Working Paper

History of agroforestry research and development in Viet Nam

Analysis of research opportunities and gaps

Nguyen Thi Hoa, Delia Catacutan

World Agroforestry Centre
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Abstract

Agroforestry is considered as one of the best approaches to deal with shifting cultivation and climate change. In Viet Nam, the practice of agroforestry has been documented since the 1960s under two common systems: 'garden-fish pond-livestock' and 'forest-garden-fish pond-livestock'. However, not until 1990 were innovative agroforestry techniques and systems at the field level introduced in line with government interventions to halt shifting cultivation. Through intensive literature review, we outline the history of agroforestry research and development activities in Viet Nam, identify the drivers and agents of change and discuss the issues and challenges facing agroforestry in Viet Nam. The paper also discusses the opportunities and research gaps in agroforestry. Our analysis indicated that it is very important to put more effort into researching agroforestry systems that take into account local ecological knowledge and designing practices that enhance the multi-functionality of landscapes. In addition, demonstrating the role of these systems in improving livelihoods, enhancing resilience and in climate-change mitigation and adaption should be an important part of a more systematic research and development agenda agroforestry in Viet Nam.

Keywords: agroforestry, alley cropping, climate change, landscape, taungya, shifting cultivation, Viet Nam

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Contents

Introduction

In recent decades, population growth accelerated in the mountainous areas of Viet Nam, driven by migration from the lowlands by farmers seeking improved livelihoods. This growth increased pressure on the environment as the demand for goods and services rose, while the land available for cultivation did not; in some cases it actually decreased due to degradation caused by poor cultivation practices. The growing population led to the intensive use of natural resources including forests and forest land, especially land under shifting cultivation, in order to meet people's basic needs. Solutions were sought to not only improve the livelihoods of local people dependent on forests and forest land, but also to protect the environment.

From the second half of the 1980s, agroforestry emerged in various parts of the world as an alternative to slash and burn cultivation in mountainous areas (Pollini 2009), because it not only provides livelihoods for local people, but also helps mitigate the impacts of climate change. There is evidence that agroforestry, as both science and practice, might contribute to the improvement of rural livelihoods, because it offers multiple alternatives and opportunities to smallholders to enhance farm production and income, while protecting the agricultural environment. Agroforestry can improve farm productivity through nutrient recycling and soil protection, using spatial or temporal intercropping of trees and other species, and diversifying farm products. It can also reduce financial risk from adverse climatic, biological or market impacts on particular crops (Nair 1992).

As defined by the World Agroforestry Centre (ICRAF 2009), agroforestry can be observed at different scales, including field (plot) level, farm level and landscape level[i]. In Viet Nam, traditional agroforestry systems at the landscape level have been used since the early 1960s, under two common practices: garden/fish pond/livestock

and the forest/garden/fish pond/livestock systems. However, it was not until 1990 that innovative agroforestry techniques and systems at the field level were introduced into different regions of Viet Nam by either non-governmental organizations (NGOs) or government agencies. Now considered an alternative to shifting cultivation, agroforestry has been adopted across the country, accelerated by government efforts to halt shifting cultivation and encourage reforestation. However, agroforestry research and development has been fragmented and the initiatives and interventions from previous decades have not been well documented. Therefore, this summary, by reviewing secondary reports and direct observation, will look at the evolution of agroforestry research and development activities in Viet Nam in recent decades; at the three different levels mentioned above; along with the drivers and agents of change, and the remaining issues and challenges for agroforestry research and development. The report also includes an analysis of opportunities for the development of agroforestry and research gaps recommended for further study.

Evolution of agroforestry practices in Viet Nam and the drivers of change

Since 1960, the term 'agroforestry' has been known in Viet Nam but agroforestry research and development has changed with various systems in different parts of the country. While it normally referred to landscape agroforestry in the early period before 1990, currently agroforestry involves a variety of systems at the field level. It includes innovative practices such as alley cropping and taungya systems; and more traditional multi-strata systems such as fruit and forest gardens. The species used in these systems also depends on the time period and location. The adoption of agroforestry practices responded to growing concerns about shifting cultivation, and was encouraged by government policies on forest plantations and reforestation. Table 1 provides a brief summary of the adoption of agroforestry across different periods and discusses the key drivers of change.

Growth of traditional landscape agroforestry and fallow systems 1960–1990

Since 1960, agroforestry has been practised in Viet Nam using two traditional landscape models: the garden/fish pond/livestock model, and the forest/garden/fish pond/livestock model. The garden/fish pond/livestock model was used by farmers and spread throughout the country. The model was then adapted into the forest/garden/fish pond/livestock system to make the practice suited to hilly areas (Nguyen et al. 2006). The system was strongly developed throughout the upland regions. As described by CARES (2004), the standard area for each landscape agroforestry system ranged 2–3 ha. The popular forestry species were *Mangetia glauca*, *Eucalytus*, *Acacia* or *Styrax tonkinensis*, planted on the top of the hill; while annual crops were located in the middle parts. In some areas, fields were terraced for crop production. In the lower,

less steep areas, fruit and perennial trees such as oranges and tea were planted, in combination with livestock farming.

The expansion of agroforestry landscapes resulted from the economic recovery after the First Indochina War's end in the north in 1954. The spread of the garden/fish pond/livestock practice served as an economic alternative in lowland areas. By 1981, the government issued Decree 100 (Khoan 100) on the distribution of paddy fields to individual households. It marked the end of the cooperative economy in Viet Nam and was the first time farmers had property rights over the land (Tran 2001). With the implementation of this policy, individual farmers were encouraged to cultivate lowlands more intensively to improve their economic conditions, creating the opportunity for the expansion of the garden/fish pond/livestock model.

In 1980, the government implemented a program (Decision 95/CP) for the establishment of new economic zones and long-term population redistribution through a mass 'organized migration' to the Central Highlands. Due to this, the population increased rapidly in the central highlands (Sunderlin and Huynh 2005) and in mountainous areas. The migrants brought with them agricultural practices from the lowlands, and as a result, the garden/fish pond/livestock practice was modified to the forest/garden/fish pond/livestock model which is more suited to mountainous areas.

In terms of shifting cultivation, the population increases in the upland regions meant fewer opportunities for farmers to clear forest for traditional pioneer shifting cultivation. In order to meet food demand, the fallow systems or rotational shifting cultivation were used to restore soil fertility, especially in the northern and central regions, where farmers returned to agricultural cultivation after resting the land for several years (CARES 2004).

Spread of landscape agroforestry, improved fallow systems and field agroforestry practices: small-scale fruit gardens, alley cropping with N-fixing species as a Sloping Agricultural Land Technology and taungya systems with forestry species (1990–2000)

While traditional landscape agroforestry was popular in both lowland and upland areas before 1990, the use of landscape systems with terraced fields increased during the 1990s. Common practices included: forest/terraced field, forest/upland crops/rice paddy, forest/upland crops/gardens/terraced fields, and forest/upland crops/terraced fields/gardens, in the mountainous northern provinces including Bac Giang, Cao Bang, Lang Son, Lao Cai, Quang Ninh and Yen Bai. Do (1994) shows that under the implementation of forestland allocation and intensive interventions to stabilize cultivation and encourage sedentary lifestyles, ethnic farmers in the northern mountains changed their shifting cultivation areas into terraced fields for rice paddy production. The limits to expanding shifting cultivation areas caused by the forestland allocation policy, accelerated the development of landscape agroforestry systems with terraced fields providing stable local livelihoods.

