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Cultivating resilience
an investigation of agricultural rehabilitation after the 2004 tsunami in Sri Lanka

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CULTIVATING RESILIENCE: AN INVESTIGATION OF AGRICULTURAL REHABILITATION AFTER THE 2004 TSUNAMI IN SRI LANKA

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CULTIVATING RESILIENCE: AN INVESTIGATION OF AGRICULTURAL REHABILITATION AFTER THE 2004 TSUNAMI IN SRI LANKA

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Abstract

Disasters have a significant impact on agriculture, particularly in lower income countries where agriculture is a primary livelihood and important source of food for many people. This thesis is based on research which set out to identify factors that contribute to the resilience of homestead garden systems – their capacity to withstand or recover from a disturbance. The study was carried out in three districts of Sri Lanka following the 2004 Indian Ocean Tsunami.

The field research focussed on homestead garden cultivation in Matara, Hambantota and Ampara districts. The approach included interviews with growers, a plot walk where possible, and interviews and discussion with organisations working on post-tsunami agricultural rehabilitation. Although the original aim of the research was to focus on the impact of agronomic practices on resilience, many of the results indicated the importance of wider livelihood, social and political issues.

Four key themes were identified. Firstly agro-ecological practices, such as integrated crops and living fences, were important to the resistance of the homestead gardens to the impact of the wave. Secondly, a diversity of livelihood options contributed to the resilience of whole household systems by providing a back-up income. Human capacities, on both individual and community levels, were also fundamental to households' ability to recover following the disaster. Finally, processes of policy and development bore an overarching impact on many different aspects of the resilience of households surveyed.

The research approach was found to have a significant impact on the results and their emphasis on the impact of broader social and political aspects on the resilience of homestead garden systems. The findings and research experience highlight both the challenges of carrying out cross-disciplinary research, and the importance of such approaches to explore the wider contexts of resilience.

The research found that agroecological approaches did enhance the resilience of homestead growers, although there was a level of impact above which recovery was not helped by the approach to cultivation. Tree and shrub cover stabilised the soil and broke the force of the water, reducing the impact on the cultivated area and infrastructure. Many trees also survived the Tsunami and enabled growers to gain an income. Diverse livelihoods, with income options such

as agro-processing or non-farm work were also found to contribute to the resilience of homestead garden households, providing an alternative income when cultivation was not possible. Community support through family and community networks was also found to be central to the recovery of many households. National and international approaches to development were found to have a significant impact on the resilience of households, in terms of its influence on agronomic practices, natural resource management, and the economic viability of homestead cultivation.

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1 The research question and context of the tsunami in Sri Lanka

1.1 Introduction and aims of this study

As global social, political and environmental climates are changing, with rising urbanisation, environmental degradation and national and international conflicts, the impact of natural and complex man-made disasters is increasing in terms of loss of life, impact on livelihoods and economic losses. Disasters are increasing in scale, incidence and complexity, disproportionately impacting populations in lower income countries where there are limited resources with which to manage and recover from disasters (DFID, 2003; Palakudiyil & Todd, 2003). This is felt most severely in lower income countries where there are less resources, infrastructure and capacity to prepare for and manage disasters. The past two decades have seen an increase in spending on post-disaster relief aid and resultant decrease in spending on development aid. For example in 1989, 70 percent of the World Food Programmes' resources went towards development aid and 30 percent towards relief, however by 1996 this had shifted to 70 percent of resources going to relief and only 30 percent on development programmes (WFP, 1998). A disaster can set back years of development, damaging infrastructure, facilities and services and causing loss of life, livelihoods and displacement. However inappropriate development, such as deforestation or construction in hazard prone areas, can actually make communities more vulnerable to the impacts of disasters (Adger & Brooks, 2003; Anderson & Woodrow, 1989; Bankhoff *et al*, 2007; Thomalla *et al,* 2006; Twigg & Steiner, 2002).

The agriculture sector can be severely affected by disasters, and particularly in lower income countries where agriculture is frequently the primary livelihood for the majority of people (Das, 2005; Desanker, & Magadza, 2001; Gomez, 2005) . Agriculture can be affected in many ways, through the destruction of crops, soil fertility, infrastructure, inputs, land and knowledge. The investigation of factors that contribute to agricultural resilience is a relatively new field, resilience being the capacity of the system to withstand or recover from a disturbance. However the identification and development of approaches to improving the resilience of agriculture to disasters is an increasing priority for many organisations working in relief and development. The disaster management sector has conventionally focussed on immediate relief activities and meeting short-term need, although it has become apparent that such interventions can, at best, provide only a sticking plaster over a much larger problem, and worse, can increase vulnerability in the longer-term. Around this a discourse has evolved on linking relief, rehabilitation and development (LRRD). In the context of escalating human and financial costs of disasters, disaster management actors are looking more at the longer-term impacts of interventions and identifying means to build resilience to future disturbances, as well as meeting immediate needs (de Armiño, 2002; Buchanan-Smith & Fabbri, 2005; Christoplos *et al*, 2004; Eberdt, 2003 .

The question that this research addresses is which characteristics of agricultural systems contribute to or undermine their resilience to disasters. The overall goal is to contribute to the expanding understanding of resilience to disasters. This study has approached the question by identifying features of agricultural resilience using the case of homestead gardens in Sri Lanka following impacted by the 2004 Indian Ocean Tsunami. This study has two main objectives:

i) To investigate, through the example of homestead gardens in Sri Lanka affected by the tsunami, conditions impacting the resilience of agriculture to disasters.

ii) To consider the potential wider applications of this analysis for agricultural development and rehabilitation approaches that build resilience as well as meet immediate needs.

The primary research was carried out in Sri Lanka in mid 2005 in areas affected by the Indian Ocean Tsunami of 26th December 2004. Sri Lanka was one of the countries worst affected by the tsunami, both proportional to its size, and in absolute terms, with the impact felt in different coastal agro-ecological and socio-political zones. Household and focus group interviews were held with homestead growers affected by the tsunami and interviews were held with government organisations and NGOs working on agricultural rehabilitation and development. Additional information was gathered through further discussion, email contact and grey literature.

This report details the findings of the study. This introductory chapter outlines the agro-ecological systems in Sri Lanka, including a description of homestead garden systems. It then gives details of the impact of the tsunami on agriculture. Chapter 2 sets out the theoretical framework of the research based on resilience theory. Chapter 3 looks specifically at agricultural resilience and broader issues affecting agricultural systems.. Chapter 4 describes the research methodology. Chapter 5 details the four key themes relating to the resilience of homestead gardens that came out of this survey. Chapter 6 looks at this research in the wider context of research and policy on agriculture and resilience.

1.2 Agriculture and disasters

Disasters can impact all aspects of affected populations, including the agricultural sector and the ability of communities to produce or access food. As the majority of the population of LEDCs live in rural areas and around 85% of these are directly or indirectly dependent on agriculture for their livelihoods (FAO, 2001), disasters can affect not only the availability of food, but also the incomes of many people through production, processing, distribution, and marketing, disruption of input supply, and formal and informal networks. Given the broad importance of agricultural systems the impact of disasters on agricultural systems can have wide implications for food security, other natural resources such as wood, fibre and medicinal herbs household income, labour availability and environmental management.

Different types of disasters have many different impacts on agriculture including loss of crops; loss of assets and inputs; soil erosion; damage to infrastructure including roads, processing plants and irrigation systems; disruption to markets; loss of land; and loss of human capacity, for instance through mortality, disability or emotional impacts (Sivakumar *et al*, 2005).

1.3 Sri Lanka: the agricultural context

1.3.1 Climate and topography

Sri Lanka is a tropical country lying 8-10 degrees north of the equator in the Indian Ocean. There is significant climatic variation across the country due to differences in rainfall, elevation and soil types. There are three major agro-ecological zones as shown on Figure 1.3.1. The wet zone covers the south-west coast, the intermediate zone covers the central highland areas, and the dry zone covers the south-east and east coast and most of the north of the country. There are two main wet seasons in Sri Lanka; Maha, which brings rainfall over the country between October and February; and Yala, which brings additional rain from March to August in the southern and western regions. There is some irrigated agricultural production in the dry season with water drawn from wells, canals and rivers, but this is only used on a large scale for valuable cash crops, although many homestead gardens in the area had some form of irrigation (Helvetas, 2001, US Federal Research Division, 1986).

The mountain zone is in the central southern region of the country and is up to 1200m above sea level. Almost three-quarters of the country, around the coast and in the north and east, is lowland. Temperature decreases with increase in altitude, average temperatures in the highlands being 13-16°C, occasionally dropping to zero at night, and temperature in the lowlands averaging 27°in the wet zone and 30°C in the dry zone (Helvetas, 2001, US Federal Research Division, 1986).

