Please note that while some aggregation index maps often look similar to connectivity maps, it is not always the case, especially when forest is surrounded by land cover dissimilar to forest, i.e., settlement, non-vegetation, non-tree based systems. When forest patches are often found in the surrounding of tree-based patches without being contiguous than connectivity is markedly different from aggregation, i.e., connectivity is much higher than aggregation.

This local (sub-landscape) analysis will be useful in terms of identifying the critical area where un-connectivity of two large blocks of forest is bound to happen and, therefore intervention could be endorsed. These visualizations should help in visioning, focus group discussion and communicating messages to public and policy makers, especially in the lights of land use planning to reconcile livelihoods options and biodiversity maintenance at local and landscape levels. Several guidelines, criteria and indicators can be negotiated among multiple stakeholders to reconcile local ecological knowledge, scientific perspectives and current policies and customary laws, such as:

1. High total core forest area should be under some measures of protection; otherwise if there are settlements close by, some awareness raising and contracts/agreements between government and the local people should be developed
2. Areas surrounding a large sized forest core area with high aggregation index should be tagged as priority areas for rehabilitation if located inside protected areas or conserved under some

mechanism of Rewards for Environmental Services if located outside protected areas with some inhabitants or minimum management, e.g., under Village Forest contract. Highly aggregated forest outside total core forest areas and outside protected areas with no human presence should be delineated as protected areas

3. Areas surrounding a large sized forest core area with high connectivity index should be tagged as priority areas for rehabilitation if located inside protected areas or (re)-planted and managed under low intensification of land uses with trees of economic values, e.g., rubber agroforestry, if located outside protected areas with some local communities
4. Areas of none above but identified as critical in connecting pieces of primary forest blocks under potentially low costs or hotspots of endemic species or particular environmental services should be delineated as priority areas for agroforestry or other low intensified tree/forest under co-investment schemes between local communities and other stakeholders

Indicative areas of each above point for each landscape are shown in Figure 41-55. If there are specific concerns of endangered species, such maps can be used as tools to delineate specific habitat and threat such as measures of protection can be determined and negotiated upon.

Indonesia (Bungo)

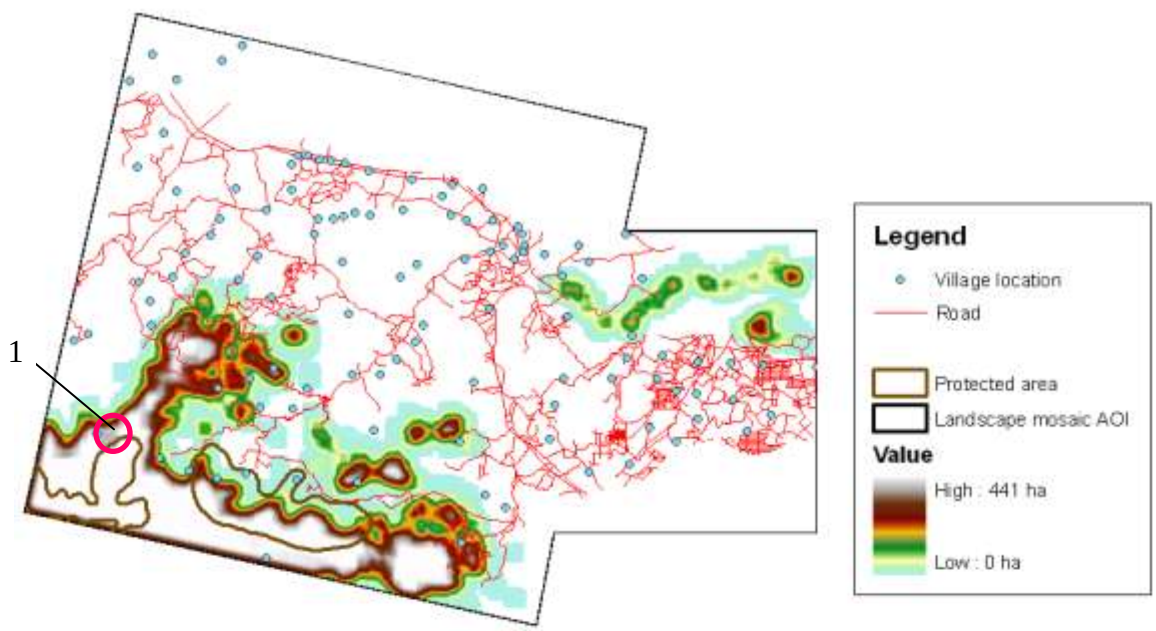


Figure 41. Current total core area of forest (0- 441 ha) of Bungo Indonesia

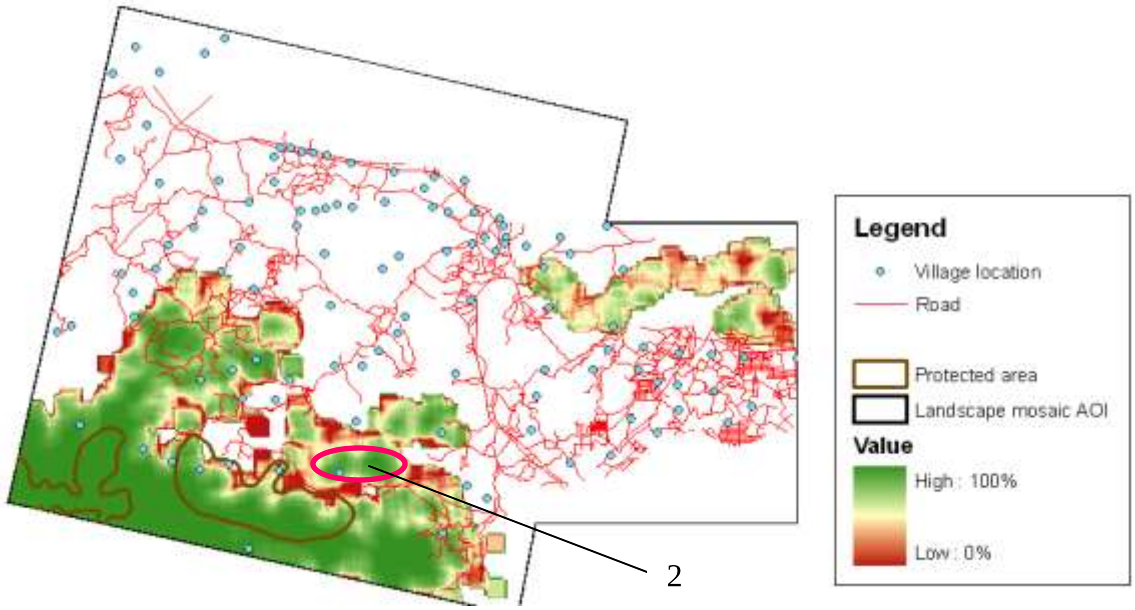


Figure 42. Current forest aggregation index (0- 100%) of Bungo, Indonesia

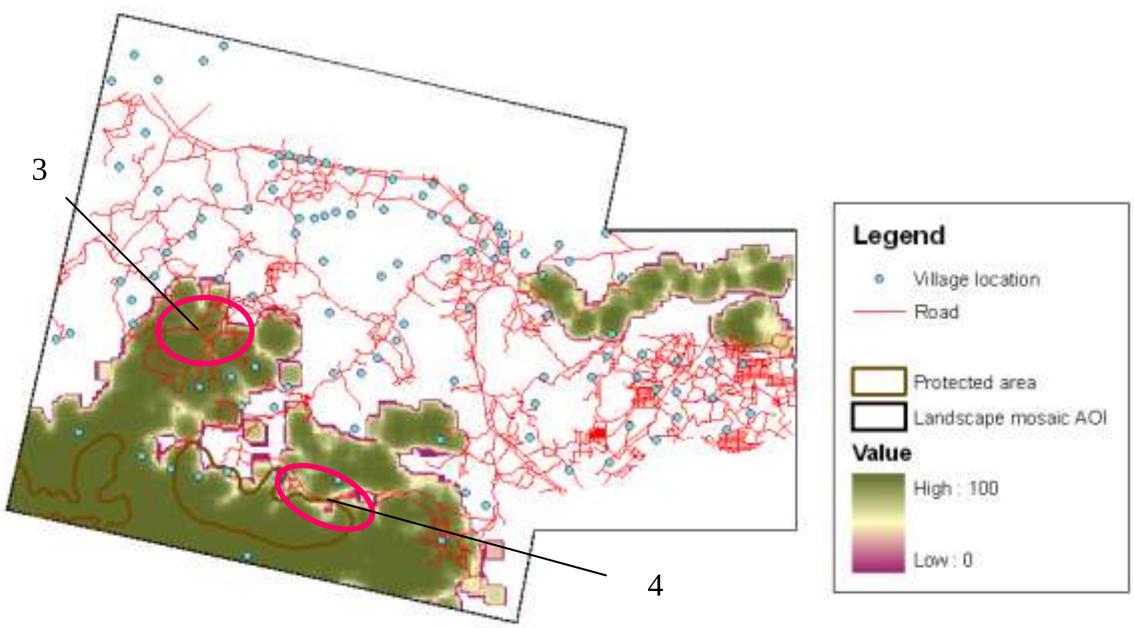


Figure 43. Current connectivity of forest (0- 100%) of Bungo, Indonesia

Laos (Viengkham)

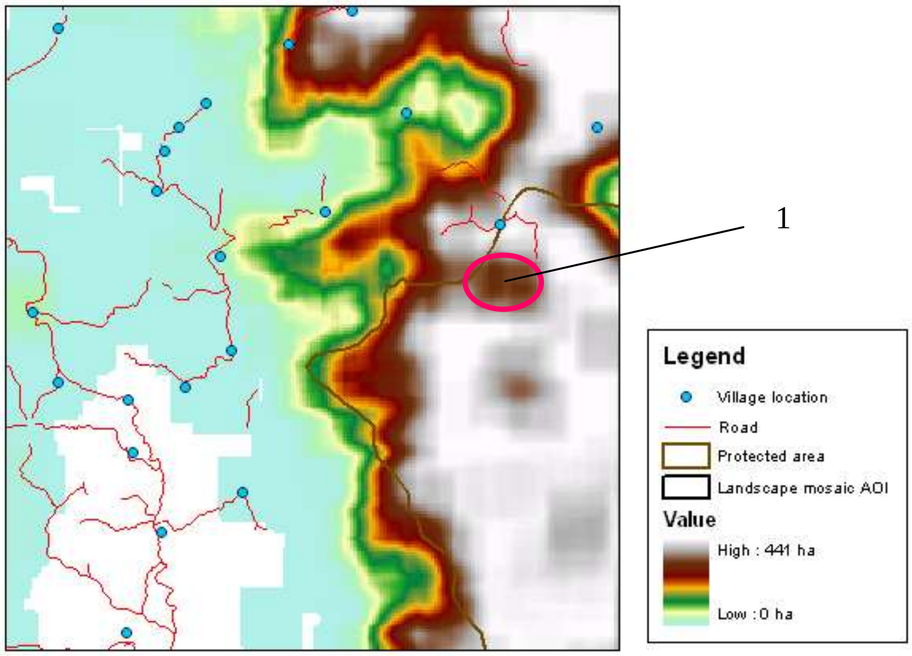


Figure 44. Current total core area of forest (0- 441 ha) of Viengkham, Laos

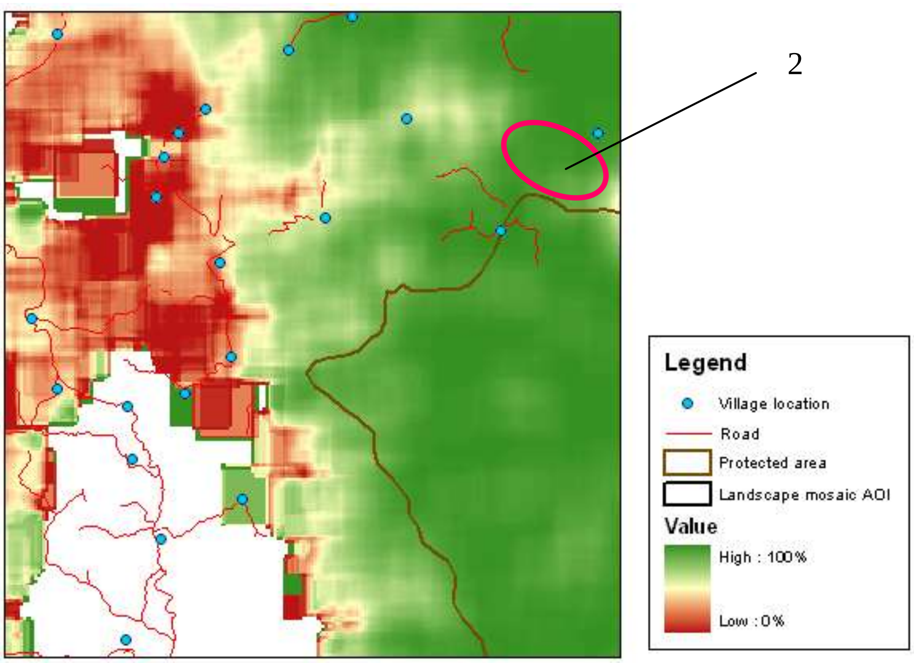


Figure 45. Current forest aggregation index (0- 100%) of Viengkham, Laos

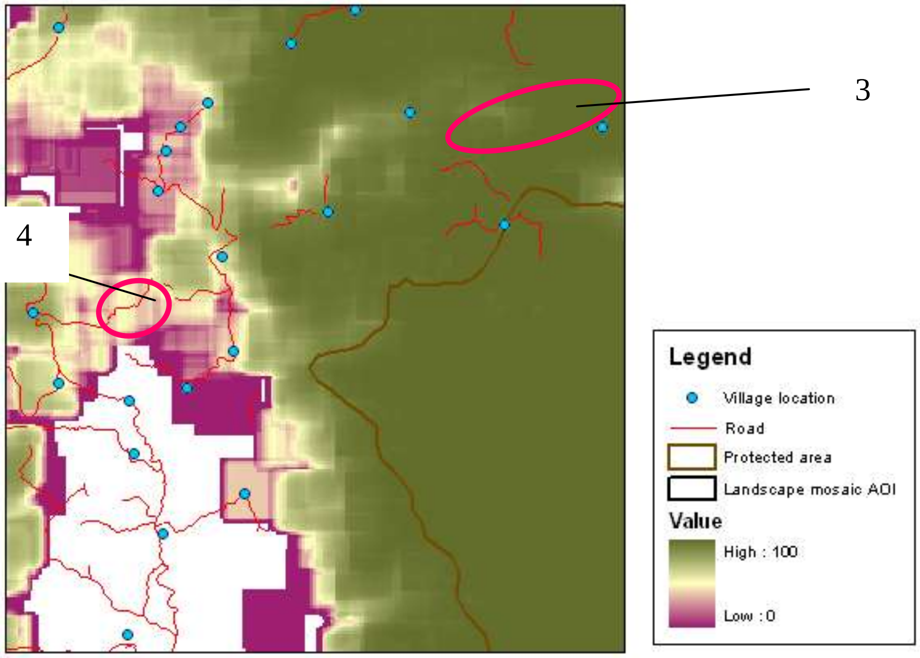


Figure 46. Current connectivity of forest (0- 100) of Viengkham, Laos

Madagascar (Manompana)