In addition, this period witnessed the expansion of improved fallow systems in rotational shifting cultivation agroforestry practices. To overcome the lack of cultivated land, farmers in many places grew crops or trees during the fallow period to provide additional income. Tran (2001) found that farmers in some areas such as Hoa Binh, Nghe An, Yen Bai and other provinces in the Northwest region had adopted melia, cinnamon and N-fixing species (*Tephoria, Leucaena* and *Desmodium*) as improved fallow strategies.

In terms of field agroforestry, multi-strata agroforestry systems were not found in Viet Nam until the 1990s. By 1997, small-scale fruit and home gardens were found throughout the country. These systems involved different storeys of fruit trees to take

full advantage of space. For example, VNAFE (2006) describes the use of *Garcinia mangostana*, *Lansium domesticum* and pineapple in Binh Duong province. The adoption of multi-strata agroforestry systems during this time was encouraged by the government policy of land allocation to farmers. The allocation of agricultural land to low land farmers for long term use by 1988, and forestland in mountainous areas by 1993, also facilitated the development of fruit gardens. Given the chance to own their land, farmers made more active investments in production in their allocated areas.

In addition to multi-strata agroforestry systems, this period also saw the emergence of innovative agroforestry techniques. While alley cropping with N-fixing species was dominant in the north, perennial tree-based alleying systems became popular in the central areas. The population increase in mountainous areas and rising concerns about the negative impacts of shifting cultivation drove the adoption of improved cultivation methods. This led to testing Sloping Agricultural Land Technologies (SALT) with N-fixing species by research and development organizations in different parts of the country.

By 1992, alleying agroforestry systems were introduced by researchers in Bac Kan and Thai Nguyen provinces. The trial used *Tephrosia candida* planted in contours on sloping lands, with fruit trees and crops intercropped between hedgerows (Tran 2001). Later on, alleying agroforestry systems were trialled in other provinces in the north. The evaluation in 1996 shows that a variety of N-fixing species were used for alleying agroforestry systems such as *Tephrosia*, *Flemingia*, pigeon pea, *Leucaena, Alnus nepalensis,* and *Plochea indica* in Phu Tho, Tuyen Quang, Lao Cai and Yen Bai provinces. Some indigenous bushes or plants were also used as hedgerows. Between these hedgerows, farmers grew crops (maize and cassava), perennial trees (tea and coffee) and fruit trees (orange, mandarin, persimmon, longan and lychee) (Bui 1996).

The revised land law of 1993 promoted land allocation to local farmers, and therefore increased the number of ethnic groups engaged in stable production. They established industrial forest plantations producing coffee, and cashew nut, and participated in forest/agriculture industry unions (Do 1994). In addition, government efforts to reduce the areas under shifting cultivation drove shifting cultivators to seek alternatives to meet demand for food and long term income. By 1994, alleying agroforestry systems with perennial trees were adopted by farmers in the central provinces of Viet Nam. In Dac Lac province, durians were intercropped as hedgerows, providing shade and shelter for pepper and coffee, and solving water shortage issues. Coffee was introduced first, with pepper and durians being intercropped two years later. During the first two years after coffee was introduced, food crops such as maize and beans were planted (Nongnghiepvn News 1994) and alleying systems using pepper and coffee with acacia/palm trees were also found in the province.

The implementation of forest plantations, reforestation and the use of bare land programs, introduced by programs 327/CT (1993–2000) and 661 (phase 1: 1998–2005), facilitated the adoption of taungya agroforestry systems in the country. The land available for food production was reduced by forest plantations and taungya systems were introduced so that farmers could meet short-term food demand while waiting for plantation forests to be harvested or for financial support from the government for the area of forest planted. Fatoux et al (2002) carried out a survey of the impact of 'revolution' policies on agricultural diversification in Viet Nam and found that during the 1990s farmers diversified their cultivation using agroforestry systems, including *Mangtelia* with annual crops, moving away from mono-cropping. Annual crops were intercropped with *Tech* and *Melia* in the first 2 or 3 years in the

north (Son La and Hoa Binh provinces). This system helped farmers to reduce management costs, increase benefits and protect the environment (CARES 2004).

Expansion of field agroforestry practices: fruit gardens at a larger scale across the country, forest gardens in the north and innovative agroforestry systems in the central part (2000–2004)

From 2000 to 2004, multi-strata systems for fruit and forest gardens spread throughout the country. The low efficiency of shifting cultivation, along with government interventions aimed at poverty reduction and efforts to halt shifting cultivation, drove farmers to adopt more productive alternatives. Intensive agroforestry capacity building activities during the 1990s increased farmers' knowledge and facilitated the adoption of agroforestry systems. CARES (2004) describes the existence of fruit gardens across the country, at larger scales than during 1990s. These systems included different storeys: durian, coconut, mango, jackfruit, lychee or longan in the highest layer; while shade was provided by fruit trees such as sapotas, orange, mandarin, custard-apple in the middle storey; and cocoa or medicinal plants were integrated in the lowest layer.

During this period, forest gardens were also growing in the northern mountains and central regions of Viet Nam. By the end of the 1990s and the beginning of the 2000s, a growing understanding of agroforestry among farmers led to the adoption of high-value forest gardens to provide them with short-term incomes. Even though the forestland allocation policy had been effective at the national level since 1993, it had not been implemented at the local level in many places until the beginning of the 2000s (Castella et al 2006). Land allocation made farmers more active in planting forest and developing forest gardens to meet their own demands. CARES (2004) documented a variety of forest gardens in the north of Viet Nam, such as in Phu Tho,

Yen Bai, Hoa Binh, Thanh Hoa and Quang Nam provinces. The forest gardens normally ranged 0.3 to 0.5 ha, and integrated forest species with perennial fruit trees and high value crops. The popular forest species found in those systems were cinnamon, bamboo, *Litsea glutinosa,* anise, *Aquilaria crassna pierre.* The common associated crops were upland rice, maize, cassava, beans, banana and medicinal plants such as ginger, saffron, and lemongrass.

In addition to multi-strata agroforestry systems, innovations continued to grow in the central regions. Alleying perennial tree-based agroforestry systems were found in Dac Lak province such as cashews, and *Cassia siamea* integrated with coffee and/or pepper, with cashews and *Cassia siamea* serving as shade trees for coffee and pepper. It was found by Nguyen et al (2002) that coffee-based systems generated higher incomes, making them popular with local farmers. Due to the reduction in land available for cultivation, and the need to increase revenue from coffee monocultures, the introduction of multi-purpose timbers into these systems became prevalent. Another driver was the slight increase in the international price of perennial tree products during the first half of the 2000s, encouraging farmers to expand their plantation area of perennial trees. The total area under coffee plantations was 155,000 ha by 1995, expanding to 500,000 ha by 2003 (Garrity et al 2006). Taungya systems of annual crops with fruit and timber trees were also found, whereas these were only found in the northern mountains during the 1990s.