1.3.2 Agriculture in Sri Lanka

Agriculture is the basis of the Sri Lankan economy with agricultural production and related industries representing around 20% of the GDP, although its share is gradually decreasing as a result of economic diversification. 30% of the total land area of Sri Lanka is put to agricultural uses, about three quarters of the population live in rural areas, 65% of rural families secure their livelihood from agriculture and about 35% of the nation’s total workforce is involved in agriculture, forestry and fisheries. The majority of agriculture is small-scale, with 80% of land under agriculture being holdings of less than 8 hectares. Two thirds of the agricultural land is used for homestead gardens with the average holding size in the small-holding sector being less than 1 hectare. Another form of small-scale agriculture carried out in Sri Lanka is *chena*, or slash-and-burn, where growers clear fell areas of forest and cultivate until the land is no longer fertile (FAO, 2006; US Federal Research Division, 1986, Ranasinghe).

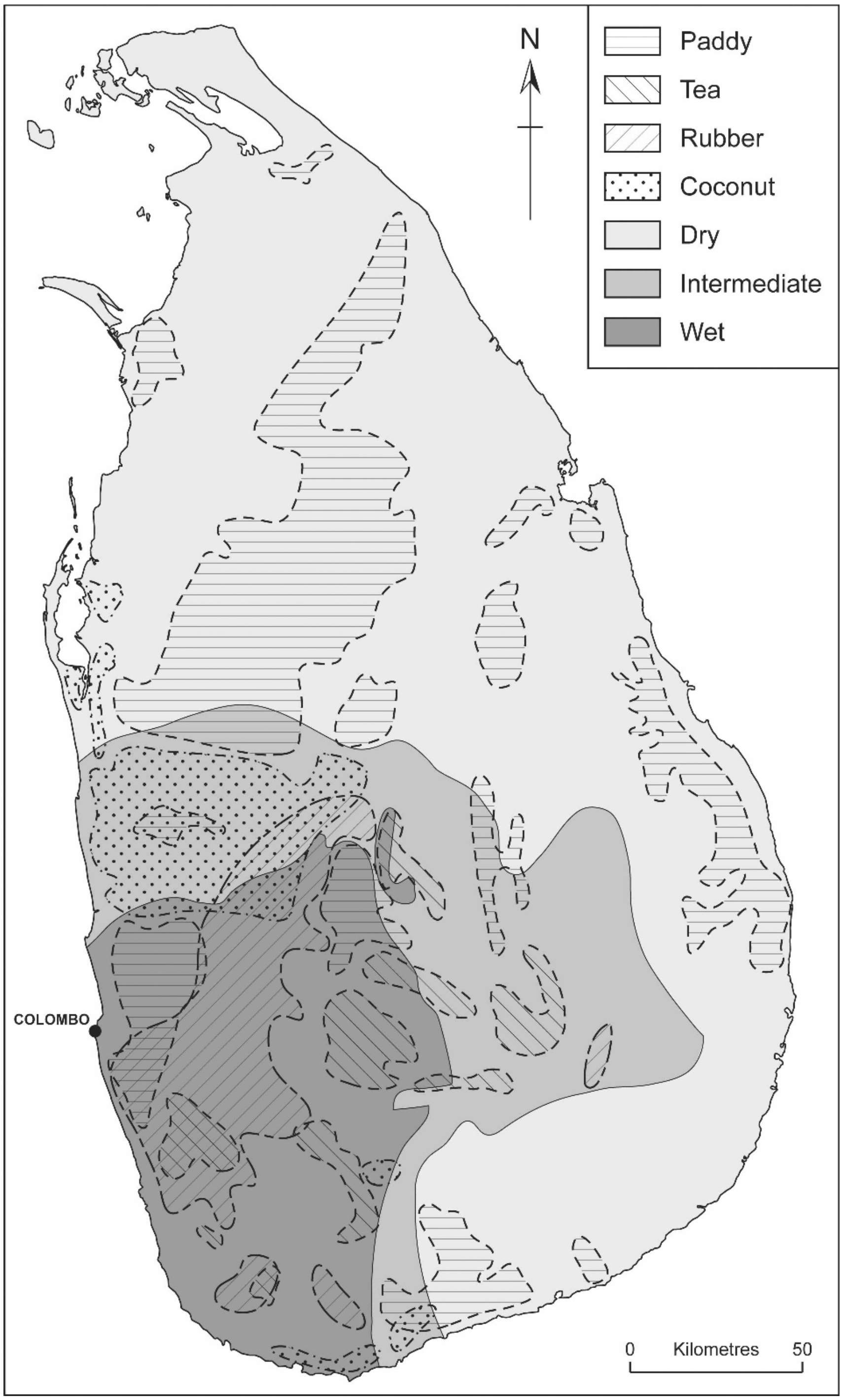


Figure 1.3.1 Map of agro-ecological zones and land use in Sri Lanka
(adapted with kind permission from the Survey Department of Sri Lanka)

The main agricultural items produced are rice for domestic consumption, coconuts for domestic consumption and export, and tea and rubber primarily for export. During the colonial period much land was sold to private landowners in order to stimulate export production, primarily tea, coffee and rubber. Sri Lanka is a net exporter of agricultural products, which make up about 24% of export income. Since the country gained independence in 1948, much development work has been focused on the production of food crops through the cultivation of unutilised land by irrigation and multi purpose projects. The increase in the area under cultivation from 1948 to 2002 is 1.7 million hectares to 2 million hectares. The most significant change since independence has been the increase in rice production due to better yields and increase in land under cultivation due to irrigation. In recent years, food imports have decreased significantly owing to improved national self-sufficiency for food (FAO, 2006; US Federal Research Division, 1986).

A wide range of other fruit, vegetables and spices are cultivated primarily for domestic consumption, although there are exports of some fruit and spice products. Temperate vegetables such as carrots, onions, leeks and cabbages are grown in the central uplands of the country. Tropical vegetables and fruit such as gourds, chillies, pumpkins, amaranth, tomatoes, okra, beans, corn, mangoes, pineapples, papaya, leafy vegetables; and spices such as cinnamon, cloves, cardamom, pepper and nutmeg, are grown in the lower lying land (Helvetas, 2001; Ranasinghe; US Federal Research Division, 1986).

In terms of economic development there is significant disparity between the south-western and central regions and the east and north, the latter having been the centre of ongoing civil conflict in Sri Lanka, between the Tamil independence movement (LTTE) and the government. The east and north have significantly lower levels of infrastructure and poor access to healthcare and education. In addition many households have been displaced due to the conflict. Before the tsunami, International NGO (INGO) presence in the country was primarily found in the conflict affected areas of the North and East, working in multiple sectors including conflict prevention, education and health as well as agriculture projects. Outside the conflict-affected areas, there was only a small presence of INGOs, primarily in Hambantota district, one of the poorest in the country, having limited natural resources, severe drought problems and limited infrastructure (US Federal Research Division, 1986).

The bulk of commercial agricultural production, around 75%, occurs in the wet and intermediate zones of Sri Lanka, with tea and intensive vegetable production in the central hill country and most coconut production in the central western region of the country. There is nonetheless some commercial production in the dry zone, which has increased with irrigation, including paddy cultivation, coconut plantations and some vegetable cultivation. Most agriculture at all scales uses some level of synthetic inputs such as pesticides and fertilisers (FAO, 2006; US Federal Research Division, 1986). However soil fertility is decreasing and with it yields and profits (unpublished comment, 2005).

Government support for farmers includes the provision of credit, the setting of minimum prices for agricultural produce and the construction of irrigation systems. Much of this has been through the support of local farmers cooperatives. Short and medium-term loans for the purchase of seeds and fertilisers and small machinery are available to individual farmers, whereas longer-term loans for larger investments such as infrastructure, storage or milling facilities are available to cooperatives. The government also subsidises inputs such as fertiliser and seeds and has specifically aimed to promote the adoption of higher-yielding varieties promoted in the 1960s and 70s (US Federal Research Division, 1986).

1.4 Homestead gardens

As in most lower income countries there is a long tradition of homestead gardens in Sri Lanka, producing a diverse range of products such as staple food, vegetables, fruit, spices, fuel wood, fodder, timber, medicinal plants and sometimes small livestock. The structures and functions of homestead gardens vary depending on ecological, cultural and economic factors. The products from homestead gardens are usually for home consumption, but are also frequently for additional income. Such livelihood systems often include additional incomes based on the garden for example processing products such as fruit, medicinal herbs or non-timber wood products. There are multiple interactions in homestead garden systems in terms of ‘inputs’ from human, social, capital and natural resources, the impact of national and international policy on these, and the outputs such as food, non-food products, nutrition and environmental impacts. Figure 1.4a below illustrates some of the interactions of a typical household scale agricultural system (Helvetas, 2001, Weerakoon *et al,* 2005).

The typical homestead garden is an agroforestry system characterised by several horizontal layers of production with a high diversity of perennial and annual crops. Studies have found a total of 227 species in homestead gardens, typically including tree crops such as coconuts, mangoes, papaya, jackfruit, rambutan, Kitul palm *(Caryota urens),* citrus and breadfruit, and vegetable crops such as tomato, okra, aubergine, leafy vegetables, squash and beans. There are also occasionally livestock. It is estimated that about 1 million hectares of the Sri Lanka is used for different forms of homestead gardens (Helvetas, 2001; Ranasinghe; Weerakoon *et al*).