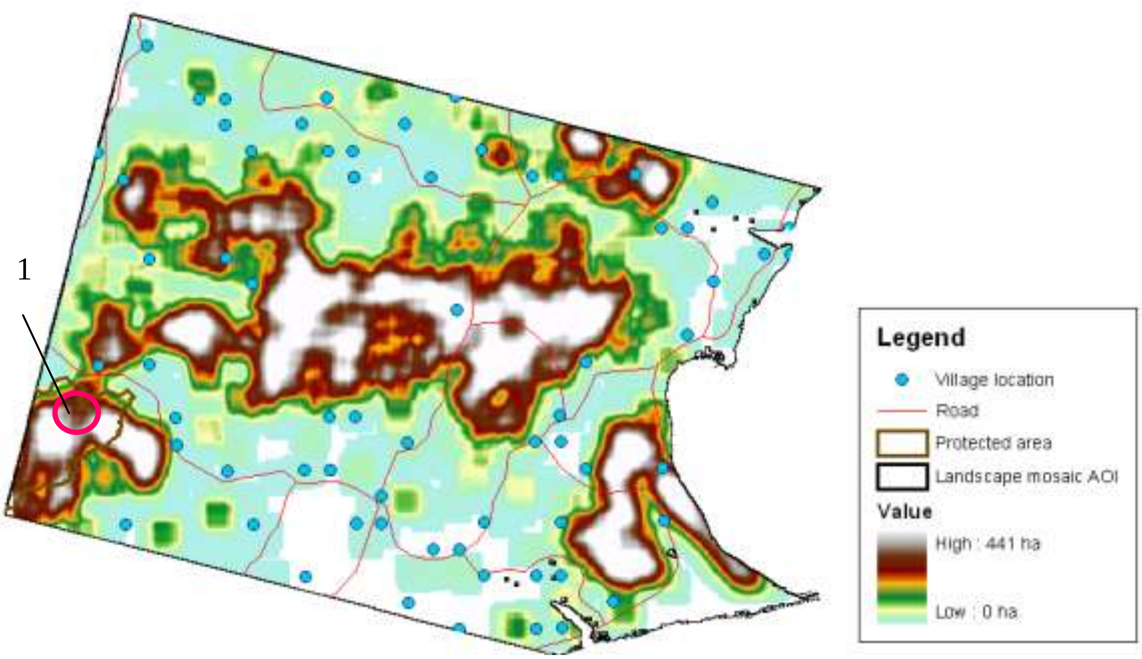


Figure 47. Current total core area of forest (0- 441 ha) of Manompana, Madagascar

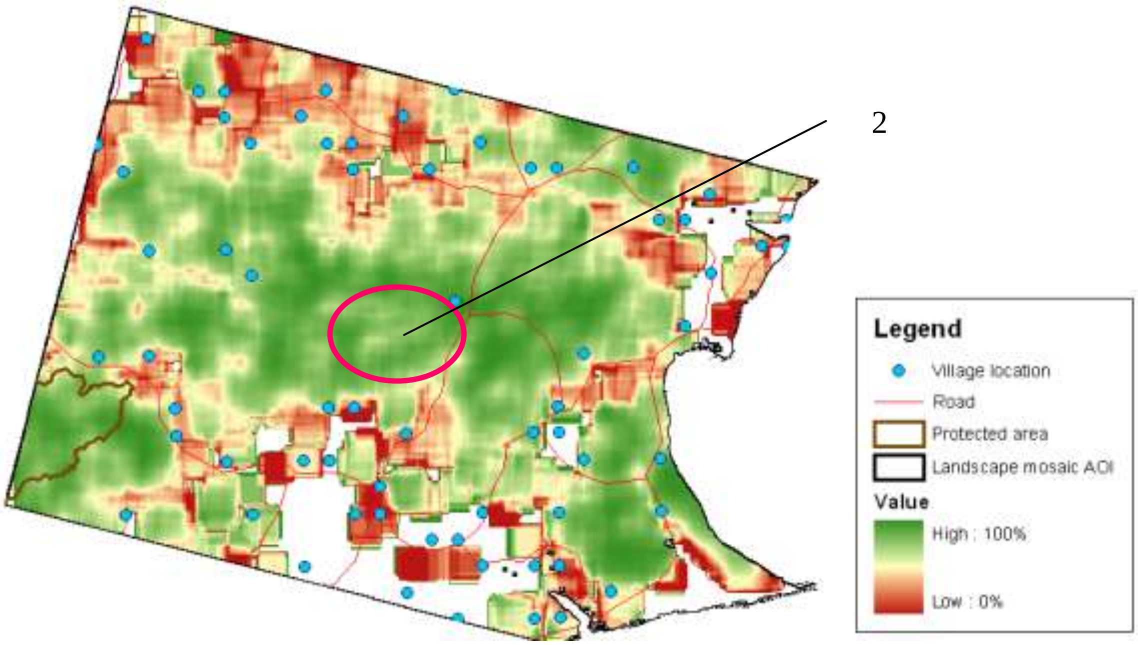


Figure 48. Current forest aggregation index (0- 100%) of Manompana, Madagascar

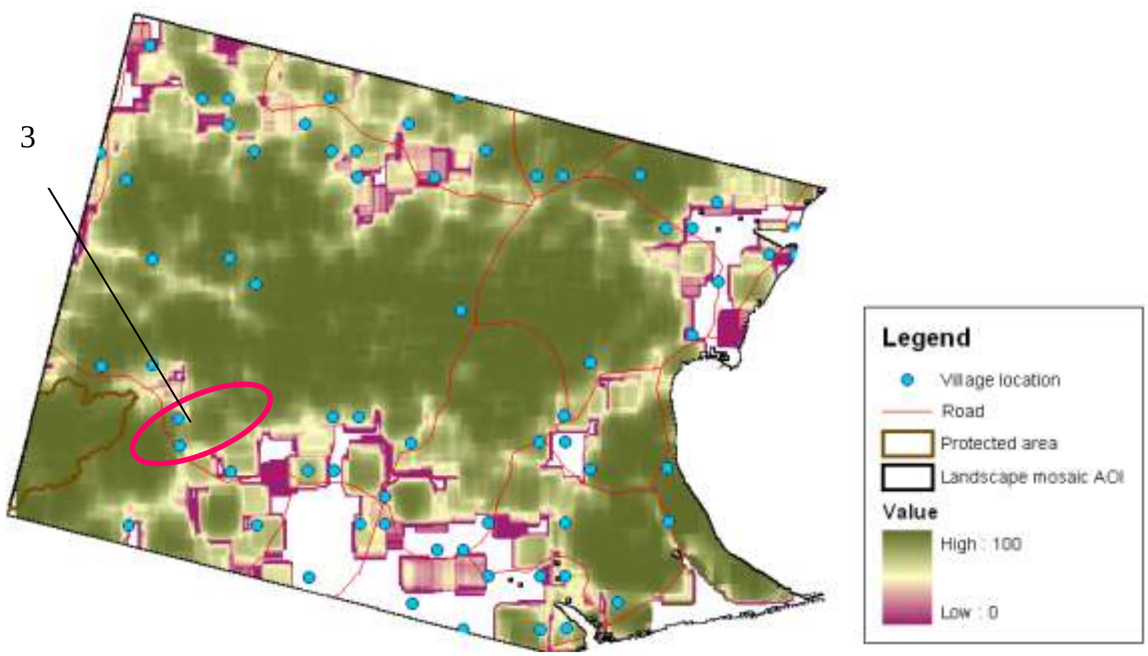


Figure 49. Current connectivity of forest (0- 100) of Manompana, Madagascar

Cameroon (Takamanda Mone)

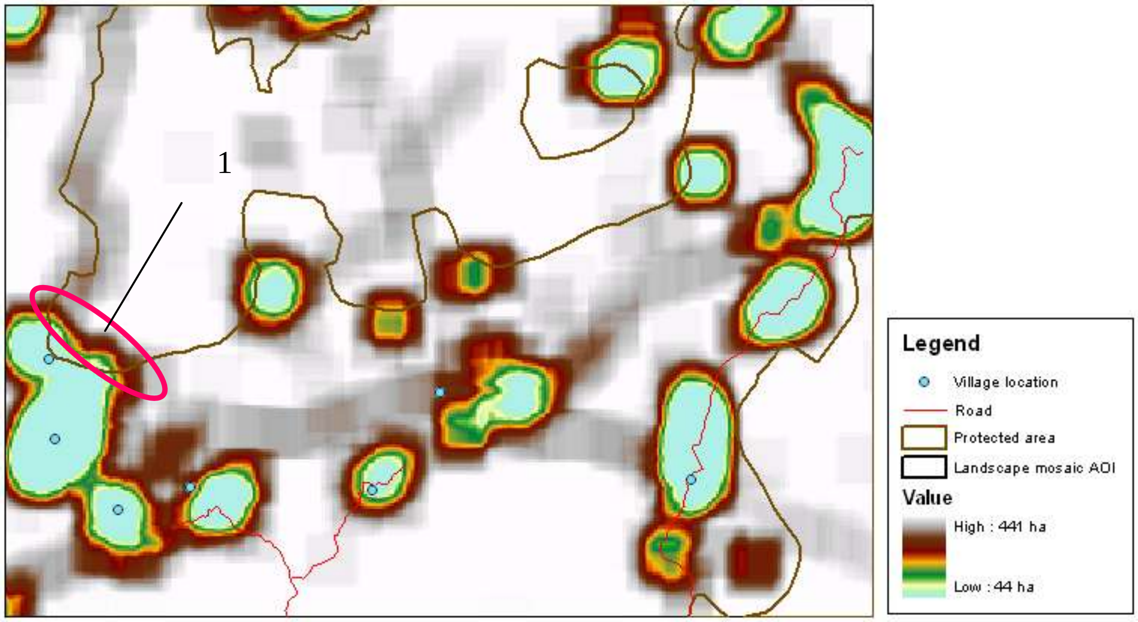


Figure 50. Current total core area of forest (0- 441 ha) of Takamanda Mone, Cameroon

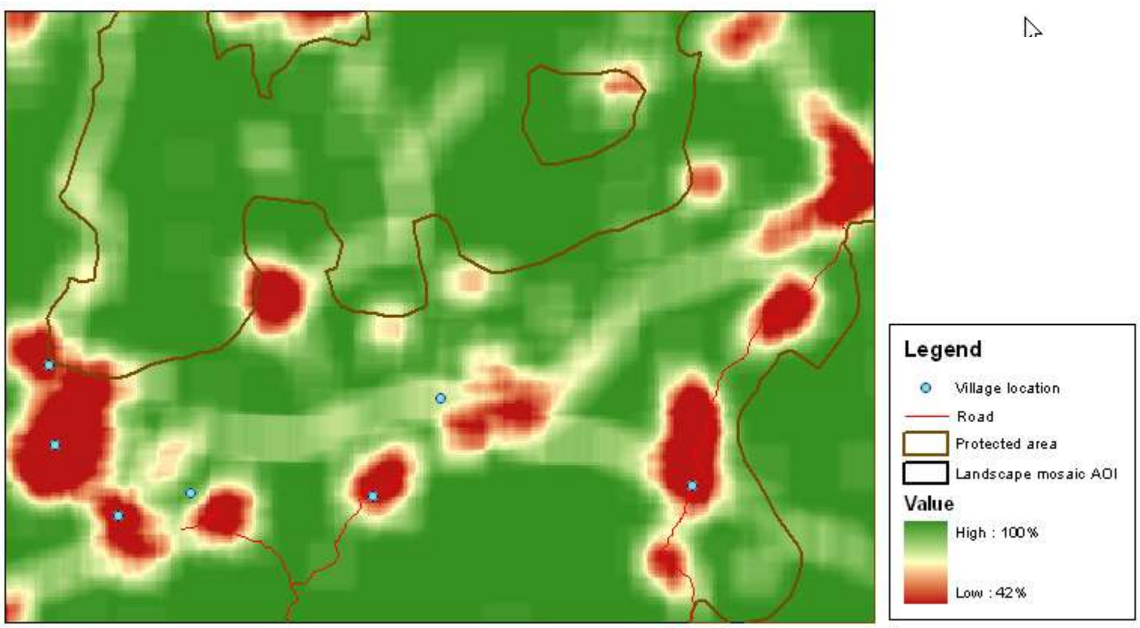


Figure 51. Current forest aggregation index (0- 100%) of Takomanda Mone, Cameroon