Increasing small woodlots used as a farm agroforestry practice, alleying and taungya systems with a wide range of species in the north and southern central parts, with intercropping agroforestry systems using different tree species in the north (2004 up to the present)

From 2004, small woodlots were adapted for use in agroforestry farms. Small woodlots were maintained adjacent to agricultural crops to meet timber demand and

improve soil quality, such as small alder plots next to maize plantations in Lao Cai province. It is believed that the expansion of small woodlots developed as a result of the reforestation programs. The field visit to Lao Cai province to study agroforestry systems[ii] revealed that during the second phase of the 661 Reforestation Program (2006–2010), food crops such as maize were integrated with alder trees during the first years. After some years, their shade no longer allowed crop production but farmers kept the trees as small woodlots in some areas, and in other areas the trees were harvested and cleared for food crops.

In terms of field agroforestry practices, green fence and windbreaks/shelterbelts were adopted in many parts of the country, especially in the central region. Alleying agroforestry systems with perennial and forest species were also maintained and increased in the central and northern central parts of Viet Nam. Farmers continued to look for more associated species and better combinations for these systems. For example, in Dac Lak province, the alleying systems of cashew, bean with maize or pumpkin, and *Cassia siamea* with pepper and passion fruit were noted (VNAFE 2006). Short crops were planted during the first five years after cashew plantation, while *Cassia siamea* served as shelter for pepper and passion fruit.

There was a growing trend in the adoption of taungya systems in the northern and South Central parts of Viet Nam. While previously taungya systems were only used with a limited number of forestry species in the north, a wider range of species were now used. Nguyen (2008) says popular taungya systems included *Mangtelia glauca* with upland rice and cassava in Tuyen Quang and Yen Bai provinces, and *Cinnamomum cassia* with cassava in Yen Bai. In addition, *Melia*, *Chukrasia,* eucalyptus, acacia or pine were also used with annual crops in the north. Taungya systems using crops with forestry tree species such as *Aquilaria Crassna pierre* and

hybrid acacia were popular in the central northern parts of Viet Nam. This increase was due to the continuous implementation of reforestation programs. Phase 2 of the 661 program was implemented at national level during 2006–2010. Farmers used taungya systems as a way for them to meet food demand while their land was occupied by young forest.

Taungya systems with N-fixing species were also found the in north. The problems caused by shifting cultivation and unsuitable cultivation on slopes drove the adoption of agroforestry systems, especially with N-fixing species, in order to reduce soil erosion. Nguyen (2008) describes a number of systems used by farmers in Phu Tho province, including beans and cassava with fruit trees, and tea and *Fallopia japonica* with *senna*. In addition, taungya systems with perennial trees were first seen in the South Central region and the north. Because perennial trees were seen to provide livelihoods, the system has been adopted in many parts of the country. For example, Decision 750/QD-TTg for planning rubber plantations to 2015, towards 2020, Viet Nam, saw plans to increase the area of rubber plantations in the Northwest region by 50 000 ha by 2020 (VOV 2011). In response, a number of agroforestry systems using rubber during the establishment phase were taken into consideration by research institutes. Research on systems using rubber with fodder grass was carried out in Mai Son, Thuan Chau, and Muong La districts of Son La province. Rubber with rice or maize, and rubber with beans and coffee were also tested (NOMAFSI 2009)[iii]. In 2006 there were a variety of systems in Phu Yen province intercropping cashew/sugar cane/rubber/coffee with beans/cassava (MONRE 2006).

In addition to taungya systems, intercropping agroforestry systems with different tree species became popular in the northern mountainous area and Central Highlands. Non-timber forest species and perennial trees were intercropped under forestry

species and the forest canopy in later stages, such as cardamom under alder, and *amomum* under forests in Lao Cai province, and tea under *Mangtelia* or *Acacia* in Phu Tho and Yen Bai provinces. Coffee, rubber, and cocoa were planted under forest species in the central areas. It is noted that these systems followed the taungya system. When forestry trees grow large in the taungya systems, the shade prevents the planting of food crops. Because of livelihood pressures, farmers use shade-tolerant species under the tree canopy for additional income in the later phases of the forest tree plantations.

Table 1. Agroforestry evolution in Viet Nam and the drivers of adoption

ADOPTION PERIOD	AGROFORESTRY PRACTICES	LOCATION	KEY DRIVERS
1960–1990	**Landscape agroforestry** Garden/fish pond/livestock, forest/garden/fish pond/livestock models	Throughout the country	Economic development after the war ended in 1954 End of cooperative economy in 1981
	Farm agroforestry Fallow systems/rotational shifting cultivation	Throughout mountainous areas	Population increase and migration to upland areas limited opportunities to clear forest for pioneer shifting cultivation. Farmers had to leave land fallow for soil improvement
1990–2000	**Landscape agroforestry** Forest/terraced field, Forest/Upland crops/rice paddy, Forest/Upland crops/Gardens/Terraced fields and Forest/Upland crops/Terraced fields/Gardens	Northern mountains: Bac Giang, Cao Bang, Lang Son, Lao Cai, Quang Ninh, Yen Bai provinces	Government interventions to stabilize cultivation and sedentarization, with direct support for converting shifting cultivation areas to terraced fields. Forestland allocation limited opportunities to expand shifting cultivation areas
	Farm agroforestry Improved fallows in rotational shifting cultivation: such us *Melia*, cinnamon and N-fixing species *(Tephoria, Leucaena and Desmodium)*	Hoa Binh, Nghe An, Yen Bai provinces and Northwest region	To overcome the lack of cultivated land, farmers in many places grow crops/trees during the fallow period to provide additional income
	Field agroforestry Multi-strata agroforestry systems: home and fruit tree gardens	Small scale in some locations Binh Duong province	Land allocation in low lands for longer use (1988)
	Alley cropping systems		
	SALT: N-fixing species as hedgerows with annual crops	Northern mountains and central northern provinces: Bac Kan, Thai Nguyen and Thua Thien Hue, Phu Tho, Tuyen Quang, Lao Cai, Yen Bai, Ha Giang	Population pressure in mountainous areas and increasing concerns regarding the impacts of shifting cultivation drove the application of improved fallow techniques
	Perennial-tree-based systems: Pepper, coffee with durian/acacia/palm trees	Central part: Dac Lak	Adoption of perennial trees in allocated forest land