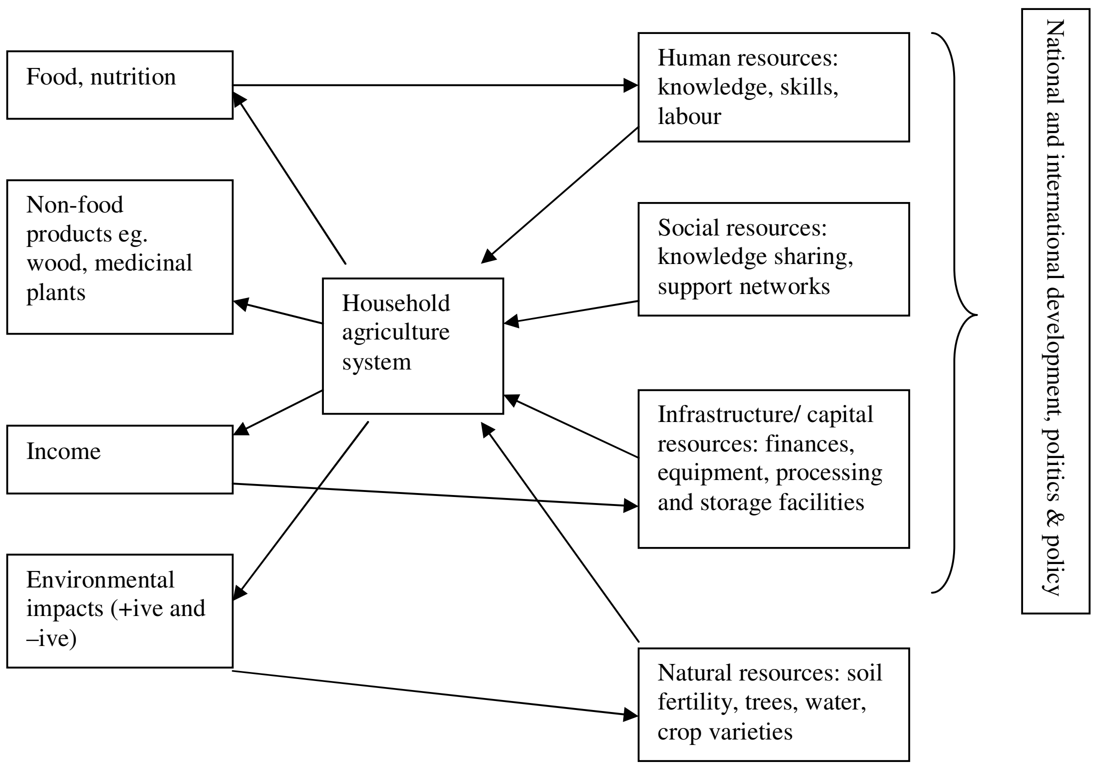


Figure 1.4a Interactions in a household agriculture system

Living fences of species such as *Gliricidia sepium* and kapok *(Bombax malabaricum*) are widely used. The leguminous tree *Leucaena leucocephala* also grows profusely in the dry-zone homegardens, increasing soil fertility and providing food and fodder. Other edible fast growing tree species such as the 'drumstick' tree, known as murunga (*Moringa oleifera)* and *Sesbania grandiflora* are also grown as fences and for food. Murunga has delicious, nutritious pods which are used in cooking, and the bark of the tree is medicinal. The leaves and flowers of *Sesbania grandiflora* can be used as vegetables and the tree is also an important source of green manure and fodder (Ranasinghe).

All members of the household typically share the development and maintenance of a garden. Much of the arrangement of homestead gardens is unplanned, with many plants growing spontaneously, but still being used by the household. However some areas are cultivated for specific crops. For example higher value vegetables are often cultivated in open areas, and crops with a high water requirement planted by the well. Although homestead gardens are fundamental to the lives of many households, there is little attention paid to them by the research and extension systems. With most labour carried out by the household there are potentially low operating costs, and the potential to be quite profitable, although the purchase of chemical inputs, which is common, can add a significant expense. With improved management, such as spacing, soil fertility improvement, thinning and the selection of genetically superior crops, the system has the potential for a continuous high level of production and high returns. Figure 1.4b shows a typical homestead garden cultivation system (Helvetas, 2001; Ranasinghe; Weerakoon *et al,*).

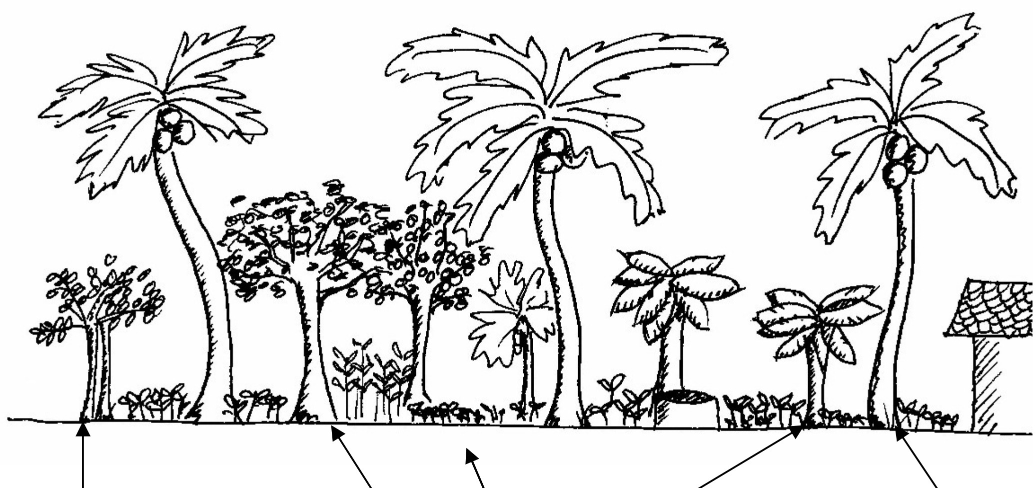


Figure 1.4b Typical homestead garden cultivation system

1.5 The impacts of the tsunami on agriculture in Sri Lanka

The Indian Ocean Tsunami of the 26th December 2004, caused by a sub-ocean earthquake measuring between 9.1 and 9.3 on the Richter scale, affected ten countries. Sri Lanka was one of the worst affected countries, both in terms of absolute numbers of fatalities, and relative to its size, it being a small island. 68% of the coastline was hit, 1200km, causing over 35,000 fatalities, displacing over 500,000 people, and affecting over 212,000 coastal families. Figure 1.5 shows the numbers of people affected in different districts. The impact on infrastructure and livelihoods was equally severe, with many homes, hospitals, schools, roads and bridges destroyed. In the affected areas nine out of ten income earning men and women lost their source of livelihood (Cossée *et al*, 2006; UNEP, 2005).