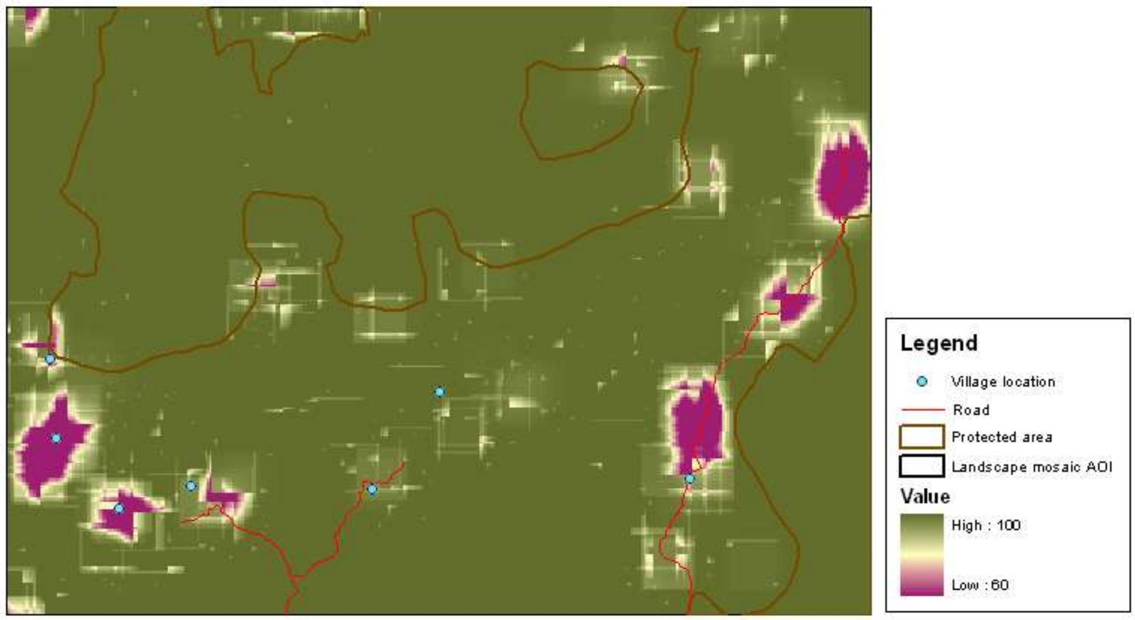


Figure 52. Current connectivity of forest (0- 100) of Takomanda Mone, Cameroon

Tanzania (East Usambara)

1

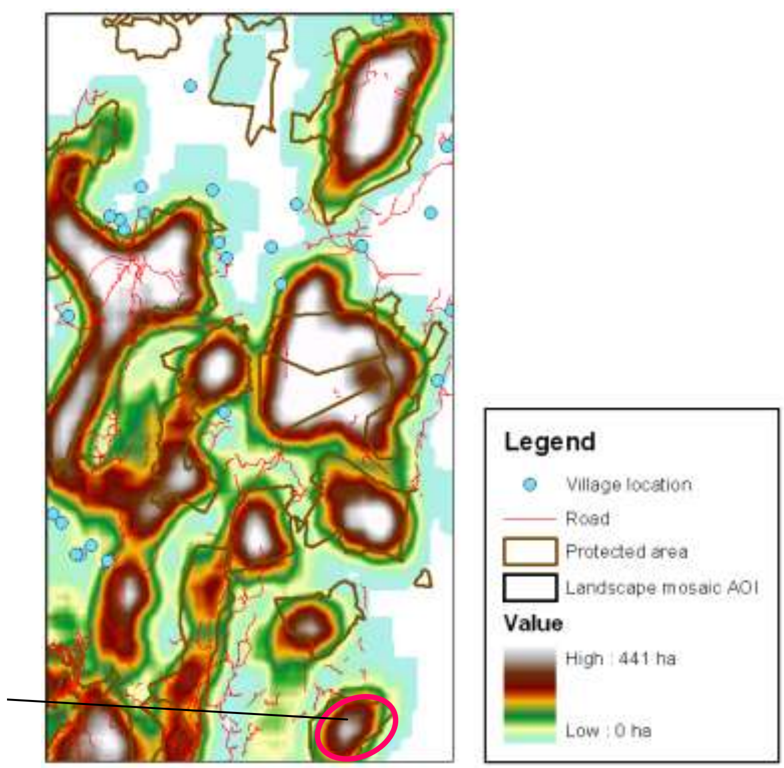


Figure 53. Current total core area of forest (0- 441 ha) of East Usambara, Tanzania

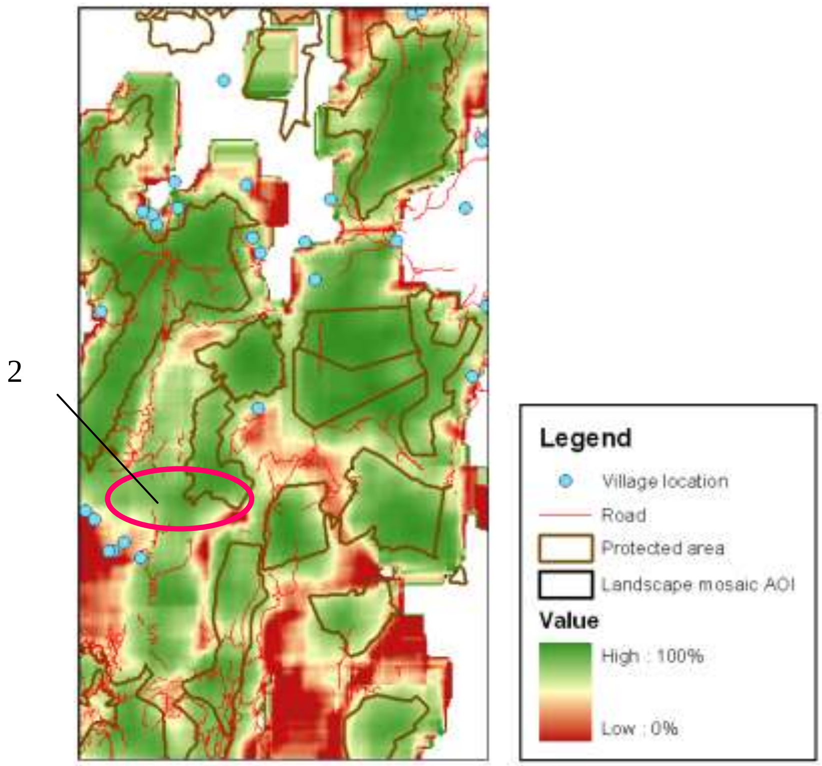


Figure 54. Current forest aggregation index (0- 100%) of East Usambara, Tanzania

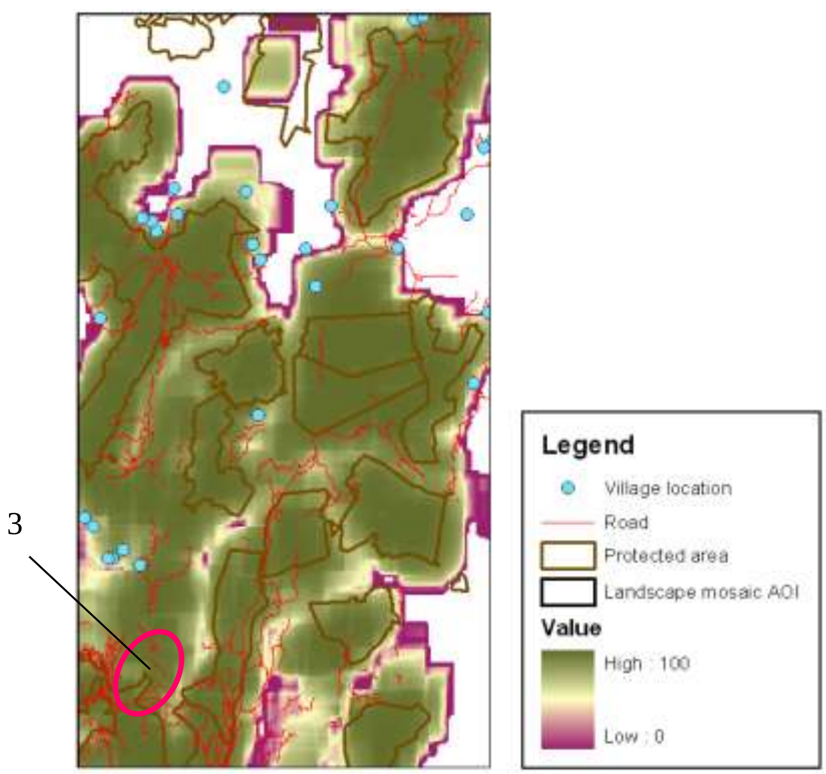


Figure 55. Current connectivity of forest (0- 100) of East Usambara, Tanzania

Landscape dynamics over time and space

In this section we will visualize changes in local (sub-landscape) configuration over time in the five sites. These analyses should be useful in projecting the future total core area, aggregation and also connectivity based on past changes. Beyond that, areas that are prone to dis-aggregation/fragmentation and un-connectivity/isolation can be identified.

By combining these analyses with scenarios to project the future land use/cover changes, we will able to provide an effective ‘negotiation’ platform with multi-stakeholders by showing the what-if situation. Showing the areas that most likely will be isolated or fragmented under particular scenarios within such and such years is a powerful way to start a discussion to land use planning.

Some guidelines, criteria and indicators to be used in the land use planning process could be derived, for instance:

- Delineating the likely loss of total forest core area based on previous pattern of deforestation, e.g., in Bungo (Figure 56), Monampana (Figure 62) and East Usambara (Figure 68) landscape cases, deforestation mainly happened as encroachment from the edge of primary forest block, while in Viengkham (Figure 59) and Takamanda-Mone (Figure 65) deforestation predominantly take places along the new road establishment and river. Apart from that settlement in the middle of primary forest blocks continues to expand in areas
- Identification of the likely loss of areas with high aggregation index surrounding large- sized primary forest blocks (Figure 57, 60, 63, 66, 69)
- Identification of the likely loss of areas with connectivity index surrounding large-sized primary forest blocks (Figure 58, 61, 64, 67, 70)

In addition to past spatial pattern of deforestation, likelihood or probability of deforestation and land use/cover changes can be derived from multi- agent modelling, empirical modelling or spatially explicit driver modelling. Further the projection or prediction can be used as a layer of information to be incorporated in identification of vulnerable areas of habitat loss, increased fragmentation and reduced connectivity. Negotiation and protection measures could be imposed in these vulnerable areas along with intervention that can be taken. Trade-offs between conservation and development should be sought, for example, identify areas of low opportunity cost (from cost-benefit analysis of land use system) with high conservation values.

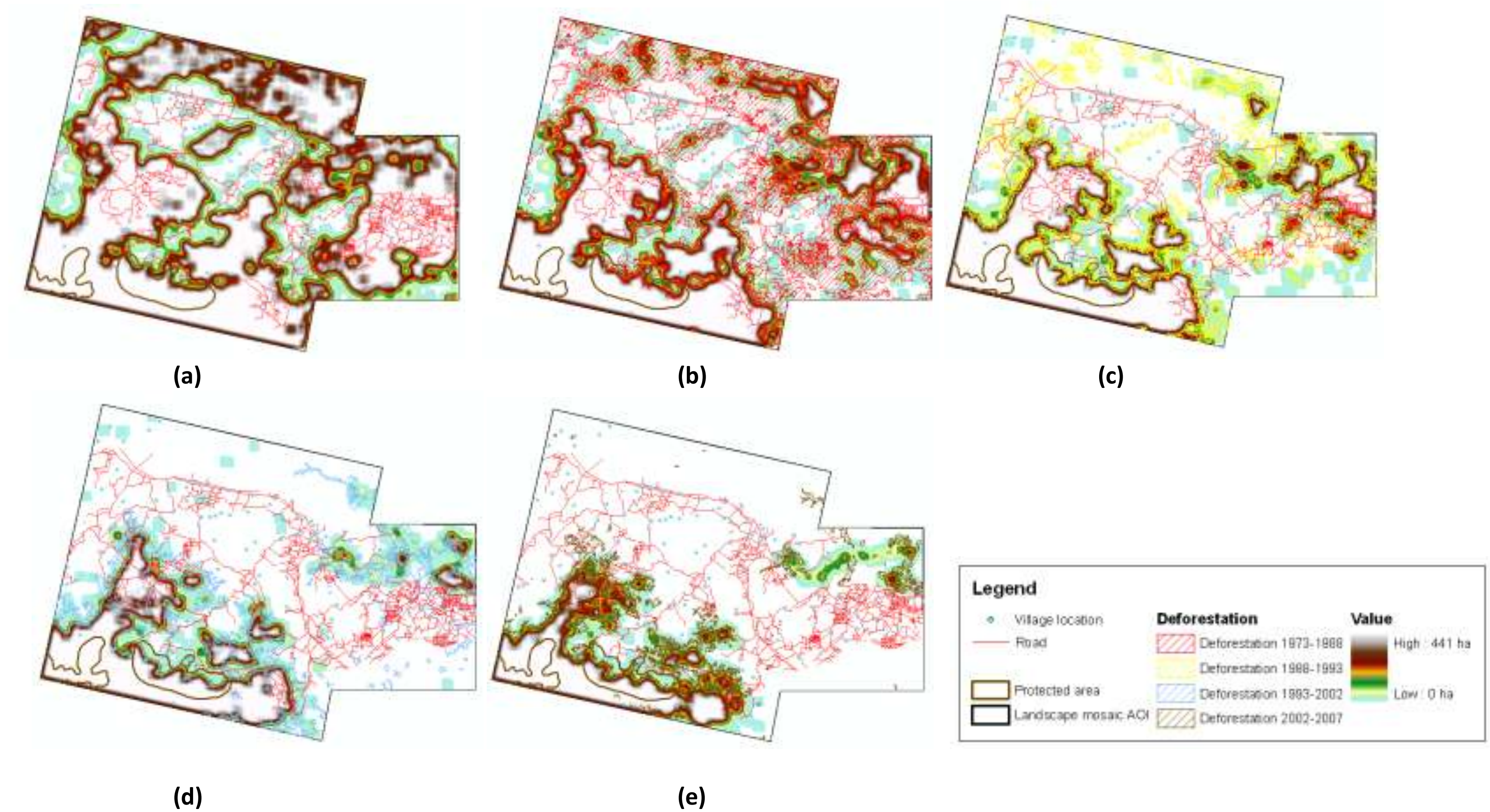


Figure 56. Time series of total core area of forest, (a) total core area in 1973 (b) total core area in 1988 with deforestation in 1973-1988 (c) total core area in 1993 with deforestation in 1988-1993 (d) total core area in 2002 with deforestation in 1993-2002 (e) total core area in 2007 with deforestation in 2002-2007