	Taungya systems		
	Annual crops (rice, maize) with timber trees: *Tech, Melia* in the first 2 or 3 years	Northern mountains: Son La, Hoa Binh and Yen Bai provinces	Forest plantations on bare lands (Program 327/CT 1992, from 1993–2000) Reforestation program (661 phase 1: 1998–2005)
2000–2004	**Field agroforestry**		Agroforestry research and development interventions before 1990
	Multi-strata agroforestry systems		
	Forest gardens Forest species: various in different regions, with fruit trees and annual crops	Northern mountains and central northern provinces: Lang Son, Phu Tho, Thanh Hoa, Hoa Binh, Yen Bai, Thanh Hoa, Quang Nam, and Binh Thuan	Reforestation programs and growing understanding of agroforestry in many parts of the country required for high-value forest gardens in the areas reforested
	Fruit tree gardens Durians/coconuts/mango/jackfruits/ lychee/longan with middle storey: sapotas/orange/custard-apple and cacao/medicinal plants in lower storey	Across different regions in the country	Growing understanding of agroforestry and need for higher value home fruit gardens
	Alley cropping systems		
	Perennial-tree-based systems: cashews and *Cassia siamea* with coffee and pepper	Central: Dac Lak	Increase in price of perennial tree products (such as coffee) by the end of 1990s Allocation of forest land for the growing of perennial trees in allocated areas
	Taungya systems		
	Annual crops with fruit, timber trees during first years	Central: Dac Lak	Reforestation program
2004–present	**Farm agroforestry**		
	Small agroforestry woodlots: small woodlots adjacent to agricultural crops (such as alder plots next to maize plantation)	Lao Cai province	Under the reforestation program, food crops were integrated during the first years. After some years, the trees are taller, and do not permit intercropping food crops. Therefore, in some areas, farmers retained trees, and in some adjacent fields trees were harvested for crop cultivation
	Field agroforestry		
	Green Fence	In rural areas	
	Windbreaks and Shelterbelts	In the Central Highlands	
	Alley cropping systems		
	Perennial-tree-based systems: Cashew with bean, maize or pumpkin, and pepper with *Cassia siamea* and passion fruit	Central: Dac Lak	Allocation of forestland for the growing of perennial trees in allocated areas
	Forest species: *Aquilaria Carassan*/hybrid acacia with banana	North Central: Quang Nam	
	Taungya systems		
	Forest-species-based: (*Mengtelia*, *Melia*, Cinnamon, *Chukrasia, eucalyptus, acacia or pine*) with annual crops Crops with forestry tree species such as *Aquilaria crassna* Pierre and hybrid acacia	Northern mountains: Tuyen Quang, Yen Bai, Bac Kan, Dien Bien South Central: Phu Yen	Increased implementation of reforestation programs and food demand caused by reduced agricultural lands

	N-fixing-species-based: beans with fruit trees, *Senna siamea* with tea and *Fallopia japonica*	Northern mountains: Phu Tho	Soil erosion due to shifting cultivation
	Perennial-tree-based: Cashew/rubber/coffee with beans/ cassava/sugar cane Rubber/coffee with fodder grass/ rice/maize/coffee	South Central: Phu Yen Northern mountains: Son La	Plantation of perennial trees in many parts of the country to create livelihood opportunities and to deal with shifting cultivation. Requires intercropping alternatives during the first years to meet food demand.
	Intercropping agroforestry systems with different tree species: Non-timber forest species under forest canopy (cardamon under alder; *amomum* under forest) Perennial trees under forest species (tea under *Mangtelia*/acacia, coffee, rubber, cocoa under forest trees)	Northern mountains: Yen Bai, Phu Tho, Lao Cai, and Central highlands	These systems are used following taungya systems. When trees grow large, shade-tolerant species were planted under the canopy for additional income.

Agroforestry research and development in Viet Nam

Since 1990 there have been significant contributions by NGOs, research institutes and government agencies to encourage the adoption of agroforestry in Viet Nam. While most agroforestry practices before 1990 were initiated by farmers, development and research organizations began testing alleying as a SALT technique in northern Viet Nam during the 1990s. Since the second half of the 2000s, government agencies in the northern mountains and central northern areas also used taungya agroforestry systems in their development strategies to address reforestation programs, and the problems of shifting cultivation and mono-cropping. Table 2 provides a brief overview of agroforestry research and development interventions in Viet Nam throughout this period.

Both development organizations and research institutes were proactive in testing and demonstrating alley cropping practices (as a SALT technique) with N-fixing species (1990–2000)

Since the beginning of the 1990s, agroforestry knowledge has been promoted in Viet Nam by both NGOs and research institutes. During the 1990s, while research

interventions focused on the establishment of SALT experiments on stations and farms, development organizations showed more interest in demonstrating and integrating SALT techniques in farms at household level.

All research interventions in agroforestry focused on the northern mountains of Viet Nam during this period. By 1991, under the Viet Nam-Sweden Forestry Cooperation Program (FCP), the Farm-Level Forestry Project (1991–1996) had established an on-station SALT trial in Phu Tho province, as described in Bui (1996). On-farm trials were held in five target provinces in the north: Phu Tho, Yen Bai, Tuyen Quang, Lao Cai and Ha Giang. The main objective in promoting SALT was to help farmers to use their land more effectively; to improve yields and soil fertility. The evaluation showed that a variety of SALT techniques were adopted in different places by farmers in the project sites. The most popular technique was a hedgerow plantation along contours on sloping lands, known as 'alley cropping'.

By 1998, the Southeast Asian Agroforestry Education Network was established under the World Agroforestry Centre's regional research and capacity-building project (1998–2005) with financial support from the Swedish International Development Agency (SIDA). Along with the demonstration sites, the network aimed to increase the capacity for agroforestry in Viet Nam. Introducing SALT to Thai Nguyen province in the northern uplands was a part of the network's activities (Hoang et al 2011).

Interventions focused on capacity building, and demonstrating and integrating agroforestry through development projects. In 1991, the Asia-Pacific Agroforestry Network (APAN), an initiative of the Food and Agriculture Organization of the United Nations (FAO), was established. The network was active during 1991–1998

and aimed to encourage the sharing of agroforestry information and development experience within the Asia-Pacific region. Viet Nam collaborated in several APAN activities, both internationally and nationally, including APAN-supported regional expert consultations, workshops and training courses and in-country activities. The APAN Viet Nam newsletter was published to share experience in agroforestry development in Viet Nam and the Asia-Pacific region (FAO 2004). agroforestry demonstration plots were established and a survey was conducted to identify the most successful farming systems in different agro-ecological areas in Viet Nam (FAO 2008).

There were a variety of development projects in which SALT was applied, mostly in the northern upland provinces such as in Hoa Binh, Son La, and Thai Nguyen. These projects supported farmers by providing seedlings and techniques for the adoption of alley cropping systems with N-fixing species, as outlined by CARES (2004).