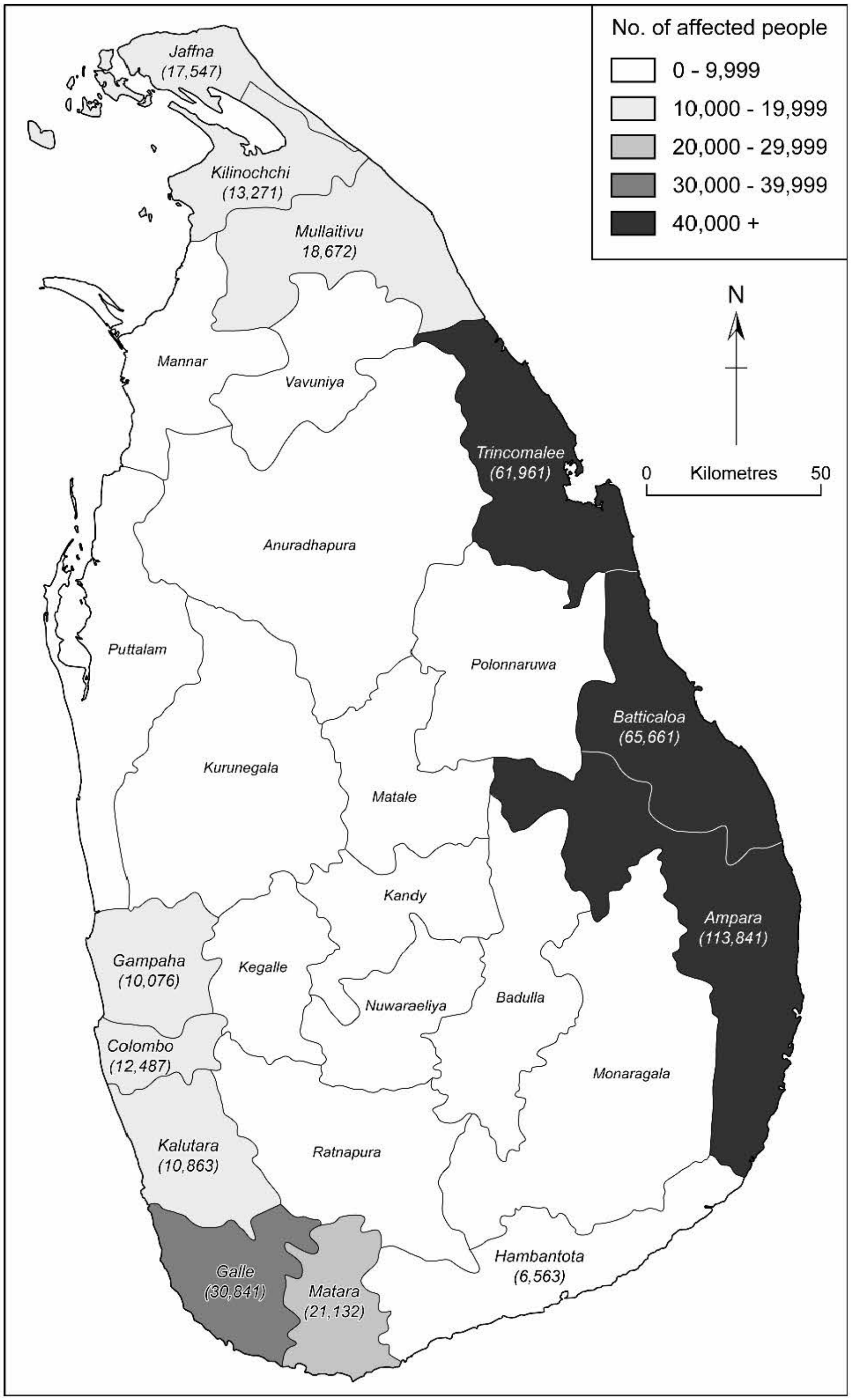


Figure 1.5 Map showing numbers of people affected by the 2004 tsunami in districts of Sri Lanka
(adapted with kind permission from the Survey Department of Sri Lanka)

Fisheries were the most severely affected livelihood sector with over half of the total fishing fleet in Sri Lanka destroyed. Although less widely covered by the media, agriculture was the second worst affected sector. Whilst the coastal areas are not Sri Lanka's most important for agricultural production, agriculture is a very significant part of the livelihoods of many coastal dwellers. Seawater came 2-3 kilometres inland, flooding about 9,670 ha of agricultural lands and home-gardens, causing estimated UD$3.5 million worth of damage, and affecting around 8000 farming families and an estimated 27, 710 home gardens (Cossée *et al*, 2006, FAO; 2005).

The tsunami had many short and long term impacts on agriculture. Inundated ground crops were invariably destroyed, either being washed away, or dying later from the increase in salinity. Many trees were uprooted and, of those that were not, most species were killed or badly damaged by the salt inundation. A study on the impact of the tsunami on home garden vegetation identified the causes of different types of damage on upper storey and ground crops as shown in Table 1.5a.

Table 1.5a Impacts of the tsunami on home garden vegetation
(adapted from Hitinayake, 2005)

Damage	Cause of damage or survival	
	Upper & under storey	**Ground vegetation**
Complete or partial uprooting or breaking of stems	Force of waves	Force of waves
Death of plants	Salinity in top soil & ground water	Inundation of salt water and/or deposition of sand and rubble
Not affected or recovery after defoliation	Plants tolerant to salinity	Plants tolerant to salinity with strong underground stems

All inundated land was contaminated with salt, and this was initially considered to be one of the most significant longer-term problems. However the scale of the problem varied greatly between regions. Areas with well draining soil and which had had high rainfall and flooding shortly after the tsunami were leached clear in a short period, whilst areas with low drainage or rainfall remained salt contaminated. The salinisation of groundwater for irrigation was also a problem in some areas depending on the water table depth and rock formation. Table 1.5b below shows the estimated time scale for reclaiming land for cultivation in different agro-ecological zones of Sri Lanka depending on the rainfall and soil type and if irrigation is possible.

Soil fertility was also affected. In many places the fertile thin topsoil layer was washed away, and in some locations the topsoil was buried under a layer of sand. It was suggested that farmers would need to apply sufficient organic manure and fertilisers in order to be able to obtain maximum potential yields. However, there was a risk of over-fertilisation which would increase the soluble salt content in the soil. It was particularly noted that the application of organic matter and manure would also help to improve and maintain soil structure, in the more loamy soils, and this way aid leaching of salts (Kielen, 2005).

Other damage to agricultural systems included destruction of fencing, damage or loss of irrigation pumps and hoses, sprayers, hand tools, inputs such as seed and fertiliser, processing equipment, and infrastructure such as sheds and barns, and livestock (FAO, 2005; GMSL, 2005; Kielen, 2005).

1.6 Beginning the investigation

This chapter set the scene for this research on agronomic resilience and rehabilitation, based on post-tsunami Sri Lanka. All agriculture is fundamental to life and livelihoods in Sri Lanka, and homestead gardens are a vital source of income and nutrition for many rural and peri-urban household. The tsunami had a significant impact on this sector. This study aims to investigate the features of homestead garden systems that impact their resilience. The objectives to answer the question are:

i) To investigate, through the example of homestead gardens in Sri Lanka affected by the tsunami, conditions impacting the resilience of agriculture to disasters.

ii) To consider the potential wider applications of this analysis for agricultural development and rehabilitation approaches that build resilience as well as meet immediate needs.

The next chapter looks at the theoretical context of resilience.

Table 1.5b Estimated time scale for reclaiming land for cultivation in different agroecological zones in Sri Lanka

(adapted from Kielen, 2005)

Climatic zone	**Rainfall mm**	**Districts**	**Soils**	**Crops**	**Growing season**	**Irrigation**	**Drainage**	**Reclaim-ability**	**Time estimate**
Wet	>2400	Kaluthara, Galle	Sand to sandy loam	Vegetable, OFC, fruit	Maha & Yala	Rainfall & irrigated	Good internal	Easy	Ready for planting
			Sandy clay to clay	Paddy	Maha & Yala	Mainly rainfed	Good surface	Easy	<1 season
Inter-mediate	>1100-1400	Matara	Sand to sandy loam	Vegetable, OFC, fruit	Maha & Yala	Rainfall & irrigated	Good internal	Easy	<1 season
			Sandy clay to clay	Paddy	Maha & Yala	Mainly rainfed	Good surface	Easy	<1 season
Dry	>900-1300	Ampara, Batticaloa, Trincomalee	Sand to sandy loam	Vegetable, OFC, fruit	Maha & Yala	Rainfall & irrigated	Good internal	Easy	<1 year
			Sandy clay to clay	Paddy	Maha	Rainfed	Good, medium to poor	Easy, medium	1 to 2 years
					(Maha) and Yala	Irrigated	Good surface	Easy	<1 irrigation season
	>800	Hambantota, Mulativu, Jaffna	Sand to sandy loam	Vegetable, OFC, fruit	Maha	Rainfall & irrigated	Good internal	Medium	1-2 years
			Sandy clay to clay	Paddy	(Maha) & Yala	Irrigated	Good surface	Easy	<1 irrigation season
						Rainfed	Medium to poor	Medium, difficult	>1 year

2 Managing for resilience

2.1 Introduction

The term 'resilience' is used widely in many different disciplines from engineering to psychology to ecology. This chapter looks at some of the key theories of resilience and defines them as they are used in this research, based on ecological resilience. The chapter goes on to look at the linked issues that are significant in this study, including sustainable development and managing systems for improved resilience.

2.2 Resilience

In the dynamic world, systems are constantly subjected to changes and pressures that impact upon their component parts. Systems are defined as a group of components or entities that form an integrated whole, which can be distinguished by their component parts and by their overall functions. In relation to social and ecological systems the use of the term 'resilience' is largely based on the work of Holling from the early 1970s onwards. Holling's definitions are originally based on his research on ecological populations, which led to a landmark paper on the resilience of non-linear ecological systems. This formed the basis for his, and many others, further research into resilience in social and socio-ecological systems. According to Holling's definition, resilience is based on a systems' capacity to maintain its overall functions following a disturbance, rather than the stability of component parts or its ability to maintain a steady state or equilibrium (Holling, 1973, 1996a & 1996b). This definition contrasts resilience to stability, which refers to the specific ecological state, including species composition and component populations, rather than the overall functions of the ecosystem. Research by May, also in the early 1970s, found that *stability* is greater in simple systems, with few interactions and low diversity of components (May; 1972 & 1973). Other studies (see for example Holling; 1986 and Jansen & Kokkoris; 2003) find that whilst stability decreases with complexity, resilience increases with complexity, and varies according to the number and strength of interactions within the system.

Resilience is a measure of the amount of disturbance that a system is able to absorb and to still maintain or return to its key functions. Natural systems are able to undergo a certain amount of change, whilst keeping their overall functions and processes in a state of dynamic equilibrium. A disturbance which is beyond the capacity of a system to absorb it will cause a complete change in the system and its functions (Schoon, 2005; Walker *et al*, 2002). Holling (1986) defines resilience as "the ability of a system to maintain its structure and patterns of behaviour in the face of disturbance" (p296). A more recent broad definition from the Resilience Alliance, a research group founded by Holling, defines resilience as "the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes" (Resilience

Alliance, 2007). Both definitions emphasise the overall set of processes of the ecosystem as the defining feature, as opposed to the specific component parts.