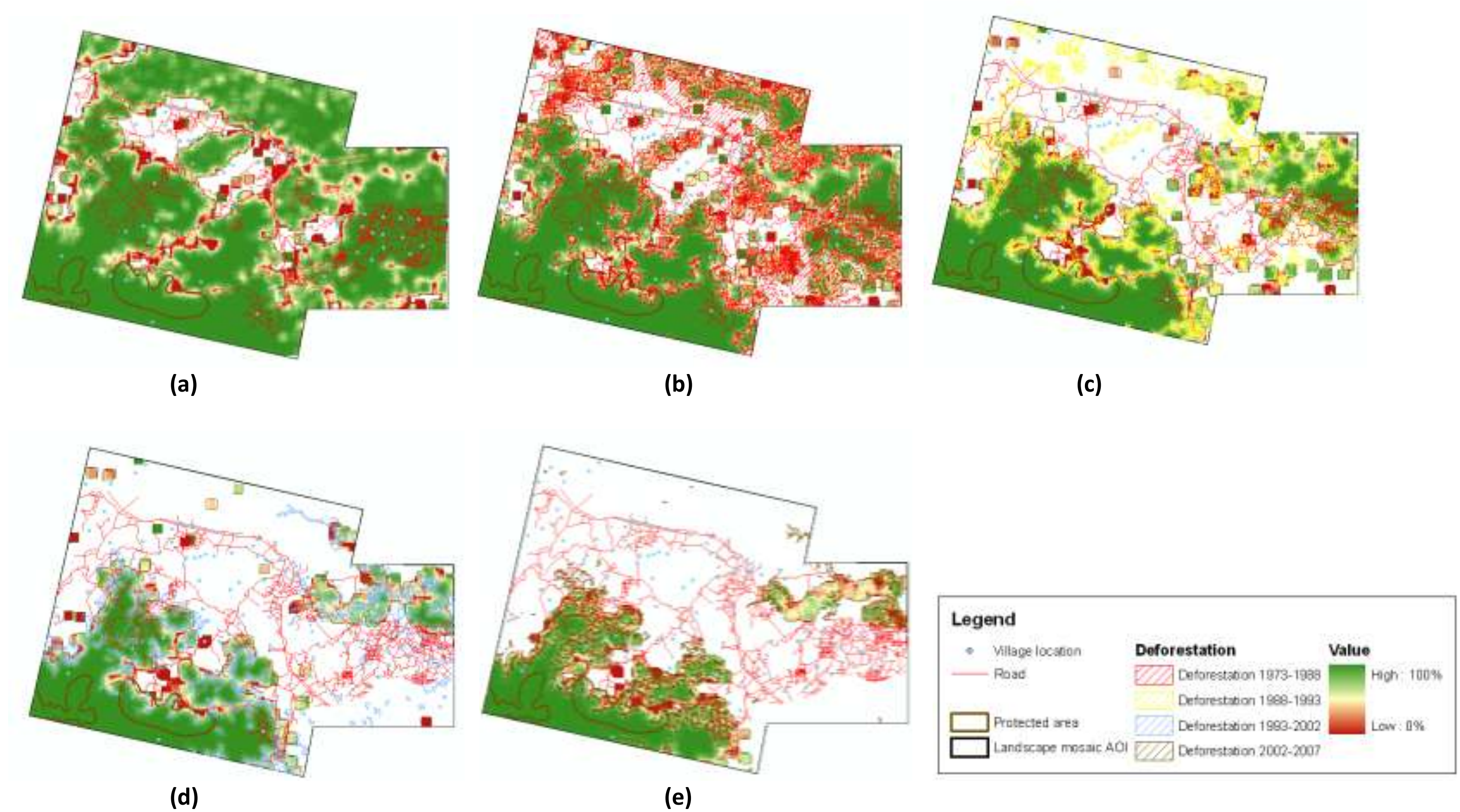


Figure 57. Time series of aggregation index of forest, (a) aggregation index in 1973 (b) aggregation index in 1988 with deforestation in 1973-1988 (c)aggregation index in 1993 with deforestation in 1988-1993 (d) aggregation index in 2002 with deforestation in 1993-2002 (e) aggregation index in 2007 with deforestation in 2002-2007

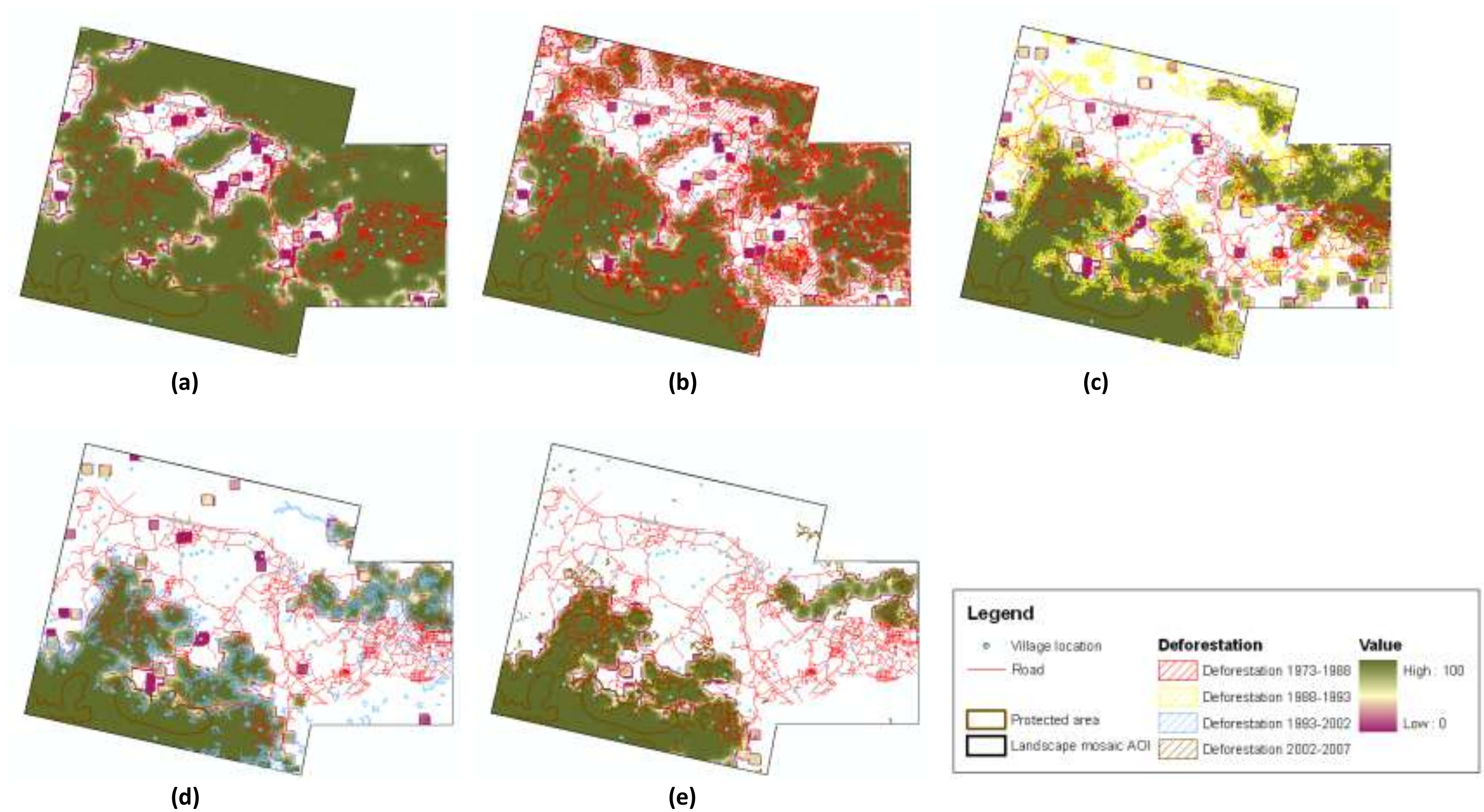


Figure 58. Time series of connectivity of forest, (a) connectivity in 1973 (b) connectivity in 1988 with deforestation in 1973-1988 (c) connectivity in 1993 with deforestation in 1988-1993 (d) connectivity in 2002 with deforestation in 1993-2002 (e) connectivity in 2007 with deforestation in 2002-2007

Laos (Viengkham)

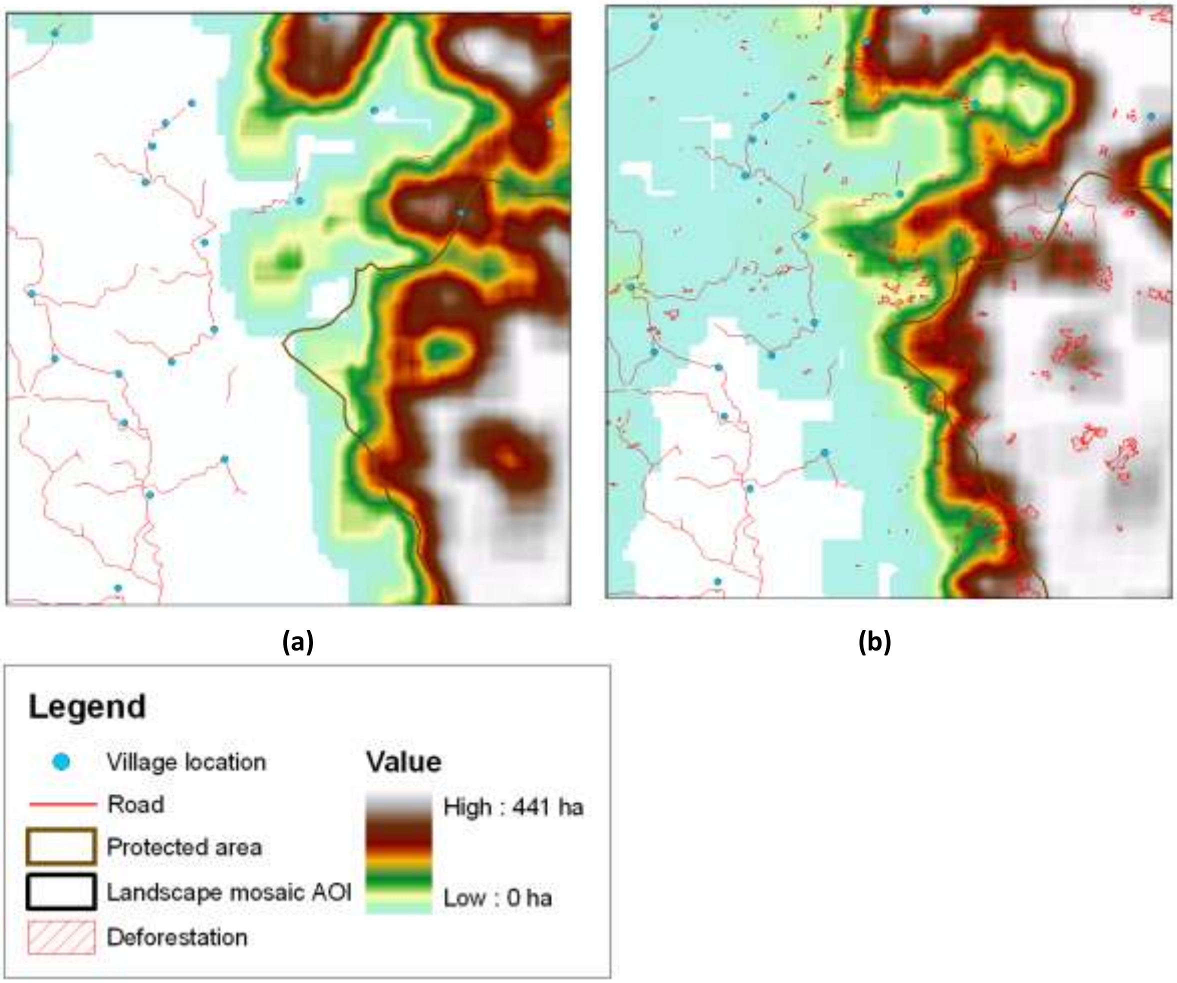


Figure 59. Time series of total core area of forest, (a) total core area in 2002 (b) total core area in 2007 with deforestation 2002-2007