Research and government agencies focus on testing and demonstrating forest species-based taungya agroforestry systems, while NGOs show more interest in forest gardens (2004–the present)

Since 2004, there have been a variety of development projects and research activities focused on expanding agroforestry systems throughout the country. In terms of research interventions, Thai Nguyen Agriculture and Forestry University tested agroforestry systems using *Chukrasia tabularis* A. Juss with cassava, *Melia azedarac* with fodder grass and *Styrax tonkinensis* with maize in Bac Kan province (Agroviet News 2008). The trial was followed by a cost-benefit analysis. In 2009, NOMAFSI conducted on-station and on-farm trials with rubber-based agroforestry systems. Research in agroforestry systems using rubber with fodder grass was carried out in Mai Son, Thuan Chau, and Muong La districts of Son la province. Rubber with crops

and coffee was also tested in the province during the establishment phase of rubber plantations (NOMAFSI 2009)[iv]. Some research into the carbon sequestration potential of agroforestry systems occurred as climate change emerged as an issue. For example, Bao and Vo (2011) estimated carbon stock in *Litsea glutinosa* and cassava agroforestry systems in Gia Lai province, and found that CO_2 absorption is around 24.7 ton per ha over five years.

Government agencies have increased the demonstration of taungya agroforestry systems with forestry species. In the central northern provinces, by 2007, Nghe An Provincial Extension Center proposed converting cultivated agricultural land to agroforestry plantations during 2008–2012 in Tuong Duong and Ky Son districts. A demonstration model of 40 ha for agroforestry development was established, with the involvement of 25 households (Baonghean 2011). By 2010, the provincial extension department of Quang Nam province had established 24 ha of demonstration models in Hiep Duc, Dai Loc and Tien Phuoc districts. The main trial agroforestry systems used *Aquilaria carassan* or hybrid acacia with banana. The demonstration trial was followed by a cost-benefit analysis. It was demonstrated that over 7 years, agroforestry systems delivered higher benefits and internal rate of return compared to mono-plantations of *Aquilaria Carassan* and hybrid acacia (Khuyennongvn 2011). By 2011, Thua Thien Hue province had adopted agroforestry for improving livelihoods in combination with biodiversity conservation in the Bach Ma national park corridor. The project focused on improving more than 45 ha of forest gardens by integrating fruit and domestic trees for 450 households in four districts: Phu Loc, Phong Dien, A Luoi and Nam Dong. The adoption of agroforestry systems provided sustainable livelihoods for local people living in the buffer zone of the national park (Baomoi 2012). In the northern mountains, by 2010, Dien Bien Provincial Extension Centre

had established demonstration sites for agroforestry systems using eucalyptus/hybrid acacia/pine with upland rice (Nongdan News 2011); while Yen Bai government prioritised agroforestry development for integrated farming systems on sloping land, and transferring technology for agroforestry development (Yenbaigov 2011).

While the interventions of research and government agencies focused on forestry based taungya systems, NGOs showed more interest in the acceleration of multi-strata agroforestry systems. The development project funded by FAO in collabouration with the government of Quang Nam province used agroforestry for poverty reduction in six communes of the province over two phases (2004–2007 and 2009–2012). The project supported the establishment of agroforestry gardens in allocated forestland with fruit and industrial trees. In particular, the project provided capacity building, extension improvement, demonstrations and technical support for the development of market-oriented forest gardens and agroforestry systems in the province (FAO 2004).

Generally, agroforestry research and development has achieved some positive results. During the 1990s, there was an effective alignment of agroforestry research with development work, focusing on alley cropping as a SALT technique. In addition, the awareness raising during this period helped accelerate the expansion of agroforestry systems by farmers in the fields. Since 2004, there has been an application of research outputs by government agencies. The trial of taungya agroforestry systems was first introduced by research institutes, and then followed by government offices, such as the demonstrations in Dien Bien province of eucalyptus/hybrid acacia/pine with upland rice in the province.

Table 2. Agroforestry research and development interventions

PERIOD	AGROFORESTRY RESEARCH	AGROFORESTRY DEVELOPMENT/POLICY INTERVENTIONS
Before 1990	No intervention observed	No intervention observed
1990–2000	The Farm-Level Forestry Project (1991–1996) under the Viet Nam-Sweden Forestry Cooperation Programme introduced SALT to household farms in the north and carried out on-station SALT experiments in Phu Tho province	By 1991, Viet Nam joined the Asia-Pacific Agroforestry Network (APAN), established by FAO. Activities included: regional workshops, training in agroforestry, the establishment of demonstration plots, a survey of successful farming systems throughout the country
	In 1998, the Southeast Asian Agroforestry Education Network was established by ICRAF. In Viet Nam, it focused on agroforestry capacity building and SALT experiments in Thai Nguyen province	A variety of development projects introduced SALT to northern uplands (Hoa Binh, Son La, Hoa Binh, Thai Nguyen provinces) supporting farmers in terms of seedlings and adoption techniques
2000–2004	No intervention observed	No intervention observed
2004–now	In 2008, an on-farm trial of taungya agroforestry systems of forestry species (*Chukrasia, Melia, Styrax*) with annual crops/grasses was established by Thai Nguyen University in Bac Kan, followed by a cost-benefit analysis	Agroforestry development project funded by FAO in Quang Nam province (phase 1: 2004–2007, phase 2: 2009–2012) focused on supporting the establishment of agroforestry gardens, capacity building, extension, demonstration of market-oriented forest gardens and agroforestry systems
	In 2009, NOMAFSI conducted on-station and on-farm trials of rubber-based agroforestry systems in Son La province (rubber with fodder grass/rice/maize/coffee and beans)	In 2010, Quang Nam government established 24 ha agroforestry demonstration models of *Aquilaria carassan* or acacia with banana in three districts, followed by a cost-benefit analysis
		Yen Bai DARD officially prioritised agroforestry development for NGOs working in the province. The province planned to integrate agroforestry on sloping lands in Yen Binh district, and transfer technology for agroforestry development in Van Chan district
		In 2010, Dien Bien DARD demonstrated agroforestry systems with eucalyptus/ hybrid cacia/ pine with upland rice in some parts of the province

Issues and challenges for agroforestry research and development

Agroforestry was considered an alternative to shifting cultivation and an effective way to improve farmers' livelihoods, encouraging agroforestry adoption in different parts of the country. The review shows that agroforestry in Viet Nam experienced recognizable changes in terms of both research and development. There are close links between research and development initiatives and farmers' self-adoption of agroforestry practices. In spite of this, agroforestry research and development in Viet Nam still has many on-going issues and challenges which need to be addressed.

Agroforestry research and development lacks strategic links with the market

The review found that there are a great number of areas where market-oriented agroforestry systems have not yet developed. In addition, as highlighted by Hoang et

al (2011), smallholders generally have weak market links and poor access to market information. For example, CARES (2004) studied the market for agroforestry products in Viet Nam and found that the development of fruit trees in Viet Nam has not met domestic market demand in either quality or quantity. Each year, a large quantity of the fruit consumed domestically has to be imported from other countries such as China and Thailand. As a result, Vietnamese fruit, which does not meet market requirements decreases in value and ultimately this means fruit trees are cleared and replaced by other tree species.