A different use of the term resilience is given by Pimm (1984), who defines a 'system' by its component parts in a steady state of equilibrium, with resilience as the measure of speed of a system's return to equilibrium following a disturbance. According to Holling, Pimm's definition is more closely related to "stability" and Holling (1996a) contests Pimm's definition in relation to ecological systems. He terms Pimm's approach 'engineering resilience', and maintains that, as ecological systems are dynamic and unstable by nature, their resilience relates to their capacity to absorb disturbance and maintain their overall functions as opposed to their specific state and component parts that Pimm infers(Holling, 1996a; Schoon, 2005). Holt-Gimenez (2002), who is widely cited in this study, bases his use of the term resilience on Pimm's definition, using the term 'resistance', to describe the "ability of a …system to resist the impact of a disturbance" and 'resilience', to describe the "ability to recover from a disturbance" (p88).

A more detailed definition from Walker *et al* (2004), associates of the Resilience Alliance, goes deeper in defining resilience, using the term to encompass four components—latitude, resistance, precariousness, and panarchy. In this explanation:

- Latitude is the maximum amount a system can be changed before losing its ability to recover ie crossing a threshold beyond which recovery is difficult or impossible;
- Resistance is the ease or difficulty of changing the system;
- Precariousness is how close the current state of the system is to a limit or threshold and;
- Panarchy envelopes the previous three by addressing the resilience of a system at a particular focal scale, depending on the influences from states and dynamics at scales above and below. For example, external politics, market shifts, or global climate change which could trigger local surprises and regime shifts.

(Adapted from Walker *et al,* 2004)

This latter definition applies the term resilience to whole system processes, their functions and external interactions, in contrast to other definitions mentioned, which focus on the component parts.

This study uses the term 'resilience' in its more commonly used ecological sense to refer to the capacity of a system to both withstand and recover from a disturbance. Where appropriate the terms latitude, resistance, precariousness and panarchy are used in reference to the ability of systems to withstand disturbance, but are also encompassed by the term resilience.

2.3 Socio-ecological resilience

Ecological systems include plants, animals and micro-organisms interacting along with the abiotic factors of their environment. As such, where humans are present they too are integral to the ecosystem, in which cases they are often called socio-ecological systems, including households, communities and organisations (Adger, 2000; Berkes *et al*, 2003; Berkes & Folke, 1998). Social and ecological systems are intimately linked, with humans being dependent on natural resources and systems, and with human management of ecological systems having a significant impact on their dynamics. As ecological systems are complex with the non-linear interactions of the component parts leading to the higher level functions of the whole system, human influences are central to the state of and stresses on the systems. These range from directly managed systems such as harvested woodland and agriculture, to indirectly impacted systems such as ecosystems affected by climate change. Whilst the resilience of ecological systems is based on their capacity to absorb disturbances and restore their processes reactively, social systems have the additional capacity to forecast changes and manage responses and recovery strategically (Adger, 2000; Berkes & Folke, 1998; Folke *et al*, 2002; Levin, 1998).

The resilience of socio-ecological systems is thus defined by Walker *et al* (2002) by the following three features

- The amount of disturbance a system can absorb and still retain the same controls on function and structure;
- The degree to which the system is capable of self-organization;
- The capacity of the system for learning and adaptive management.

(Walker *et al*, 2002)

2.4 Adaptation and managing for resilience

Adaptation relates to the latitude of a system, or the amount that it can be changed and still recover. The use of the term ‘adaptation’ varies considerably between authors. It is generally agreed to relate to an adjustment in behaviour or management in response to a change, however the question of whether this is reactive or pre-emptive of changes is contested (Galopi *et* al, 2006; Schoon, 2005). It is frequently, and particularly in relation to climate change, contrasted with mitigation, where mitigation is carried out pre-emptively to prevent a change from occurring and adaptation occurs after the event in the form of planned or unplanned changes to cope with it (Wilbanks, 2005). However where resilience is defined in terms of overall system functions, adaptation is a function of the systems’ resilience in terms of its capacity to change pre-emptively or in response to a change (Galopi *et* al, 2006; Walker *et al*, 2004). In this context adaptive capacity is linked to resilience in that a highly resilient system will be able to adapt in preparation for or response to changes, and re-organise whilst maintaining its original functions. By contrast, systems that are unable to adapt and respond to changes and will undergo a shift or breakdown in functions, indicating low resilience. In natural systems adaptive capacity is related to genetic and biological diversity, as discussed further in the next chapter. In social systems it is also linked to institutions that store and share knowledge and experience, which facilitate responses to problems and balancing power (Corbacioglu & Naim, 2006; Folke *et al*, 2002).

Theories on the management of socio-ecological systems for resilience are somewhat different to most conventional management approaches, which are based on output or profitability. The component parts of ecological systems have multiple functions and shift and respond to change in unpredictable ways which is the basis of their capacity to adapt to change. This contrasts with the current tendency for humans to design or manage systems for simple, predictable and linear processes and interactions, to decrease variability and increase the quantitative efficiency of the target output or product (Adger, 2000; Berkes & Folke, 1998; Folke *et al*, 2002; Levin, 1998).

Folke *et al* (2002) describe certain factors that enhance the adaptive capacity of systems:

Learning to live with change and uncertainty

Adaptive systems use change as a positive opportunity for development. For example many societies have developed mechanisms that allow for disturbance and change at a smaller scale, in order to prevent it accumulating to larger scales. An example of this in modern societies is the 3-5 year democratic election cycle.

Nurturing diversity for resilience

Diversity provides an insurance against uncertainty allowing for different possibilities and options, and also provides a mix of components with accumulated experience to facilitate redevelopment and innovation following a crisis. Many ecosystems have species which appear to be redundant, but in fact contribute to their resilience.

Combining knowledge systems

Different types of knowledge and understanding of systems, management and patterns can be combined to facilitate coping with and adaptation to changes, such as using local heritage crop varieties as the basic material for crop breeding programmes. Scientific and traditional or local knowledge can be complementary in terms of designing and applying principles for coping with change. Knowledge generation, storage and transfer structures are also fundamental to the capacity for knowledge to be shared and used. The learning process includes the ongoing monitoring and reflection to generate and share knowledge and understanding of ways to manage change.

Creating opportunity for self-organisation

The first three factors combined allow for the self-organisation of systems in the face of dynamic change. The process of learning from change is central to social-ecological capacity for building resilience. A self-organising system will require little high-level management.

(Adapted from Folke *et al*, 2002 and Walker *et al,* 2002)

An example of an adaptive management system which combined these qualities comes from the development of a co-management system for wetland in southern Sweden (Olson *et al,* 2004). The wetland in this case study was recognised as providing multiple services including great biodiversity of wild habitats for flora and fauna, unique flooded agricultural land, and Europe's largest groundwater aquifer. The expansion of the local town had begun to place increasing pressure on the ecosystem services, and in at attempt to protect it, was designated as having international importance by the Convention on Wetlands of International Importance. However the Convention alone was found to have marginal impact and ongoing degradation of the ecosystem was observed in the decade following its adoption. The eventual transformation of the system was based on the establishment of a new municipal organisation, which served as a bridge between local and governmental bodies involved in the wetland management, allowing for the linking of different groups of people and knowledge sharing. Much of the change was led by an individual who initiated dialogue between the various stakeholders to identify a desired state for the wetland, and mobilised people, information and activities to work towards this goal.

The co-management approach facilitated stakeholders, who had previously been in competition, to self-organise and work together as they realised that they were stronger as a team. One example was the collective decision of local boat owners to be more careful with fuel and oil to avoid pollution, which also led to their publicising the importance of this in schools and the local community. The cohesion between the stakeholders also facilitated political action, as the community were equipped with the knowledge and agreement of the practical management actions that they wanted the government to take, and the government could undertake these actions without concern that it would go against local wishes. In this case the social transformation and cohesion at the community and institutional levels was essential in order to enable sustainable ecosystem management for human and ecological well-being. The key point from this case are that the transformation required the community involvement, as the international convention made little impact. It is also notable that a key individual was significant in initiating this change, and raises the question of how, or by whom, such transformations are inspired, and how this can be transferred to other situations.

In another example research on the response to six earthquakes in Turkey by Corbacioglu and Naim (2006) found considerable evidence of a shift in organisational learning and adaptive change in response to the fifth earthquake, which facilitated more effective responses to the next disaster. The key factors identified that inhibited learning and change in response to the first disasters studied were lack of inter-organisational communication infrastructure, skilled personnel and lack of investment in recommendations. The trigger for change was the exceptionally destructive fifth Maramara earthquake in 1999, which killed four hundred times as many people as the largest of the previous earthquakes, and was followed by investment and planning which led to greatly improved communications, personnel training and implementation of earthquake codes, enabling much more effective responses to a subsequent earthquake. In this case the trigger for change was a disaster out of all proportion compared to previous disasters.