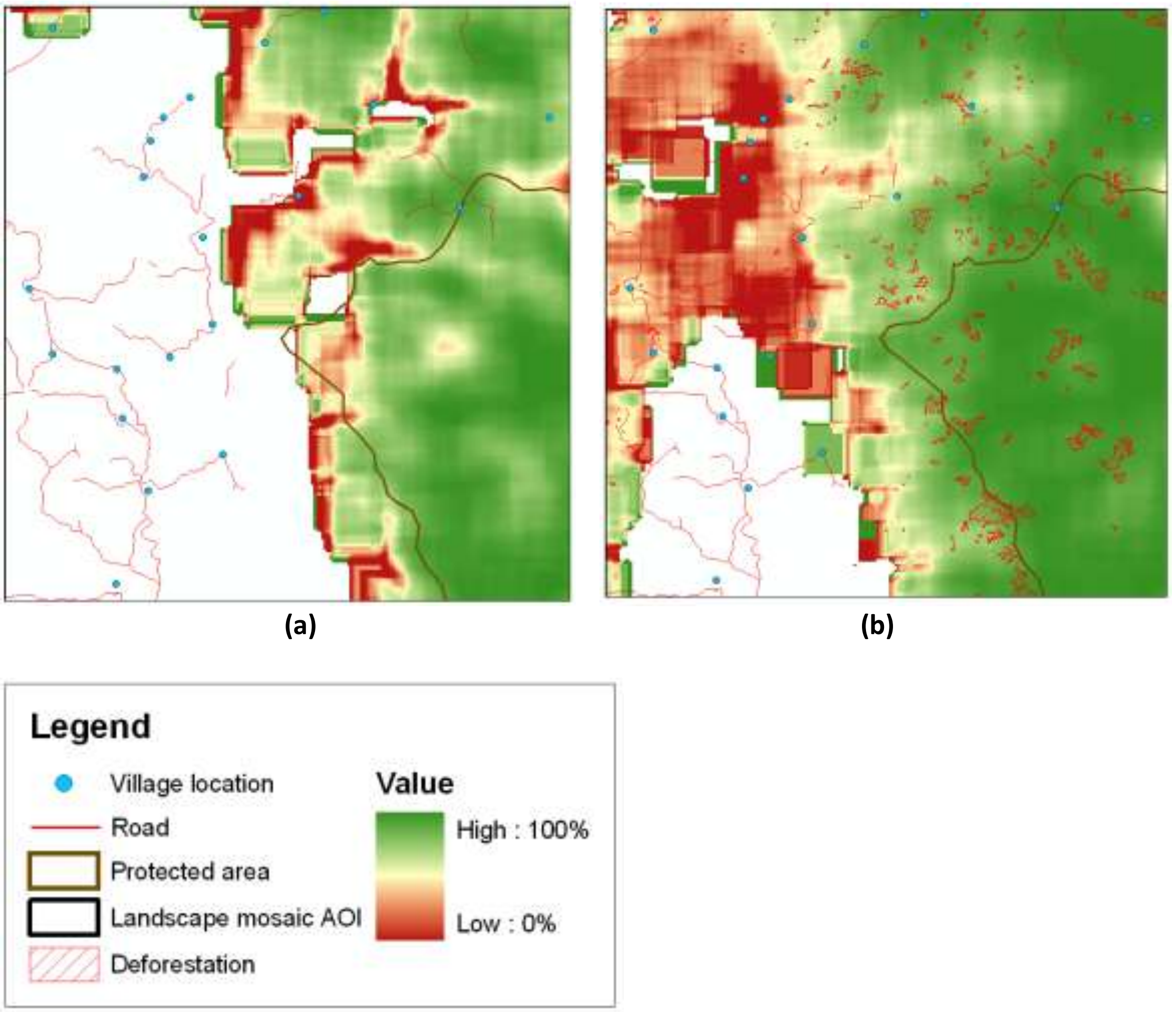


Figure 60. Time series of aggregation index of forest, (a) aggregation index in 2002 (b) aggregation index in 2007 with deforestation 2002-2007

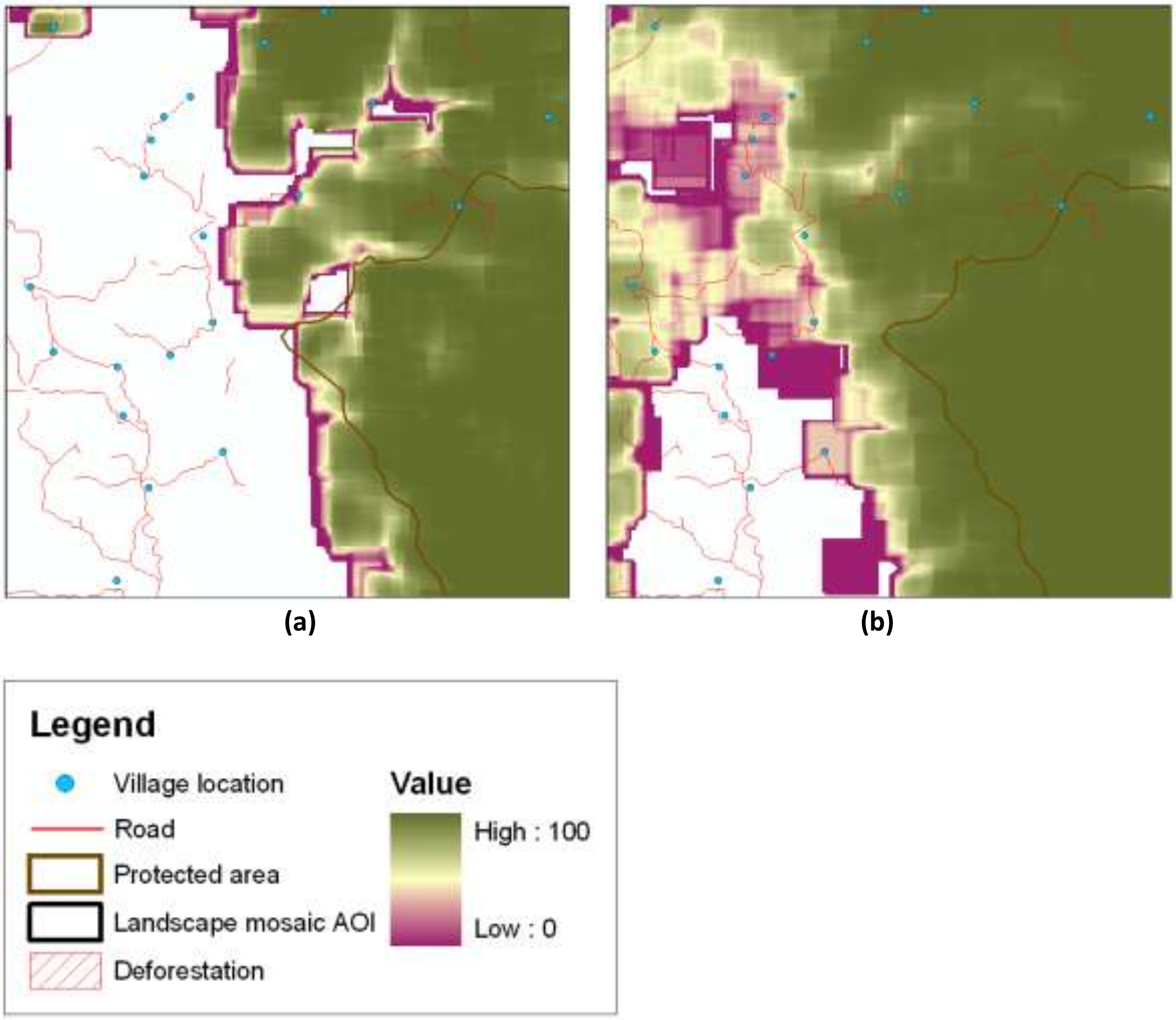
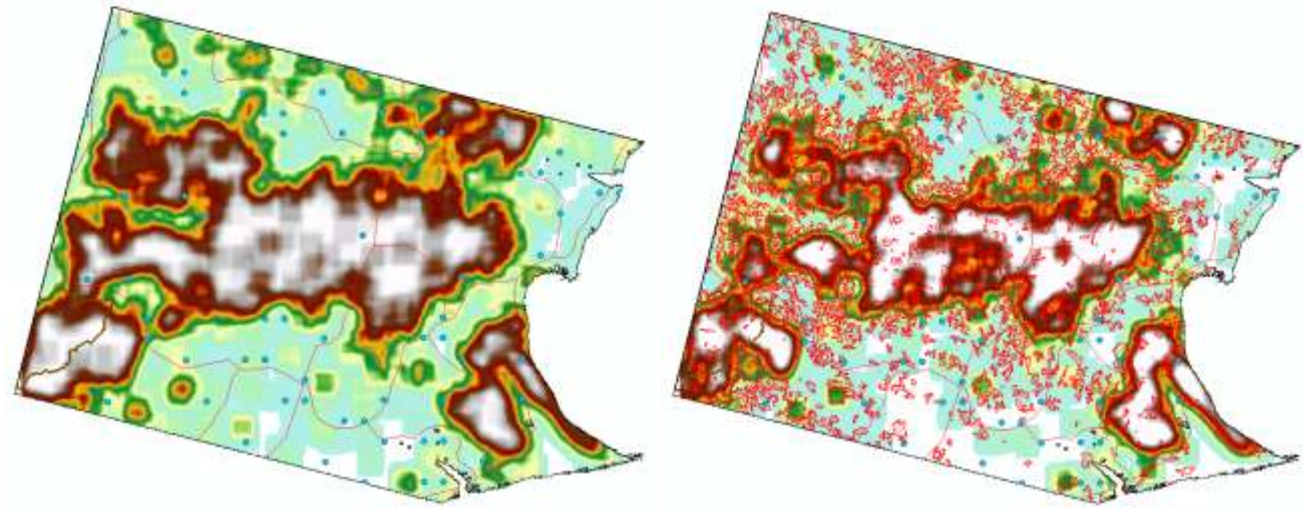


Figure 61. Time series of connectivity of forest, (a) connectivity in 2002 (b) connectivity in 2007 with deforestation 2002-2007

Madagascar (Manompana)



(a) (b)

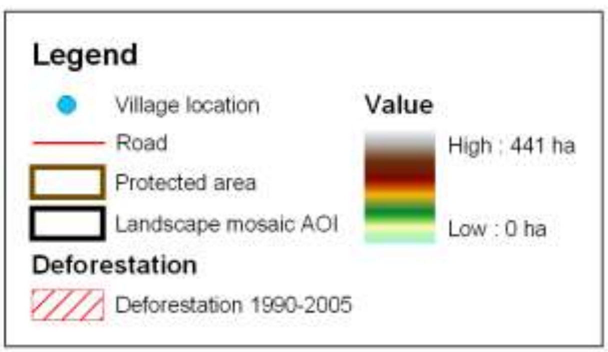


Figure 62. Time series of total core area of forest, (a) total core area in 1990 (b) total core area in 2005 with deforestation1990-2005

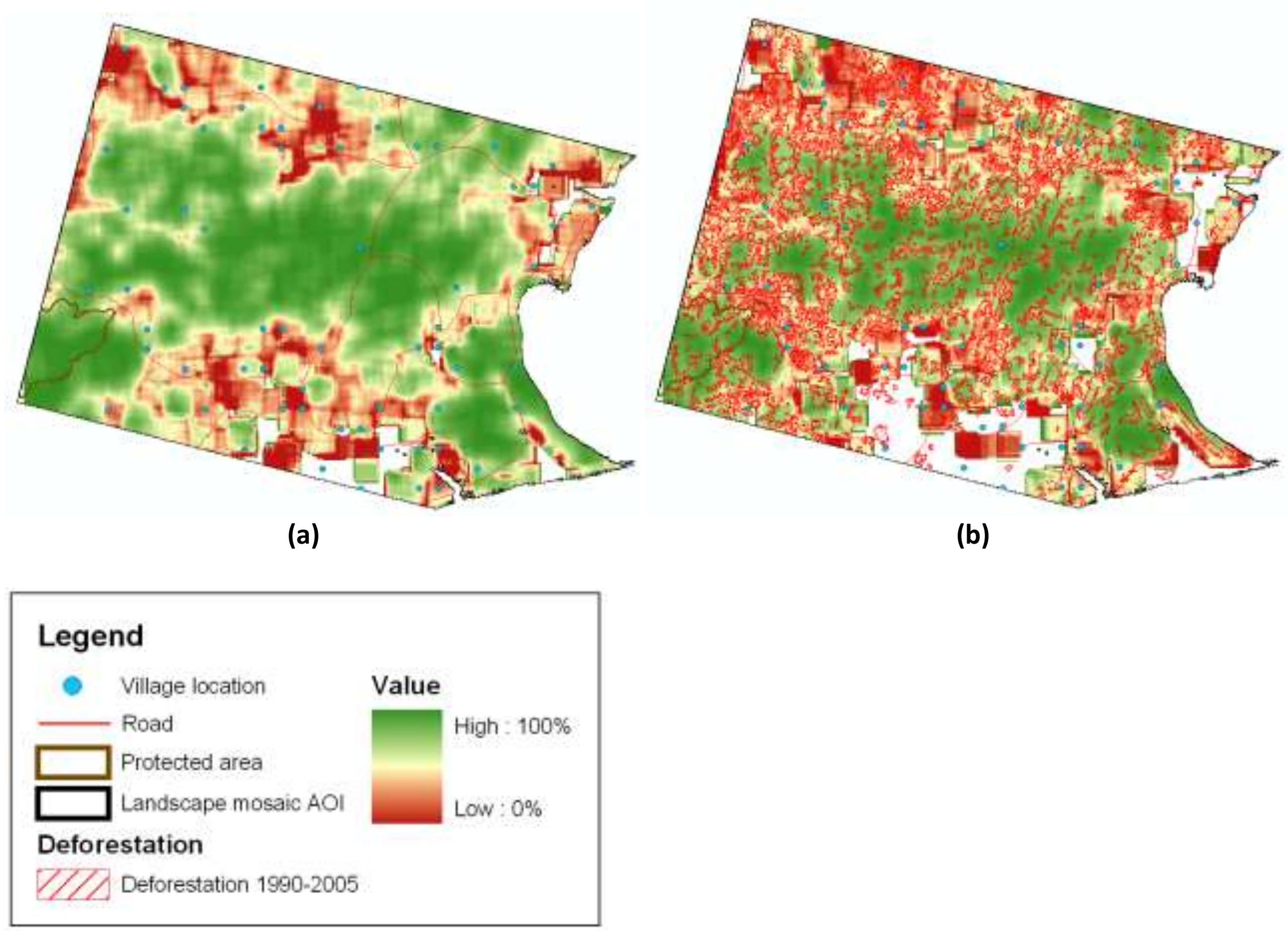


Figure 63. Time series of aggregation index forest, (a) aggregation index in 1990 (b) aggregation index in 2005 with deforestation1990-2005