In terms of the international market, some agroforestry products have experienced significant variability in price, affecting the benefits delivered by those systems. As noted by Garrity et al (2006), there has been a recognizable trend of decreasing prices for perennial tree products since 1980, such as coffee and rubber (which are popular perennial trees in agroforestry systems in Viet Nam). The price of arabica coffee fell from USD 500/ton in 1980 to approximately USD 100/ton in 2004. The price variability of perennial tree products causes problems for associated tree-crop agroforestry systems, requiring cutting down and replacement with other trees. For example, due to the recent increases in the price for black pepper, farmers in the central part of Viet Nam chopped down coffee in the harvesting period and replaced it with pepper for improved revenue (Nongnghiepvn News 2012).

Agroforestry does not deliver attractive financial benefits to farmers

Despite the positive impacts of agroforestry on the environment as studied above, farmers do not consider such systems financially attractive. Recent research carried out by the World Agroforestry Centre on the net present value (NPV) of land uses in Bac Kan province[v] indicated that the agroforestry system of *Mangtelia glauca* with

cassava had an estimated value of VND 2.7 million per year per ha (cycle of 10 years), which is higher than mono-plantations of *Mangtelia glauca (*VND 616 000/year/ha) but lower than mono-cropping of annual crops (VND 4.2 million/year/ha for one season of upland rice and one season of maize per year). The adoption of agroforestry systems means the integration of more perennial trees and/or forestry species in crop fields. Trees require longer time cycles before harvesting. Therefore, because of growing concerns for food security and reduced cultivated agricultural land, mono-cultivation of annual crops is more attractive in economic terms for farmers to meet short term food demand. It seems that agroforestry systems are more suitable for farmers who can set aside a part of land area for agroforestry, or in the fields where fertility is limited, or they are forced or want to convert to forest plantations.

In addition, the planting of trees on farms is usually more labour-consuming than mono-copping of annual crops and therefore hinders the maintaining of agroforestry systems by farmers. During the scoping survey of the project, 'Agroforestry for livelihoods of smallholder farmers in northwestern Viet Nam', Hoang et al (2011) found that some systems such as pine trees with maize, maize/upland rice with *Teprosia candida* as boundaries in the Northwest region were labour-intensive and failed to prevent farmers from turning back to swidden farming practices.

Most agroforestry practices are small scale and innovative agroforestry systems are at quite an early stage

The review indicates that most agroforestry practices Viet Nam by research institutes, development and governmental agencies in Viet Nam are small scale and at farm level. The trials and sites were presented as technical or demonstration models, but upscaling by farmers is very limited, and difficult to sustain. This is due to either a

lack of scientific knowledge about which species suit different agro-ecological conditions, as highlighted by Simelton and Hoang (2011), or the lack of links between recent research and development initiatives in agroforestry and land use planning (Bao and Vo 2011). Even where innovative field-level agroforestry systems were adopted after the 1990s, they are still quite young in Viet Nam. A recent survey by the World Agroforestry Centre in Lao Cai province of alder-tree-based agroforestry systems highlighted that the systems (cardamom with alder and *Strobilanthes cusia* with alder) were mostly 2–6 years year old. The system was initiated by farmers with only a few households incorporating it into their farming practices at a small scale (0.2–0.3 ha). This hinders the implementation of further research due to a lack of sites for comparison.

There is a lack of specific policies at local level favourable to agroforestry research and development

The adoption of agroforestry systems involves the support of policy interventions. In Viet Nam, at national level agroforestry has been considered a measure for dealing with the problems of cultivation on sloping land. Decision 2945/QD-BNN-KL on 'Supporting farmers in upland areas for sustainable farming' from 2008–2012, targeted the conversion of 200 000 ha of rotational shifting cultivation on protected forestland to taungya agroforestry systems of food crops with fruit, industrial or forestry species. In addition, 400 000 ha of low-efficiency, cultivated, sloping land are planned for agroforestry between annual crops with industrial/fruit trees and animal production. However, at local level, there is a lack of policies favourable to agroforestry research and development. According to Hoang et al (2011), the provincial strategies in the Northwest region to 2015 are to reduce annual crop cultivation areas (for crops such as maize and upland rice) and expand the areas of

perennial trees, including coffee, rubber, tea and fast-growing timber species. This creates opportunities for larger-scale agroforestry development, but there is still lack of supporting measures and policy interventions at the local level.

Opportunities and research gaps

Opportunities for agroforestry research and development in Viet Nam

Under the existing trends in agroforestry research and development in Viet Nam and internationally, there are some opportunities for agroforestry.

First, agroforestry has been recognized by the Government of Viet Nam as a remedy for, and an alternative to, shifting cultivation. In the past, traditional agroforestry practices such as improved fallow were considered to deal with soil erosion and shortened fallow cycles. Recently, the Government has considered agroforestry, especially systems at field level, as a solution to shifting cultivation areas and low-efficiency sloping cultivation, as mentioned above. The Government's recognition of the role of agroforestry in addressing issues of shifting cultivation and low-efficiency sloping land will expand the practice's role in policy interventions.

The expansion of perennial trees (especially rubber) in the north and the implementation of reforestation programs are creating opportunities for field-level agroforestry systems. Perennial-tree-based agroforestry practices have become popular and are intensively used by farmers in the central part of Viet Nam with positive economic benefits. The recently approved Decision 750/QD-TTg promotes the expansion of 220 000 ha of rubber plantations in five ecological zones throughout the country by 2015, creating opportunities for research and development of rubber-based agroforestry systems, especially in the Northwest region where those systems are still very rarely used by farmers. In addition, the reforestation program under

Program 147[vi] will be advantageous for the development of phased field-level agroforestry systems with forestry species, such as taungya and later-phased intercropping systems, which have been popular in the last decade.

Agroforestry is now recognized in the international literature as a way to address the emerging issues of climate change, both in terms of adaptation and mitigation. It has been highlighted that agroforestry systems have the potential to store high amounts of carbon in the landscape. As noted by ASB (2011), agroforestry can reduce emissions from forest degradation by increasing on-farm timber and fuel wood production, especially where there is limited accessibility and availability of forests for those resources. In terms of climate change adaption, Nair (1992) shows that agroforestry can diversify the range of outputs from a given area and improve farmers' income, therefore reducing the risk to income from adverse climatic threats, while increasing resilience to climate change. There are other ways that agroforestry can help farmers to adapt to climate change such as controlling soil erosion and enhancing the efficiency of rain water use (Roy and Tewari 2011). Recently, climate change has been become a growing concern in Viet Nam. The national targets in response to climate change were approved by the Government in 2007, followed by action plans for each sector. By 2011, Decision 543/QD-BNN-KHCN of the Ministry of Agriculture and Rural Development (MARD) authorised the issuance of their action plan in response to climate change for the agricultural and rural development sector 2011–2015, towards 2050. The enforcement of those policies creates new opportunities for climate-smart practices which can help to mitigate and adapt to climate change, and agroforestry can be one of these alternatives.