Both these examples demonstrate that communities and institutions have the capacity to respond positively to disturbances by developing coping and management strategies that enable them to continue, resume or adapt their activities. Flexible social networks and organisations, with a fluid hierarchy and decision making processes that maximise the available social capital, such as knowledge, skills and networks, and adapt better to changes than those with a rigid structure. The value of such systems is often not recognised as they appear to be messy and inefficient. However growing discourse in the area demonstrates that dynamic and diverse social systems with multi-level governance are better able to self-organise to meet new circumstances (Berkes *et al,* 2003; Corbacioglu & Naim, 2006; Dore & Etkin, 2003; Folke, 2006; Folke *et al*, 2002; Gallopı´n, 2006; Gallopı´ n *et al,* 2006; Pelling & High, 2005; Thomalla *et al*, 2006; Walker *et al,*2002).

Several frameworks or sets of principles have become available to facilitate planning and design on a more holistic system level, some of which are summarised in Tippet *et al* (2007). These include: Strategic Environmental Assessment & Environmental Impact Assessment, which is a systematic process for evaluating the impact of a proposed development or project, and is now a legal requirement in many countries around the world (Baker et al., 2005); Holistic Management, which aims to change the way decisions are made by measuring them against a vision of a desired future state (Savory & Butterfield, 1999); and Permaculture, which is an approach for applying the principles of ecological systems to human productive land, landscape and settlement design and management (Holmgren, 2003). An assessment of these as options for planning resilient systems is beyond the scope of this thesis, but their existence and increasing, and in some cases statutory use indicates an increasing concern with management approaches based on a whole system perspective, rather than a linear output perspective.

2.5 Resilience and disaster management: linking relief, rehabilitation and development (LRRD)

This thesis was carried out in the context of increasing pressure from disasters around the world, and greater concern with addressing the risks and impacts of these disasters. The overall goal of this research is to identify characteristics of systems that contribute to their resilience, and can feed into strategies for LRRD. Whilst this study does not directly apply the findings to relief, rehabilitation and development approaches, a review of this background is made here to place the thesis in context and to enable discussion on the application of findings at the end.

Disaster management includes all the processes and phases around a disaster. The relief phase occurring in the immediate aftermath of a disaster with emphasis on meeting the basic needs of food, water, shelter and sanitation; rehabilitation working on longer-term issues such as livelihoods, permanent housing, infrastructure and market systems; development describing the processes of change in society, such as infrastructure, education, employment and politics; and preparedness referring to specific activities, including planning, prediction and education, which aim to minimise the impacts of future disasters (Adger & Brooks, 2003; Anderson & Woodrow, 1998; Christoplos *et al,* 2001; Herbold Green, 2000; Lewis, 1999; Wisner *et al,* 2004; White *et al*, 2005). As the occurrence of and spending on relief and rehabilitation following disasters has increased, focus has rested on how relief and rehabilitation processes can link into sustainable development and increased resilience to future disasters, including international drivers such as the International Strategy for Disaster Reduction (de Armiño, 2002; Buchanan-Smith & Fabbri, 2005; Christoplos *et al,* 2004). This has been termed linking relief, rehabilitation and development (LRRD). Understanding the characteristics and conditions of resilient systems is fundamental to LRRD, and sets the goal which relief, rehabilitation and development must aim.

Buchanan-Smith and Fabbri (2005) explain that: "better 'development' can reduce the need for emergency relief; better 'relief' can contribute to development, and better 'rehabilitation' can ease the transition between the two" (p2). Current practice frequently only addresses one disaster phase. In the relief system problems include interventions that are short-term in scope and address only immediate needs without considering their potential longer-term impacts. It has also been found that some relief and rehabilitation can actually have negative longer-term impacts, undermining the capacity of beneficiary communities to recover, for example where ongoing food-aid distributions establish dependency of communities on handouts, affect motivation to generate income and undermine local economies (Harvey & Lind, 2005). Another tendency in disaster relief is to view the situation as a *tabla rasa* and introduce generic interventions aiming towards an externally imposed goal rather than identifying specific needs and capacities of communities (de Armiño, 2002; Buchanan-Smith & Fabbri, 2005; Christoplos *et al*, 2004; Herbold Green, 2000).

In terms of development practice, this is frequently disassociated from disasters and seen as a separate longer-term agenda to be engaged with a community during “normal” life. However many stakeholders in disaster management now reason that changes in conditions and disasters are part of normal life and thus that development must address issues of disaster mitigation and disaster management must link into development (Korf & Bauer, 2002; FAO, 1998; UNDP, 2004; White *et al*, 2005; WFP, 1998). Preparedness has often been completely disregarded, with each sector seeing it as the domain of the other (La Trobe & Venton, 2003; Twigg & Steiner, 2002; Twigg *et al*, 2000).

Building the resilience of socio-ecological systems is the key to LRRD, and thus needs an understanding of what makes a resilient system. This chapter has looked at some of the general principles that have been found to contribute to resilient ecological and socio-ecological systems. The next chapter looks specifically at agricultural resilience and agriculture in the context of disasters, the impact and characteristics of agronomic systems that influence their resilience to disasters, and how approaches to agricultural development can impact these characteristics.

3 Resilience in agricultural systems

3.1 Introduction

Agriculture is fundamental to social and ecological systems. It has many roles, including the production of food and other resources, impacts on biological diversity and habitat, and social functions such as labour, income and cultural activities around agricultural cycles, with environmental and human health being a cross-cutting theme. The need to feed the increasing global population is widely seen as a priority for agriculture, with the resilience of systems being essential in changing environmental conditions. Climate change is set to have a considerable impact on agricultural systems, and is likely to cause changes in regional climates and increasing weather extremes (Desanker & Magadza, 2001; Fischer *et al,* 2002). There are also a great diversity of approaches to agriculture in terms of scale, crops and management methods. This chapter looks at the roles of agriculture, focussing on food production, ecosystem interactions and social and economic functions, in relation to different approaches to and practices in agricultural systems. This sets the context for this research on the resilience of agriculture to the Tsunami in Sri Lanka. The final section of this chapter looks at the resilience of different agricultural systems, linking back to theories from the previous chapter, and identifying theories and examples of agricultural resilience.

3.2 Food security

In the 1960's and 1970's agricultural policy and research focused on the need to feed the growing global population, and led to the widespread adoption of the so called Green Revolution technologies, which forms the basis of, or significantly influences, most agricultural practice today. The issue of feeding the current and growing population is still significant today, with the global population predicted to exceed 7.5 billion by 2025, and climate change impacting agricultural potential in unpredictable ways (Swaminathan, 2007). The Green Revolution was instigated and funded by public research bodies and introduced a collection of new technologies aimed at increasing agricultural productivity. This delivered breeding programmes for staple foods such as rice and wheat, for early maturing and high yielding varieties, the distribution of inputs such as fertilisers and pesticides, and the expansion of irrigation infrastructure (Conway & Barbie, 1998).

The aim of the Green Revolution was to increase food production, and develop markets for agricultural produce, leading to economic growth. In many important ways the movement has been successful with Asia's productivity having increased by over 27% per capita since the 1960s (Singh, 2000). However, although overall food productivity has increased, the Green Revolution's impact on global food security has not been totally successful. Per capita food production in Africa has declined, and even in areas where productivity has increased, the Green Revolution has not addressed the key issues relating to food secuirty. Amaryta Sen’s Entitlement Theory of famine currently forms the basis for approaches to assessing food security. Sen’s theory explains that food insecurity is not the result of an absolute lack of food, but lack of access to enough food (Sen, 1981). Sen’s work was seminal in terms of breaking the assumption that lack of availability of food was the overriding cause of famine. A households access to food can be influenced by multiple natural, social and political factors including production capacity (such as natural resources, access to inputs, access to land, labour), material capacity to purchase food, market forces and national and international policy. The approach to food security analysis that has come out of this concept focuses much more broadly on all aspects of food production and access, rather than only yield, including markets, inputs, cultivation practices, natural resources, social systems, peace and national and international policy (Devereux, 2000).

In terms of the Green Revolutions approach, new High Yielding Varieties (HYVs) work well in their optimum conditions, with adequate irrigation and fertilisers, but when grown in marginal areas or without additional inputs, they gave little or negative impact on yield (Conway & Barbie, 1998; Singh, 2000). Chakravarti (1973) states that HYVs only respond adequately to fertilisers given adequate water availability, yet 70% of land in India has rainfall that is too low or unreliable to grow HYVs introduced in the 1970s. The Green Revolution technologies were targeted at favourable agro-climatic regions and farmers with the best potential to increase their productivity, for instance in regions with good rainfall and soil structure. The main beneficiaries have been larger farmers on high potential land, whilst smaller farmers and those on marginal land have seen little benefit from the technologies, for example where that have little access to the inputs due to the high cost (Altieri, 2002; Conway & Barbie, 1998; Singh, 2000). Thus the technologies and targeting approach of the Green Revolution failed to address the food security issues at large. Green Revolution technologies do have the potential to increase productivity in more marginal conditions if used appropriately. For example, targeted synthetic fertilisers used in conjunction with the application of organic matter, to improve water and nutrient retention, could improve yields and long term-fertility in low potential soil. However they have largely failed to meet their potential in such situations due to the one-size-fits-all approach to their promotion and lack of accessibility and relevant training to smaller, marginal growers (Altieri, 2002; Conway & Barbier, 1998; Singh, 2000).