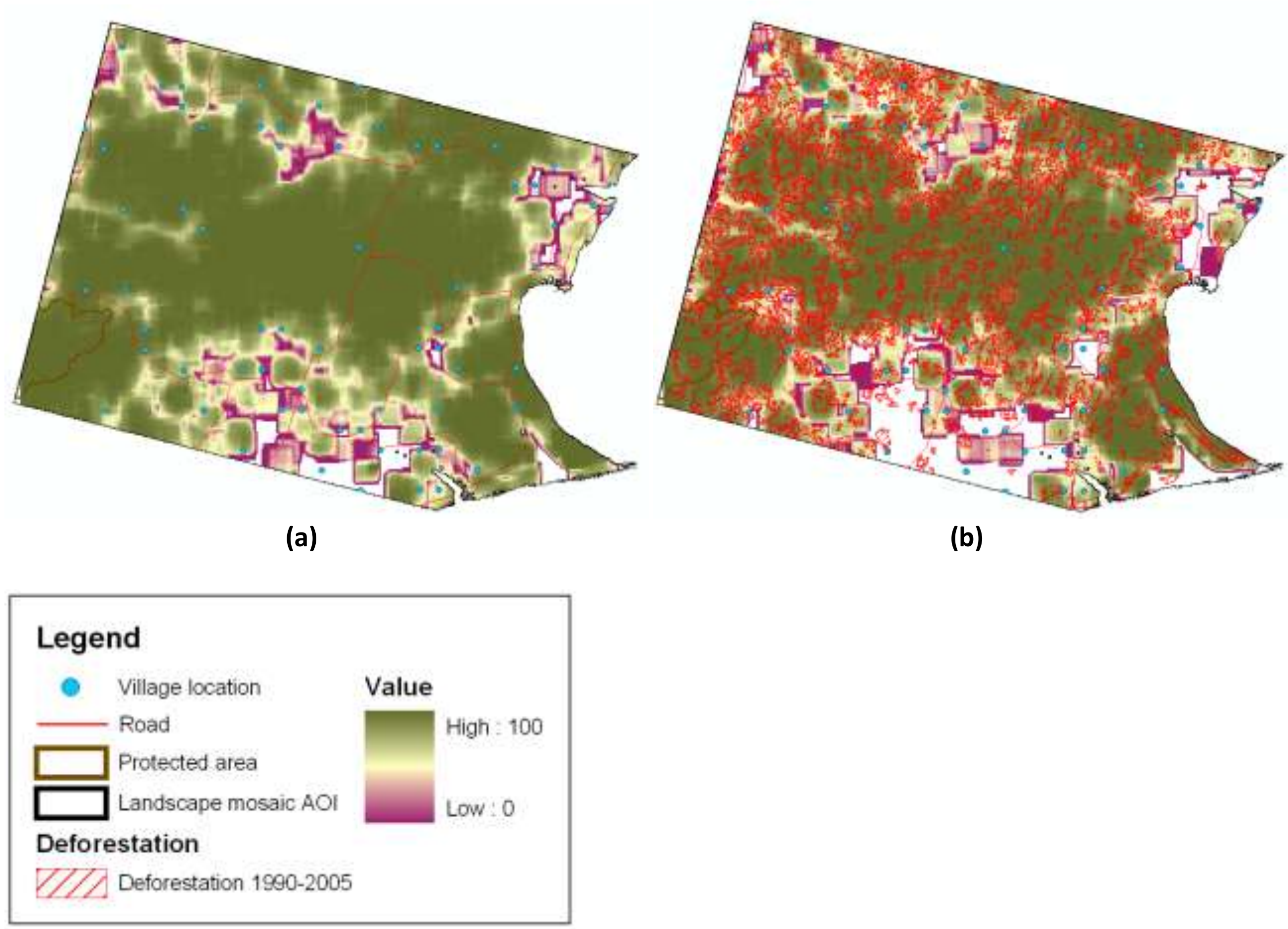


Figure 64. Time series of connectivity of forest, (a) connectivity in 1990 (b)connectivity in 2005 with deforestation 1990-2005

Cameroon (Takamanda Mone)

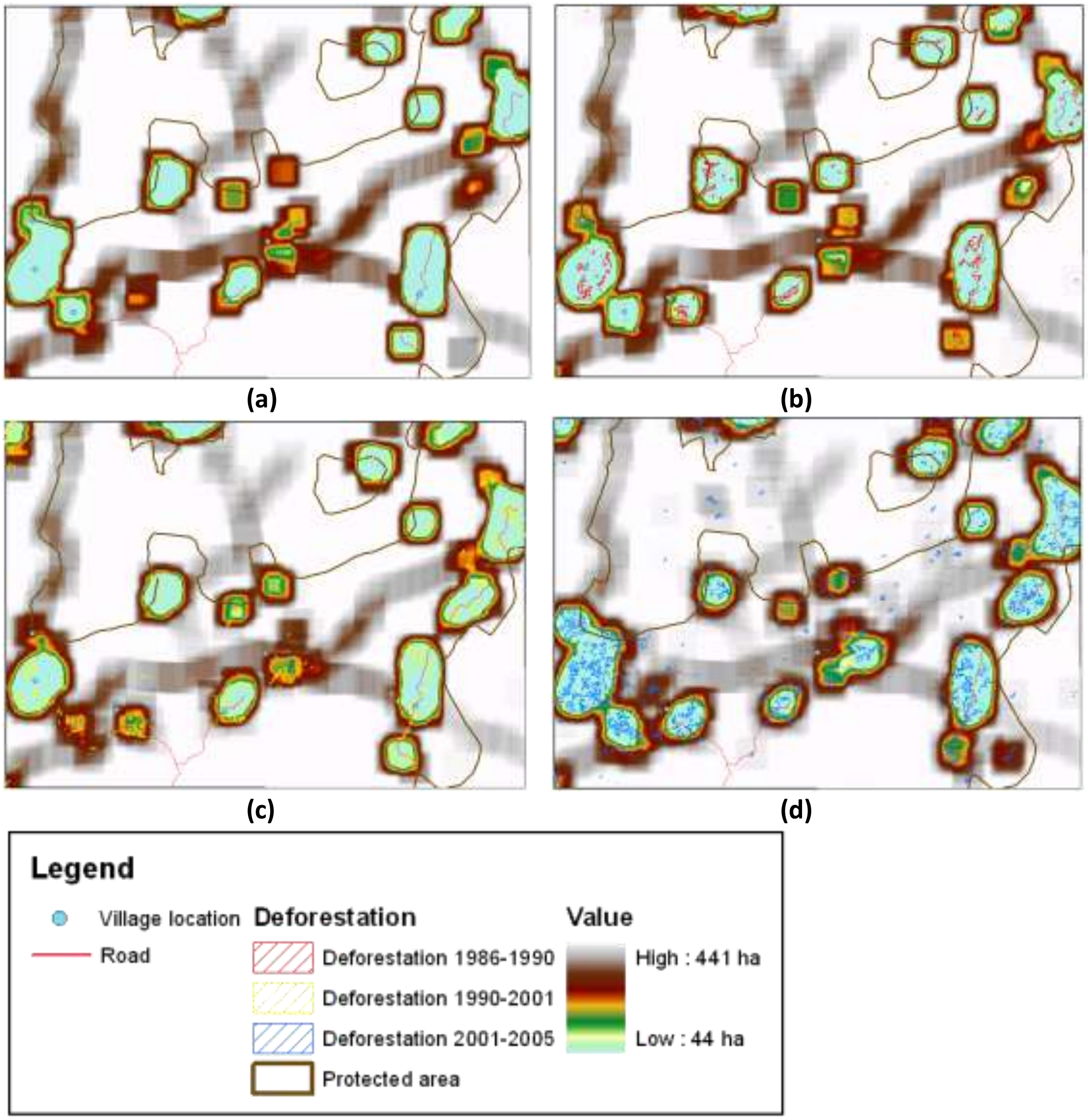


Figure 65. Time series of total core area of forest, (a) total core area in 1986 (b) total core area in 1990 with deforestation in 1986-1990 (c) total core area in 2001 with deforestation in 1990-2001 (d) total core area in 2005 with deforestation in 2001-2005

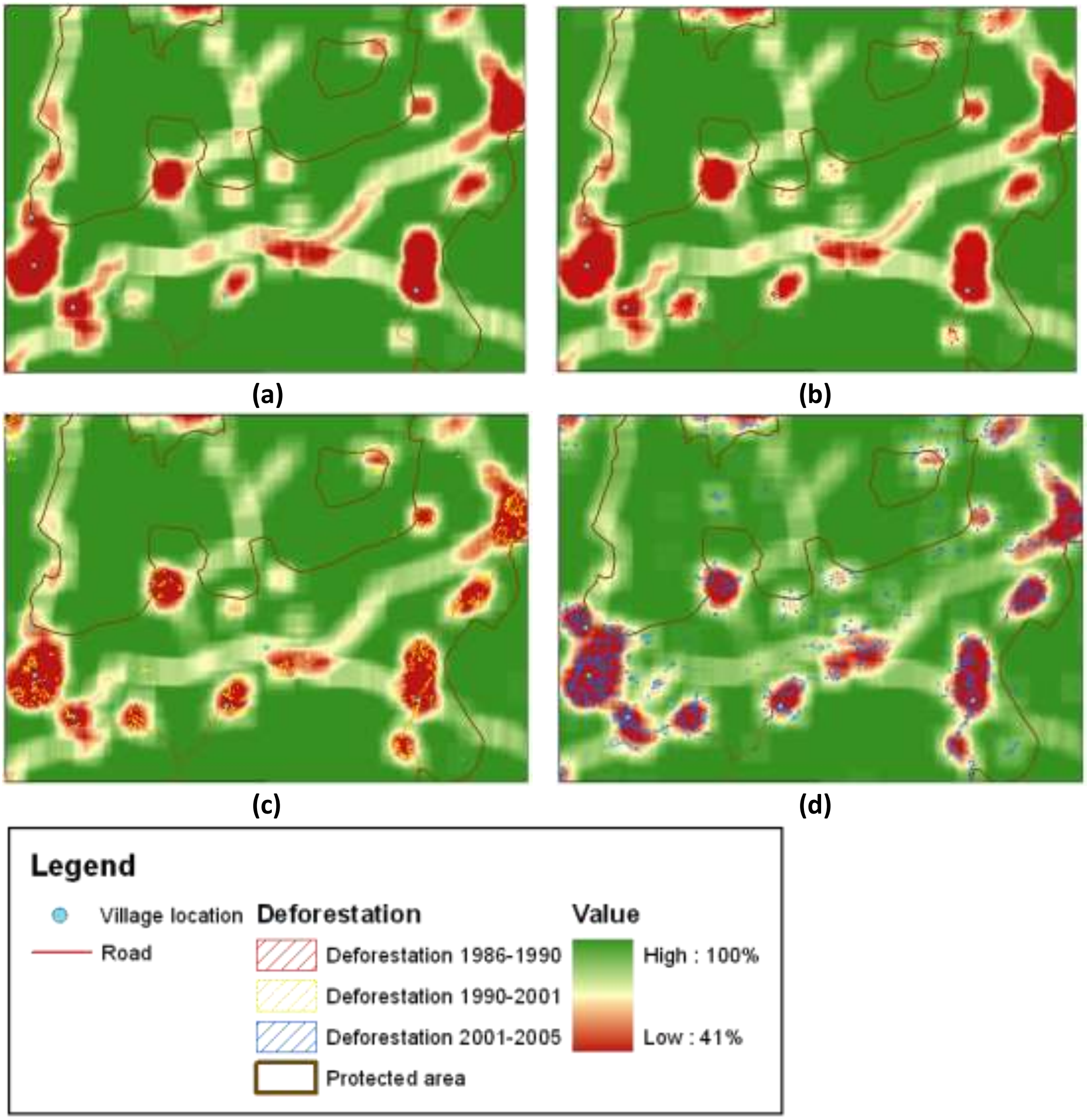


Figure 66. Time series of aggregation index of forest, (a) aggregation index in 1986 (b) aggregation index in 1990 with deforestation in 1986-1990 (c) aggregation index in 2001 with deforestation in 1990-2001 (d) aggregation index in 2005 with deforestation in 2001-2005