Research gaps

In order to maximizing underlying opportunities, there are some gaps remaining in agroforestry research which need to be addressed in the near future. In addition to the research gaps mentioned below, it will be necessary to develop suitable market strategies in line with proposed agroforestry systems, as well as a supporting policy mechanism for agroforestry development at the local level.

More emphasis should be placed on the role of agroforestry in climate-change mitigation and adaptation

In Viet Nam, the role of agroforestry systems in carbon accumulation has been studied, but seems focused on a limited number of practices (Bao and Vo 2011)[vii]. Further research is needed in order to provide critical information on the contribution of different types of agroforestry practice in Viet Nam in mitigating climate change. In addition, there is limited documentation on the role of agroforestry systems for adapting to climate-change impacts at the local level. There has also been little literature on the role of traditional agroforestry practices in climate-change adaptation. Nguyen et al (2012) studied the role of home and forest gardens as a climate-change resiliency option for farmers in Viet Nam and concluded that the yield of tree-based systems with cattle were less affected by extreme drought or flood than rice and rain-fed crops (an estimated 40% of rice or rain-fed crop yield is lost in years of extreme drought or flood). Therefore, in terms of climate-change adaptation it is necessary to launch research on the role of innovative agroforestry practices popular in many parts of the country rather than traditional ones. Specifically, better information is required on the role of agroforestry in buffering against floods and droughts from both the biophysical (hydraulic lift, soil fertility) and financial (diversification, income risk) points of view (Verchot et al 2007).

There is a need to focus on the role of agroforestry in solving ongoing concerns of mono-cropping and shifting cultivation

Low-efficiency mono-cropping and shifting cultivation are critical issues in the mountains of Viet Nam. As reported by Hoang et al (2011), such issues in the Northwest region have been causing significant impacts on soil degradation and erosion, leading to a decrease in crop yield and increasing concerns for food security. The Government of Viet Nam has adopted different policy interventions in order to halt shifting cultivation and deal with the issues of mono-cropping, but they remain critical issues. The international literature has indicated that agroforestry can offer a suitable alternative to shifting cultivation and mono-cropping. Bertomeu (2003) studied smallholders' maize/timber agroforestry systems in the Philippines and concluded that the systems provided an alternative to maize mono-cropping at a 10–12% discount rate, only if timber yields are above 100 m^3/ha/year for short-rotation trees (8–9 years) and around 200 m^3/ha/year for trees with rotations of 10–15 years. Such timber yields could be realized by planting trees in widely spaced lines, like the hedgerow system tested, rather than on blocks or woodlots, because hedgerow systems promote greater diameter growth. In terms of shifting cultivation, according to Rasul and Thapa (2006), the economic returns from agroforestry (trees on crop fields) are better than from shifting cultivation in all three criteria: cost-benefit ratio, NPV, and return on labour, especially when the economic benefits of the two land-use systems are analysed by taking into account the cost of nutrient depletion arising from soil erosion.

In Viet Nam, research on the topic focuses on comparing the NPV of a limited number of agroforestry systems in comparison with shifting cultivation and mono-cropping. There is a need to focus on establishing agroforestry alternatives at the field level to improve the practice of shifting cultivation and mono-cropping. This

should analyse not only the financial aspects, but also the environmental and social costs of different scenarios. Moreover, additional research is required to quantify the benefits to various stakeholders, to deal with the variability in benefits, to assess the effects and trade-offs of different policies, and to examine the impact of agroforestry practices on forest protection (FAO 2005).

Techniques and species to be recommended for agroforestry in each region, with a consideration of local ecological knowledge

There are large differences among tree species and their response to different environments and conditions. These factors will determine the results of interaction between the different components of the systems (such as between crops and trees) and how the systems will develop (Muschler and Bonnemann 1997). Therefore, agroforestry-forestry systems are generally site-specific.

In Viet Nam, agroforestry systems are variously established by development, research, government organizations and farmers. However, the systems are small scale, at only farm or plot level in some parts of the country. A specific approach for agroforestry systems suitable for each region is lacking, especially innovative agroforestry systems at the field level. It is necessary to develop a list of trees and crops which can be integrated in respective agroforestry systems in each agro-ecological region throughout the country. The integration of local ecological knowledge of indigenous species and existing agroforestry practices is needed, taking into account the issue of climate change, shifting cultivation and mono-cropping in each region. In addition, more focus should be put on studying methods for designing and structuring those systems. The outputs will serve as a scientific basis for land-use planning and policy interventions for the development of agroforestry at the local level. During the ongoing trend of reforestation, while the taungya systems in early

stage forestry species were well developed and researched, there is a need to focus on agroforestry combinations at later stages (for example from year 4). This will be necessary for providing additional incomes for farmers while they are waiting to harvest forest, or even give them the option to maintain forests.

Conclusion

In summary, agroforestry research and development in Viet Nam has achieved some successes. Starting as a traditional practice at the landscape level, more innovative systems at the field level have been adopted such as phased-intercropping systems between trees and crops, and alleying practices. The adoption of agroforestry systems is aligned with government efforts to encourage reforestation and deal with shifting cultivation. In addition, the interventions of research and development organizations have played an important role in the evolution of agroforestry in Viet Nam.

However, the research and development of agroforestry has yet to address many issues and challenges. Lack of links with potential markets, low economic appeal to farmers, development at small scale, and limited policy measures at the local level have hindered further research and development. Currently, recognition by the national government, the expansion of perennial tree plantations and growing concerns about climate change in Viet Nam are opening opportunities for agroforestry, especially in responding to climate change, shifting cultivation and improving local livelihoods. Putting more effort into researching agroforestry systems, especially with consideration of local ecological knowledge, designing techniques, and the role of those systems in solving the issues of climate change and shifting cultivation, could be an important outcome of more systematic research and development of agroforestry in Viet Nam.

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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.
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 policies.
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.
35. Report of African regional workshop on compensation ecosystem services.
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
38. The conditions for effective mechanisms of compensation and rewards for environmental services.
39. Organization and governance for fostering Pro-Poor Compensation for Environmental Services.
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.
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.
60. Kajian Kondisi Hidrologis DAS Kapuas Hulu, Kabupaten Kapuas Hulu, Kalimantan Barat.
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 shared 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. Towards mainstreaming climate change in grassland management policies and practices on the Tibetan Plateau
68. An Assessment of the Potential for Carbon Finance in Rangelands
69 ECA Trade-offs Among Ecosystem Services in the Lake Victoria Basin.
69. The last remnants of mega biodiversity in West Java and Banten: an in-depth exploration of RaTA (Rapid Land Tenure Assessment) in Mount Halimun-Salak National Park Indonesia

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 economic 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 capacity toward region-wide curriculum and teaching materials development in agroforestry education in Southeast Asia
92. Overview of biomass energy technology in rural Yunnan (Chinese – English abstract)