More recent developments in agricultural technology have focussed on breeding crop varieties for characteristics such as high yield, tolerance of certain conditions such as drought or salinity, and resistance to pests and diseases, using both conventional plant breeding methods and genetic modification. Such approaches have the potential to improve productivity in marginal land, and decrease the use of pesticides and fertilisers, through crops with their own resistance and tolerance of low-potential land. It has been argued that such developments are essential to feed the increasing population, with greater constraints on land quality and availability (Reece & Haribabu, 2007; Spielman, 2007; Swaminathan, 2007). Lessons from the Green Revolution have fed into discourse on the applicability of such new technologies to poorer, more marginal regions. It is recognised that developments relevant to poorer farmers need to be made in conjunction with the farmers themselves and that this must be led by public sector organisations (Reece & Haribabu, 2007; Spielman, 2007). The significance of community leadership in development approaches is discussed in a later section.

Research into ecological approaches to agriculture, discussed in detail in the following section, also indicates a great potential to increase productivity in marginal areas in many ways including improving water and nutrient retention through increased organic matter content, and soil stabilisation through increased ground cover (e.g. Bulluk *et al,* 2002; Siegrist *et al*, 1998). As food production is one of the key functions of agricultural system, the maintenance of this is fundamental in defining a resilient agricultural system. In broader terms the capacity of the system to provide income with which to purchase food can also be considered in relation to resilience, depending on the context and wider availability of food to buy.

3.3 Ecosystems and agriculture

Agricultural systems differ from other ecosystems in that they require management to produce food and fibre for people and, as most of the nutrients are taken out of the system at harvest, they usually require external inputs of energy and nutrients to maintain their intended productive state (Altieri, 2002; Gliessman, 1998; Okey, 1996). Most current agricultural approaches are based on, or at least significantly influenced by the Green Revolution technologies. Agroecosystems are currently managed for the maximum yield of a few select crop or animal types, and usually have a highly simplified trophic structure and decreased diversity in comparison to natural ecosystems (Fletcher & Hilbert, 2007; Conway, 1987; Gliessman, 1998).

Ecological agriculture or agroecology, is defined as that which is managed according to the concepts and principles of ecological systems (Gliessman, 1998). The agro-ecosystem includes the air, soil, water, plants, animals, microorganisms and abiotic elements that are managed by people for agricultural production. Ecological agriculture is an approach that is based on the interrelatedness of all of these components, including humans (Altieri, 2002; Conway, 1987) In contrast conventional agriculture takes a more linear approach based on tangible inputs and outputs, with a focus on profitable crop yield. The key principles of ecological agriculture include:

- Recycling of biomass and balancing nutrient flow and availability;
- Creating favourable soil conditions for plant growth, through enhanced organic matter and soil biotic activity;
- Minimizing losses of solar radiation, air, water and nutrients through microclimate management, water harvesting and soil cover;
- Enhancing species and genetic diversification of the agroecosystem in time and space;
- Enhancing beneficial biological interactions and synergisms among agrobiodiversity components resulting in the promotion of key ecological processes and services, such as fertility improvement and pest control.

(Altieri, 2002).

A key feature of ecological agricultural systems is that they are grounded in complexity and biological diversity. Agro-forestry systems are one example, supporting a wide diversity of multifunctional plants and animals (Altieri, 1999 & 2002; Fernandes & Nair, 1986; Hart, 1996; Holmgren, 2003). For example assessments of small gardens systems in Honduras (Barrance *et al,* 2003) found the farmers actively protected 41 different species, with around 5 being actively cultivated, and the composition of these changing in response to scarcity of preferred species. In ecological agriculture systems there is both planned biodiversity, such as multipurpose crops and trees, and unplanned biodiversity, including soil life, insects and non-crop plants. All the different aspects of the biodiversity have been found to contribute different properties to the system. For example different plants and trees use different parts of the environment such as shade and nutrients, and bring different qualities such as pest control and water retention. Functions include biological nitrogen fixation, nutrient uptake enhancement from arbuscular mycorrhizal fungi, decomposition of organic materials into simpler compounds by decomposer organisms, and greater resistance to disease and pest attacks as a result of higher nutritional status (Altieri & Nicols, 2003; Barrios, 2007; Giller, *et al*, 1997). Because of this, the overall productivity of ecological systems can be 20-60% greater than monocultures. However this productivity is less well suited to producing for markets, due to the variety of produce and spread out timing of harvest (Altieri, 2002; Barrios, 2007; Gliessman, 1998; Giller *et al,* 1997).

The yield increases from modern conventional agriculture rely on externally sourced replacements for ecosystem functions including high yielding genotypes, fertiliser, pesticides and irrigation, but this overlooks the other ecosystem services that do not directly impact on primary production (Jackson *et* *al,*2007; Mogina, 2000; Swift *et al*, 2004). For example a study of grazing systems looking at different grassland management approaches demonstrated that those which prioritise yield or stocks, without reacting to changes in natural capital (eg. fertility, soil structure and biodiversity), were at high risk of driving the system to collapse, in comparison to those which managed the ratio of yield to natural capital (Fletcher & Hilbert, 2007). The management of agricultural systems with yield as a priority can overlook or undermine the other ecosystem services, which are not directly profitable, but are nonetheless vital for agroecosystems. Examples of services particularly important for agroecosystems include genetic diversity for crop and animal breeding; nutrient cycles; biological control of pests and diseases; erosion control and sediment retention; and water regulation. At a global scale other services become significant, such as atmospheric gas regulation (Swift *et al,* 2004).

Ecological agriculture is based in traditional agricultural systems that have developed over centuries in specific ecological regions. Whilst current conventional agricultural approaches are based on a limited range of new crop varieties and inputs used around the world, traditional agricultural systems are typically complex, diverse and specific to the ecological and cultural context (Gliessman, 1998; Altieri, 2002). In some references the terms "ecological" and "traditional" agriculture are used interchangeably (eg. see Altieri, 2001). However, as the context of agriculture has changed greatly over the past few decades, the appropriateness of traditional agricultural approaches has also changed, and ecological agriculture has developed beyond traditional agriculture. For example, shifting cultivation is a traditional system that can be maintained without damaging environmental impacts when supporting a low population, and with a sufficiently long rotation period. Increasing population pressures have led increased demand for production, pressure on land and shorter rotation periods, and land degradation and contested land rights as a result of shifting cultivation practices, not to mention problems with land ownership (Cairns & Garrity, 1999). As such, traditional agricultural approaches hold great value in terms of the depth of knowledge and skills that have developed over generations, but ecological agriculture takes these a step further to ensure their applicability to the changing context of agriculture now (Conway, 1987; Gleissman, 1998; Shi, 2002).

Going back to the definition of resilience from Walker *et al* (2002) in the previous chapter, the component 'panarchy' links the resilience of a system at a particular scale into wider political, economic and environmental factors. The Livelihoods Framework, discussed in the next section, recognises the impact of these factors and illustrates the links. Agricultural systems can be strongly influenced by broader economic, political and environmental factors, in terms of the actual agricultural practices used, and the market and environmental context in which they operate, for example through the promotion of particular agricultural approaches, or infrastructure development, such as dams, which have a knock-on impact on agriculture. Subsidies on agricultural production and the sale of cheap subsidised produce on world markets has had an impact on the livelihoods of farmers from lower income countries with unsubsidised agriculture to compete in international and domestic markets (Green & Grifith, 2002; Poulton *et al,* 2000; Robinson, 2003). For example, the damming of the River Volta in Ghana stopped the annual flooding, which farmers relied on to bring fertile sediment and water, and led to the virtual collapse of agriculture in the area. A knock-on effect was that mangrove cutting increased as a means of income for farmers, yet the dispersal of mangrove seeds was reduced as a result of reduced flooding (Rubin *et al,* 1999).

A case study from the Dominican Republic demonstrates how the commercialisation and simplification of agriculture has influenced the islands capacities in response to natural disasters. In the mid twentieth century much of the agricultural land and forest was cleared to make way for sugar cane plantation. The Dominican Republic is prone to cyclones and consequent flooding and landslides, and this has increased vulnerability in three ways. Firstly flooding and erosion have increased following deforestation in what were the most fertile areas. Secondly many smaller producers were displaced to marginal land or to shanty towns, increasing their vulnerability in terms of location and population density. Finally the sugar cane market is sensitive to volatile world market prices, which makes reliance on it a risky business (Jeffery, 1982). In another study it was found that in the Indian state of Haryana around 60% of the area faces soil degradation, water logging, salinity and alkalinity. Soil organic matter levels were found to be declining, thus increasing the need for chemical inputs and, as new crop varieties tend to need irrigation there has been consequent water pollution and changes to the water table. Reliance of farmers on the purchasing of external inputs rather than traditional sources was found to have put many of them into situations of debt (Singh, 2000).