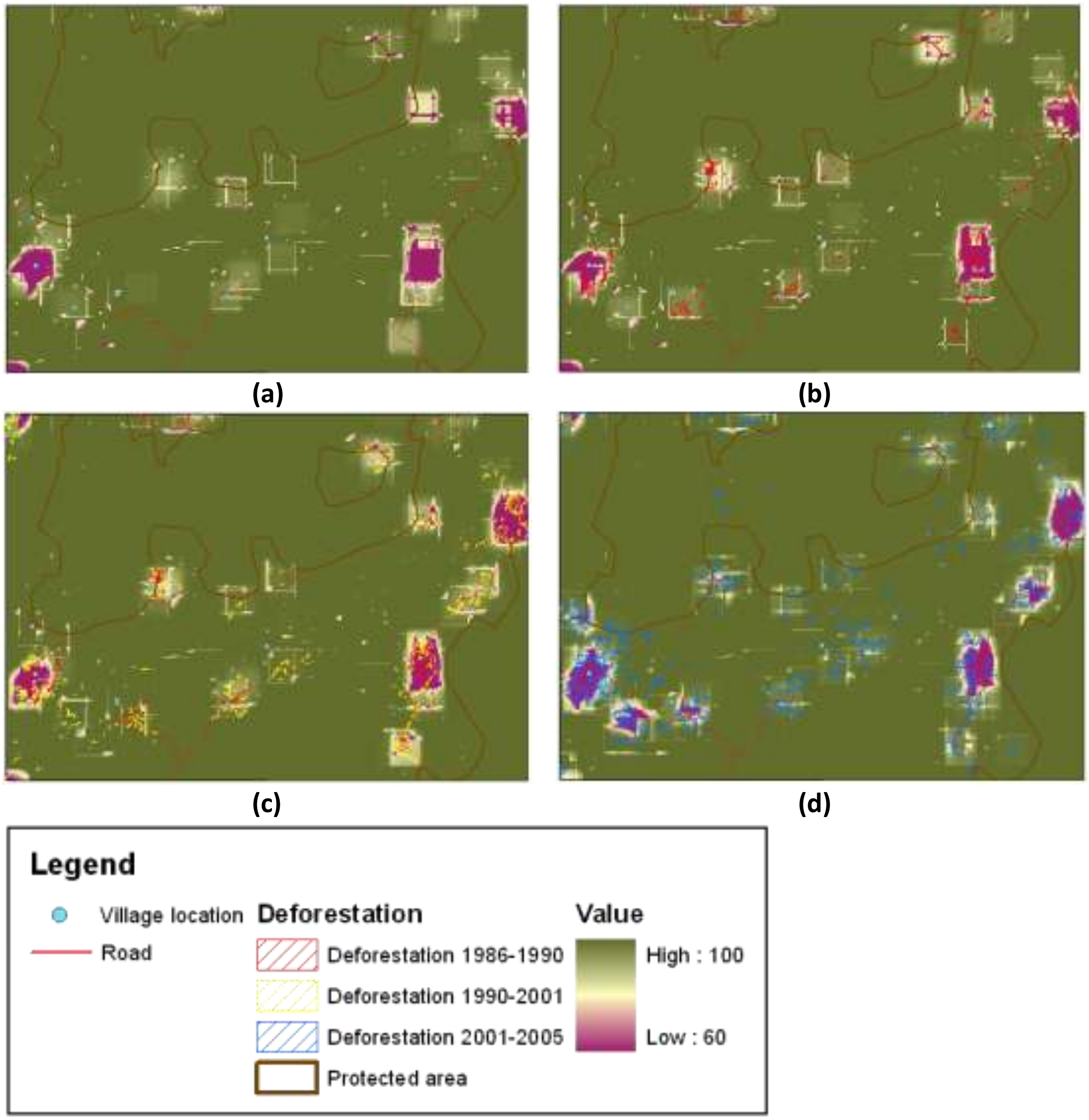


Figure 67. Time series of connectivity of forest, (a) connectivity in 1986 (b) connectivity in 1990 with deforestation in 1986-1990 (c) connectivity in 2001 with deforestation in 1990-2001 (d) connectivity in 2005 with deforestation in 2001-2005

Tanzania (East Usambara)

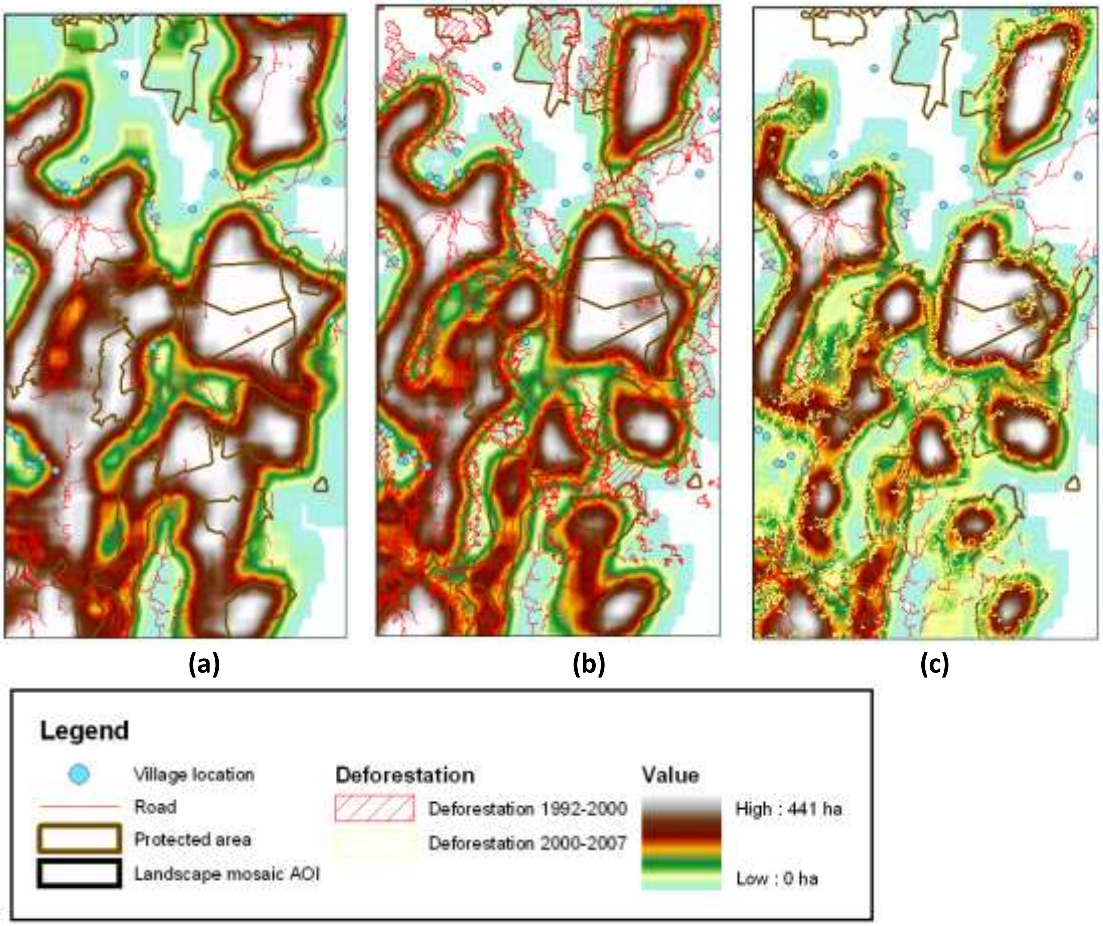


Figure 68. Time series of total core area of forest, (a) total core area in 1992 (b) total core area in 2000 with deforestation in 1992-2000 (c) total core area in 2007 with deforestation in 2000-2007

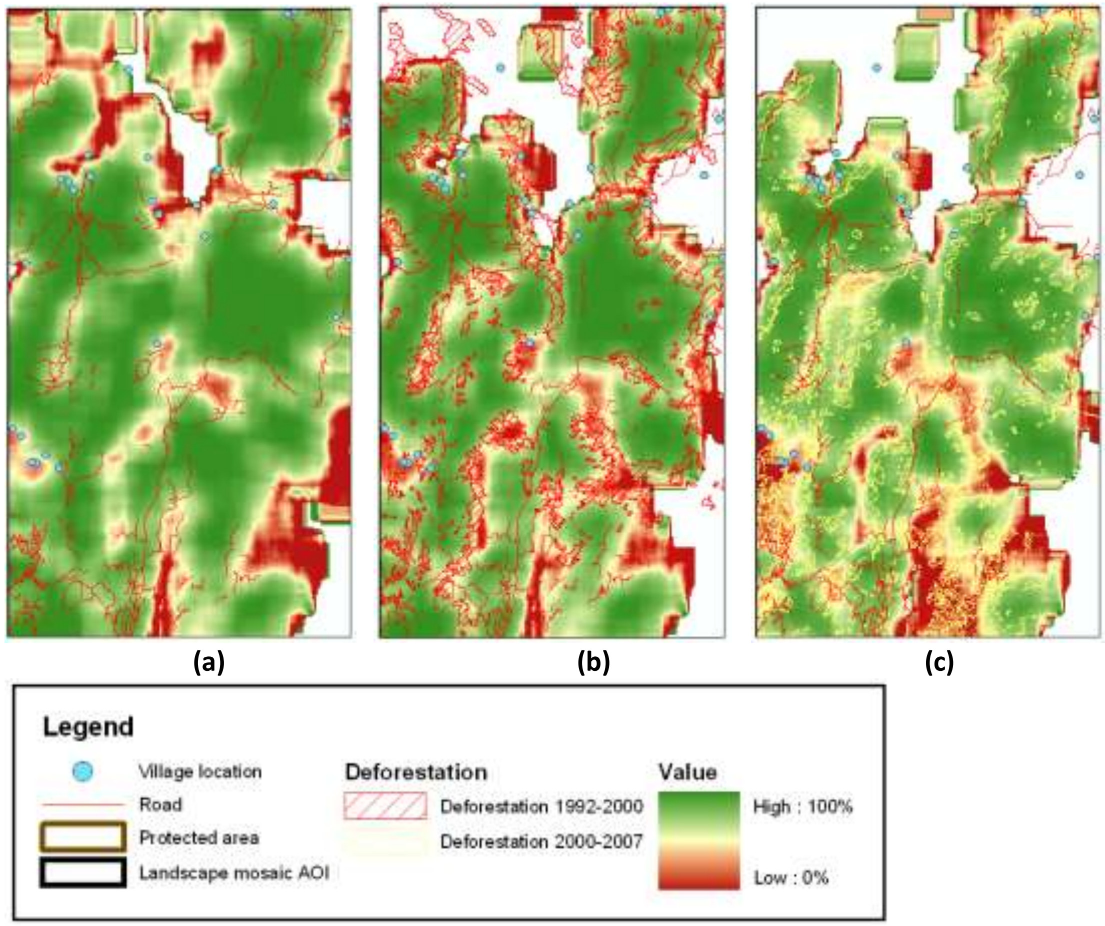


Figure 69. Time series of aggregation index of forest, (a) aggregation index in 1992 (b) aggregation index in 2000 with deforestation in 1992-2000 (c) aggregation index in 2007 with deforestation in 2000-2007

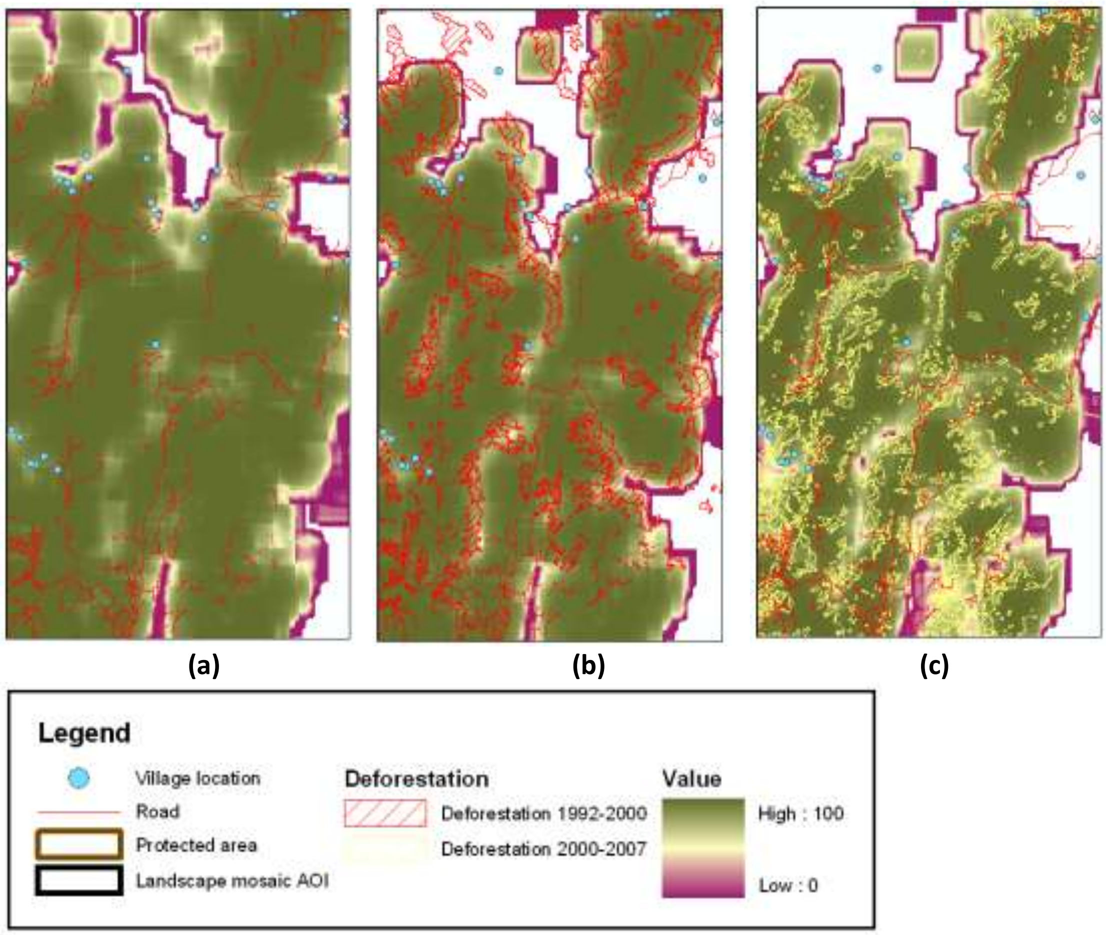


Figure 70. Time series of connectivity of forest, (a) connectivity in 1992 (b) connectivity in 2000 with deforestation in 1992-2000 (c) connectivity in 2007 with deforestation in 2000-2007