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

2010

96. Agroforestry education in the Philippines: status report from the Southeast Asian Network for Agroforestry Education (SEANAFE)
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
103. Landscape dynamics over time and space from ecological perspective
104. Komoditisasi atau koinvestasi jasa lingkungan: skema imbal jasa lingkungan program peduli sungai di DAS Way Besai, Lampung, Indonesia
105. Improving smallholders' rubber quality in Lubuk Beringin, Bungo district, Jambi province, Indonesia: an initial analysis of the financial and social benefits
106. Rapid Carbon Stock Appraisal (RACSA) in Kalahan, Nueva Vizcaya, Philippines
107. Tree domestication by ICRAF and partners in the Peruvian Amazon: lessons learned and future prospects in the domain of the Amazon Initiative eco-regional program
108. Memorias del Taller Nacional: "Iniciativas para Reducir la Deforestación en la region Andino - Amazónica", 09 de Abril del 2010. Proyecto REALU Peru
109. Percepciones sobre la Equidad y Eficiencia en la cadena de valor de REDD en Perú – Reporte de Talleres en Ucayali, San Martín y Loreto, 2009. Proyecto REALU-Perú.
110. Reducción de emisiones de todos los Usos del Suelo. Reporte del Proyecto REALU Perú Fase 1
111. Programa Alternativas a la Tumba-y-Quema (ASB) en el Perú. Informe Resumen y Síntesis de la Fase II. 2da. versión revisada
112. Estudio de las cadenas de abastecimiento de germoplasma forestal en la amazonía Boliviana
113. Biodiesel in the Amazon
114. Estudio de mercado de semillas forestales en la amazonía Colombiana
115. Estudio de las cadenas de abastecimiento de germoplasma forestal en Ecuador

116. How can systems thinking, social capital and social network analysis help programs achieve impact at scale?
117. Energy policies, forests and local communities in the Ucayali Region, Peruvian Amazon
118. NTFPs as a Source of Livelihood Diversification for Local Communities in the Batang Toru Orangutan Conservation Program
119. Studi Biodiversitas: Apakah agroforestry mampu mengkonservasi keanekaragaman hayati di DAS Konto?
120. Estimasi Karbon Tersimpan di Lahan-lahan Pertanian di DAS Konto, Jawa Timur
121. Implementasi Kaji Cepat Hidrologi (RHA) di Hulu DAS Brantas, Jawa Timur.
122. Kaji Cepat Hidrologi di Daerah Aliran Sungai Krueng Peusangan, NAD,Sumatra
123. A Study of Rapid Hydrological Appraisal in the Krueng Peusangan Watershed, NAD, Sumatra.

2011

124. An Assessment of farm timber value chains in Mt Kenya area, Kenya
125. A Comparative financial analysis of current land use systems and implications for the adoption of improved agroforestry in the East Usambaras, Tanzania
126. Agricultural monitoring and evaluation systems
127. Challenges and opportunities for collaborative landscape governance in the East Usambara Mountains, Tanzania
128. Transforming Knowledge to Enhance Integrated Natural Resource Management Research, Development and Advocacy in the Highlands of Eastern Africa
129. Carbon-forestry projects in the Philippines: potential and challenges The Mt Kitanglad Range forest-carbon development
130. Carbon forestry projects in the Philippines: potential and challenges. The Arakan Forest Corridor forest-carbon project
131. Carbon-forestry projects in the Philippines: potential and challenges. The Laguna Lake Development Authority's forest-carbon development project
132. Carbon-forestry projects in the Philippines: potential and challenges. The Quirino forest-carbon development project in Sierra Madre Biodiversity Corridor
133. Carbon-forestry projects in the Philippines: potential and challenges. The Ikalahan ancestral domain forest-carbon development
134. The Importance of Local Traditional Institutions in the Management of Natural Resources in the Highlands of Eastern Africa
135. Socio-economic assessment of irrigation pilot projects in Rwanda
136. Performance of three rambutan varieties*(Nephelium lappaceum* L.*)* on various nursery media
137. Climate change adaptation and social protection in agroforestry systems: enhancing adaptive capacity and minimizing risk of drought in Zambia and Honduras

138. Does value chain development contribute to rural poverty reduction? Evidence of asset building by smallholder coffee producers in Nicaragua
139. Potential for biofuel feedstock in Kenya
140. Impact of fertilizer trees on maize production and food security in six districts of Malawi.

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141. Fortalecimiento de capacidades para la gestión del Santuario Nacional Pampa Hermosa: Construyendo las bases para un manejo adaptativo para el desarrollo local. Memorias del Proyect
142. Understanding rural institutional strengthening: A cross-level policy and institutional framework for sustainable development in Kenya
143. Climate change vulnerability of agroforestry
144. Rapid assesment of the inner Niger delta of Mali
145. Designing an incentive program to reduce on-farm deforestationin the East Usambara Mountains, Tanzania
146. Extent of adoption of conservation agriculture and agroforestry in Africa: the case of Tanzania, Kenya, Ghana, and Zambia
147. Policy incentives for scaling up conservation agriculture with trees in Africa: the case of Tanzania, Kenya, Ghana and Zambia
148. Commoditized or co-invested environmental services? Rewards for environmental services scheme: River Care program Way Besai watershed, Lampung, Indonesia.
149. Assessment of the headwaters of the Blue Nile in Ethiopia.
150. Assessment of the uThukela Watershed, Kwazaulu.
151. Assessment of the Oum Zessar Watershed of Tunisia.
152. Assessment of the Ruwenzori Mountains in Uganda.

Endnotes

[i] As defined by the World Agroforestry Centre (ICRAF 2009), ***field agroforestry practices*** focus on the role of trees within specific fields or plots of land where discrete groups of tree, animal and/or crop components are managed together, such as complex agroforest gardens, integrated tree-crop systems; ***farm agroforestry systems*** focus on the role of trees in overall farm management of mainly smallholders' households, such as fallow systems and woodlots; while ***landscape agroforestry*** focuses on patterns, processes and interactions that emerge from combinations of farm-level agroforestry systems present in larger natural resource management units.

[ii] A feasibility field trip was organized by the World Agroforestry Centre Viet Nam to Lao Cai province in July 2012 to assess the potential for studies on interactions among different components in alder-based agroforestry systems.

[iii] [NOMAFSI] Northern Mountainous Agriculture and Forestry Science Institute. 2009. *Các hệ thống nông lâm kết hợp với cao su Dem lại lợi ích kinh tế.* Agroforestry systems with rubber for economic benefits*.* A brief summary prepared for personal discussion with ICRAF Viet Nam.

[iv] NOMAFSI (2009) (ibid)

[v] The research was contracted by the World Agroforestry Centre Viet Nam to be carried out by Forestry Science Institute of Viet Nam in 2011, on the NPV assessment of land-use types in Bac Kan province, as a part of the 'Reduced Emissions from All Land Uses' (REALU) project.

[vi] Decision 147/2007/QD-TTg on the development of protection forests during 2007–2015, approved by the Prime Minister on 10/9/2007.

[vii] Bao and Vo (2011) estimated that the absorption of CO_2 in lisea and cassava agroforestry system was 24.7 ton per ha in 5 years.

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.

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