Next steps

The results of the on-going research will further be analyzed and synthesized as well as being used for more detailed studies, including the following:

- Linking the analysis to the on-the-ground knowledge of trends and drivers and livelihoods
- Adding more data in the time series of Laos (period I and II), Cameroon and Madagascar (period II)
- Further classifying the land use/cover types by differentiating forests based on density and by differentiating tree cover based on number of dominant tree species (monoculture or mixed)
- Comparing land use and land cover changes inside and outside protected areas
- Ground-truthing for accuracy analysis
- Linking the analysis with the results of quick tree diversity survey
- Based on 'Quick Tree Diversity Survey' and analysis of dispersal, experimenting different sets of parameters to derive functional indices that reflect ecological processes and species-specific characteristics
- Exploring more indices that can quantify ecological properties of landscapes beyond visualization
- Scenario analysis from visioning exercise to identify opportunity and constraints for biodiversity conservation in the landscape mosaics, and therefore options and possible interventions (policies, rewards for environmental services)

Conclusion

Changes in landscape composition and configuration over time due to land use/cover changes, including deforestation, are marked in the five landscapes of Bungo (Indonesia), Viengkham (Laos), Manompana (Madagascar), Takamanda-Mone (Cameroon) and East Usambara (Tanzania). Except for Viengkham (with only two time series such that data is very limiting), other landscapes experience decreases of forest cover over time with varying rates. Subsequent land use/cover post-deforestation also varies from fallow, mixed-tree based system such as rubber and cinnamon or monoculture trees such as oil palm and acacia, cropland and settlement. In most recent year, based on forest and tree cover fraction, the order of forest transition stages from earliest to the most advanced of the landscapes under study is Takamanda-Mone, Viengkham, Manompana, East Usambara and Bungo, with Bungo being close to reaching the reversal mode from declining forest cover to increasing tree cover. Spatial pattern of deforestation is determined by topography and transportation network (road and river) as well as the configuration of forest blocks and settlement locations/population densities. Changes in landscape level indices indicate the loss of forest core area, increased fragmentation and reduced connectivity over time, and can be used as a quick criteria to assess risks of extinction of species with particular characteristics (habitat specialized species is sensitive to rapid reduction of forest core area; species with no ability to migrate swiftly is sensitive to rapid increase of fragmentation and species which do not disperse their propagules broad enough are sensitive to rapid decrease of connectivity). The case of East Usambara is the worst among the five landscapes for such habitat specialized, sedentary and narrowly disperses species because of its high rate of habitat loss is simultaneous with rapid increase of fragmentation and decrease in connectivity.

Spatial variations of forest core area, aggregation and connectivity indices across the landscapes (indices at sub-landscape level computes across the entire landscape), which can be visualized as maps can offer valuable information and function as tools for negotiation platform within land use planning process. Past spatial pattern of deforestation can suggest where within the landscape the future deforestation will take place. In conjunction with scenario simulation based on multi-agent modelling, empirical modelling or spatially-explicit driver modelling, projection of likely areas of deforestation based on past spatial deforestation pattern can spot vulnerable area of forest core area loss, fragmentation and reduced connectivity. This will help multiple stakeholders to jointly produce guidelines, criteria and indicators of multifunctional landscapes concerning biodiversity, and further identifying options and deciding on 'optimal' landscapes where opportunity lost is lowest and conservation potential is highest.

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3. Invasion of prosopis juliflora and local livelihoods: Case study from the Lake Baringo area of Kenya
4. Leadership for change in farmers organizations: Training report: Ridar Hotel, Kampala, 29th March to 2nd April 2005.
5. Domestication des espèces agroforestières au Sahel : situation actuelle et perspectives
6. Relevé des données de biodiversité ligneuse: Manuel du projet biodiversité des parcs agroforestiers au Sahel
7. Improved land management in the Lake Victoria Basin: TransVic Project's draft report.
8. Livelihood capital, strategies and outcomes in the Taita hills of Kenya
9. Les espèces ligneuses et leurs usages: Les préférences des paysans dans le Cercle de Ségou, au Mali
10. La biodiversité des espèces ligneuses: Diversité arborée et unités de gestion du terroir dans le Cercle de Ségou, au Mali

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11. Bird diversity and land use on the slopes of Mt. Kilimanjaro and the adjacent plains, Tanzania
12. Water, women and local social organization in the Western Kenya Highlands
13. Highlights of ongoing research of the World Agroforestry Centre in Indonesia
14. Prospects of adoption of tree-based systems in a rural landscape and its likely impacts on carbon stocks and farmers' welfare: The FALLOW Model Application in Muara Sungkai, Lampung, Sumatra, in a 'Clean Development Mechanism' context
15. Equipping integrated natural resource managers for healthy agroforestry landscapes.
16. Are they competing or compensating on farm? Status of indigenous and exotic tree species in a wide range of agro-ecological zones of Eastern and Central Kenya, surrounding Mt. Kenya.
17. Agro-biodiversity and CGIAR tree and forest science: approaches and examples from Sumatra.
18. Improving land management in eastern and southern Africa: A review of polices.
19. Farm and household economic study of Kecamatan Nanggung, Kabupaten Bogor, Indonesia: A socio-economic base line study of agroforestry innovations and livelihood enhancement.
20. Lessons from eastern Africa's unsustainable charcoal business.
21. Evolution of RELMA's approaches to land management: Lessons from two decades of research and development in eastern and southern Africa
22. Participatory watershed management: Lessons from RELMA's work with farmers in eastern Africa.

23. Strengthening farmers' organizations: The experience of RELMA and ULAMP.
24. Promoting rainwater harvesting in eastern and southern Africa.
25. The role of livestock in integrated land management.
26. Status of carbon sequestration projects in Africa: Potential benefits and challenges to scaling up.
27. Social and Environmental Trade-Offs in Tree Species Selection: A Methodology for Identifying Niche Incompatibilities in Agroforestry [Appears as AHI Working Paper no. 9]
28. Managing tradeoffs in agroforestry: From conflict to collaboration in natural resource management. [Appears as AHI Working Paper no. 10]
29. Essai d'analyse de la prise en compte des systemes agroforestiers pa les legislations forestieres au Sahel: Cas du Burkina Faso, du Mali, du Niger et du Senegal.
30. Etat de la recherche agroforestière au Rwanda etude bibliographique, période 1987-2003

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31. Science and technological innovations for improving soil fertility and management in Africa: A report for NEPAD's Science and Technology Forum.
32. Compensation and rewards for environmental services.
33. Latin American regional workshop report compensation.
34 Asia regional workshop on compensation ecosystem services.
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36 Exploring the inter-linkages among and between compensation and rewards for ecosystem services CRES and human well-being
37 Criteria and indicators for environmental service compensation and reward mechanisms: realistic, voluntary, conditional and pro-poor
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40 How important are different types of compensation and reward mechanisms shaping poverty and ecosystem services across Africa, Asia & Latin America over the Next two decades?
41. Risk mitigation in contract farming: The case of poultry, cotton, woodfuel and cereals in East Africa.
42. The RELMA savings and credit experiences: Sowing the seed of sustainability
43. Yatich J., Policy and institutional context for NRM in Kenya: Challenges and opportunities for Landcare.
44. Nina-Nina Adoung Nasional di So! Field test of rapid land tenure assessment (RATA) in the Batang Toru Watershed, North Sumatera.
45. Is Hutan Tanaman Rakyat a new paradigm in community based tree planting in Indonesia?
46. Socio-Economic aspects of brackish water aquaculture (Tambak) production in Nanggroe Aceh Darrusalam.
47. Farmer livelihoods in the humid forest and moist savannah zones of Cameroon.

48. Domestication, genre et vulnérabilité : Participation des femmes, des Jeunes et des catégories les plus pauvres à la domestication des arbres agroforestiers au Cameroun.
49. Land tenure and management in the districts around Mt Elgon: An assessment presented to the Mt Elgon ecosystem conservation programme.
50. The production and marketing of leaf meal from fodder shrubs in Tanga, Tanzania: A pro-poor enterprise for improving livestock productivity.
51. Buyers Perspective on Environmental Services (ES) and Commoditization as an approach to liberate ES markets in the Philippines.
52. Towards Towards community-driven conservation in southwest China: Reconciling state and local perceptions.
53. Biofuels in China: An Analysis of the Opportunities and Challenges of Jatropha curcas in Southwest China.
54. Jatropha curcas biodiesel production in Kenya: Economics and potential value chain development for smallholder farmers
55. Livelihoods and Forest Resources in Aceh and Nias for a Sustainable Forest Resource Management and Economic Progress.
56. Agroforestry on the interface of Orangutan Conservation and Sustainable Livelihoods in Batang Toru, North Sumatra.

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57. Assessing Hydrological Situation of Kapuas Hulu Basin, Kapuas Hulu Regency, West Kalimantan.
58. Assessing the Hydrological Situation of Talau Watershed, Belu Regency, East Nusa Tenggara.
59. Kajian Kondisi Hidrologis DAS Talau, Kabupaten Belu, Nusa Tenggara Timur.
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61. Lessons learned from community capacity building activities to support agroforest as sustainable economic alternatives in Batang Toru orang utan habitat conservation program (Martini, Endri et al.)
62. Mainstreaming Climate Change in the Philippines.
63. A Conjoint Analysis of Farmer Preferences for Community Forestry Contracts in the Sumber Jaya Watershed, Indonesia.
64. The Highlands: A shower water tower in a changing climate and changing Asia.
65. Eco-Certification: Can It Deliver Conservation and Development in the Tropics?
66. Designing ecological and biodiversity sampling strategies. Towards mainstreaming climate change in grassland management.
67. Participatory Poverty and Livelihood Assessment Report, Kalahan, Nueva Vizcaya, the Philippines
68. An Assessment of the Potential for Carbon Finance in Rangelands
69. ECA Trade-offs Among Ecosystem Services in the Lake Victoria Basin.
70. Le business plan d’une petite entreprise rurale de production et de commercialisation des plants des arbres locaux. Cas de quatre pépinières rurales au Cameroun.

71. Les unités de transformation des produits forestiers non ligneux alimentaires au Cameroun. Diagnostic technique et stratégie de développement Honoré Tabuna et Ingratia Kayitavu.
72. Les exportateurs camerounais de safou (Dacryodes edulis) sur le marché sous régional et international. Profil, fonctionnement et stratégies de développement.
73. Impact of the Southeast Asian Network for Agroforestry Education (SEANAFE) on agroforestry education capacity.
74. Setting landscape conservation targets and promoting them through compatible land use in the Philippines.
75. Review of methods for researching multistrata systems.
76. Study on economical viability of Jatropha curcas L. plantations in Northern Tanzania Assessing farmers' prospects via cost-benefit analysis
77. Cooperation in Agroforestry between Ministry of Forestry of Indonesia and International Center for Research in Agroforestry
78. "China's bioenergy future. an analysis through the Lens if Yunnan Province
79. Land tenure and agricultural productivity in Africa: A comparative analysis of the economics literature and recent policy strategies and reforms
80. Boundary organizations, objects and agents: linking knowledge with action in agroforestry watersheds
81. Reducing emissions from deforestation and forest degradation (REDD) in Indonesia: options and challenges for fair and efficient payment distribution mechanisms

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82. Mainstreaming Climate Change into Agricultural Education: Challenges and Perspectives.
83. Challenging Conventional mindsets and disconnects in Conservation: the emerging role of eco-agriculture in Kenya's Landscape Mosaics.
84. Lesson learned RATA garut dan bengkunat: suatu upaya membedah kebijakan pelepasan kawasan hutan dan redistribusi tanah bekas kawasan hutan.
85. The emergence of forest land redistribution in Indonesia.
86. Commercial opportunities for fruit in Malawi.
87. Status of fruit production processing and marketing in Malawi.
88. Fraud in tree science.
89. Trees on farm: analysis of global extent and geographical patterns of agroforestry
90. The springs of Nyando: water, social organization and livelihoods in Western Kenya.
91. Building cpacity toward region-wide curriculum and teaching materials development in agroforestry education in Southeast Asia.
92. Overview of Biomass Energy Technology in Rural Yunnan.
93. A Pro-Growth Pathway for Reducing Net GHG Emissions in China
94. Analysis of local livelihoods from past to present in the central Kalimantan Ex-Mega Rice Project area
95. Constraints and options to enhancing production of high quality feeds in dairy production in Kenya, Uganda and Rwanda

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97. Economic viability of Jatropha curcas L. plantations in Northern Tanzania- assessing farmers' prospects via cost-benefit analysis.
98. Hot spot of emission and confusion: land tenure insecurity, contested policies and competing claims in the central Kalimantan Ex-Mega Rice Project area
99. Agroforestry competences and human resources needs in the Philippines
100. CES/COS/CIS paradigms for compensation and rewards to enhance environmental Services
101. Case study approach to region-wide curriculum and teaching materials development in agroforestry education in Southeast Asia
102. Stewardship agreement to reduce emissions from deforestation and degradation (REDD): Lubuk Beringin's Hutan Desa as the first village forest in Indonesia

The World Agroforestry Centre is an autonomous, non-profit research organization whose vision is a rural transformation in the developing world where smallholder households strategically increase their use of trees in agricultural landscapes to improve their food security, nutrition, income, health, shelter, energy resources and environmental sustainability. The Centre generates science-base knowledge about the diverse role that trees play in agricultural landscapes, and uses its research to advance policies and practices that benefit the poor and the environment.

United Nations Avenue, Gigiri - PO Box 30677 - 00100 Nairobi, Kenya
Tel: +254 20 7224000 or via USA +1 650 833 6645
Fax: +254 20 7224001 or via USA +1 650 833 6646
Southeast Asia Regional Programme - Sindang Barang, Bogor 16680
PO Box161 Bogor 16001, Indonesia
Tel: +62 251 625 415 - Fax: +62 251 625 416
www.worldagroforestry.org