3.4 Social and economic interactions

Agricultural systems are set within the wider context of rural lives, communities, landscapes and development. The Sustainable Rural Livelihoods approach, illustrated in Figure 3.4a, is framework developed by the Institute of Development Studies around the early 1990s as a tool for looking at the interactions of rural households' activities towards food security and income, with the wider social and political context in which they act. A livelihood comprises the assets (natural, physical, human, financial and social capital) and the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by the individual or household. The framework also looks at the wider context including the government and private sector, laws and policies, and potential shocks or disasters (Chambers & Conway, 1991; Barrett et al. 2001; Carney, 1998; Scoones, 2005). The basic inputs

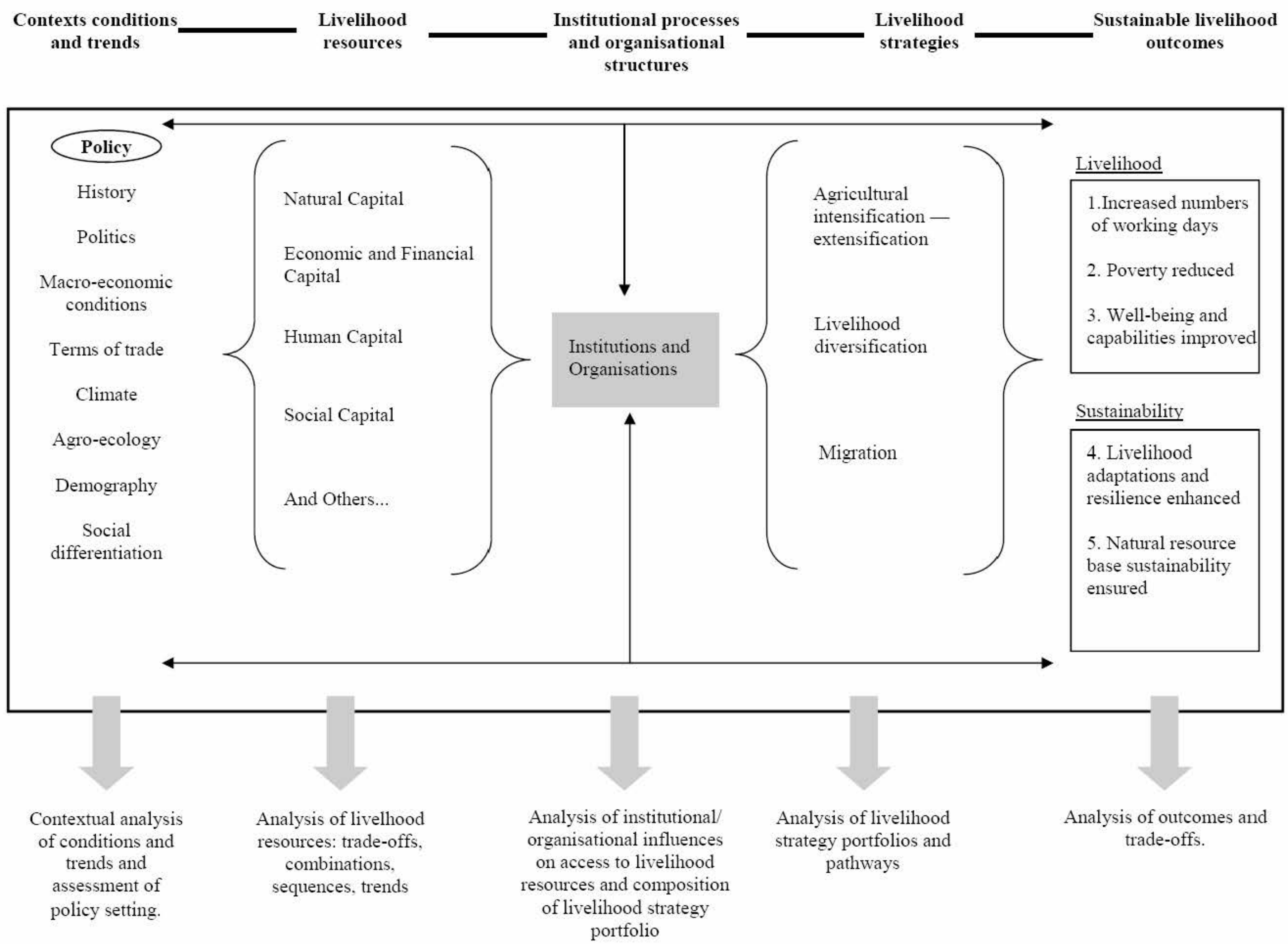


Figure 3.4 Sustainable Rural Livelihoods: a framework for analysis
(adapted from Scoones, 2005, p4)

to the livelihood system are resources and assets available to the household. These include human resources such as knowledge, skills and labour; material resources, such as land, money, tools, water supply, transport; and environmental resources including the landscape and infrastructure and institutions such as markets, community groups and kinship networks. All these features affect rural livelihoods is different ways.

This section looks at agricultural systems within their social and economic context, including both local interactions, within the system, and broader national and international interactions. The section considers first the role of human and social capacity, then other livelihood options which complement, or in some cases substitute, the functions of agricultural systems. The section then looks at the broader context of development, and its impact on agriculture. These issues, combined with the production and ecological roles, form a complete picture of agricultural systems and their interaction with component social and ecological parts and external drivers. This forms the basis of the review on agricultural resilience in the following section.

3.4.1 Human and social capacity

In the Livelihoods Framework human capital represents the skills, knowledge, health and ability of people to pursue livelihood options. Social capital represents formal and informal networks and organisations which may provide, for example, support, training or access to resources. Social and human factors such as formal and informal social organisation and networks within a local, regional or national context, skills and appropriate knowledge have a strong influence on how households make a living and what is possible for them (Anderson & Woodrow, 1989; Hilhorst & Bankoff, 2004; Wisner *et al,* 2004). Research in post-Soviet Georgia found that households that were part of informal support networks were considerably less likely to describe themselves as vulnerable in terms of their housing security, finances or food. The strongest differences between perceived vulnerability of households that were part of informal networks and those that were not, was between those with single responsible adult and young and/or elderly dependents (Dershem, & Gzirishvili, 1998).

In terms of the resilience of systems there are various types of human coping strategies following a disturbance or disaster, many of which are reliant on strong human capacities, such as health and skills, and social networks, such as between individuals, families and community institutions, such as religious groups. Social support networks within and between households and families are an important mechanism in many situations for coping with disturbances through cooperation, redistribution of resources, and assistance from households not affected by the disaster. In more extreme situations families may relocate to temporary shelter or to non-affected households or migrate for work or to better food sources of food (Carter *et al,* 2004; Palakudiyil & Todd, 2003; Wisner *et al,* 2004).

Examples of remarkable human and social capacity are found in the 2004 World Disasters Report (IFRC, 2004), which focussed on the fundamental resilience of communities and their timely and organised responses to disasters such as the Afghan crisis. A study by the FAO looked at the role of community organisations and institutions in disaster mitigation in rural areas across three continents (Battista & Baas, 2004). The study found that local level organisations have some important advantages in disaster mitigation compared to higher-level institutions for several reasons:

- they often represent local perspectives in policy making and DRM planning fora;
- they bridge and promote two-way communication between higher and local policy levels;
- they assist and guide locally the implementation of DRM activities;
- they mobilise local participation; and
- they handle at the local level the full emergency cycle, better linking in particular, emergency prevention and rehabilitation activities.

(Battista & Baas, 2004)

The study found that locally organised disaster mitigation and response has a significant impact on disaster mitigation and is crucial to complement higher-level activities. It also identified that there was a general lack of understanding amongst higher level organisations about local knowledge and experiences and methods for strengthening such institutions. Overall the study concluded that "local institutions derive their strengths from proximity, responsiveness to social pressures and adaptation" (Battista & Baas, 2004, p.12). However there was a limit to the capacity of local institutions in very extreme disasters. For example, where the human capacity of the organisations was severely affected, through injury or death, there was a need for both institutional capacity building, and working in partnership with other larger or stronger organisations in order to provide support in such situations.

Overall the human and social capacity of systems is fundamental to how they interact, and how they respond to changes i.e. their resilience. Although this is the case with all social systems, and not exceptional to agricultural systems, it is mentioned here specifically because it is a fundamental factor in the resilience of these systems.

3.4.2 Diverse livelihood opportunities

Although agriculture is a significant part of the livelihood of many rural households, it is widely recognised that most rural households have multiple ways of gaining food security and income. These include activities such as processing natural resources for market, working locally and family members working elsewhere and sending back money (Barrett *et al,* 2001; Ellis, 1999; Niehof, 2004). Diversification occurs for many reasons and variously in different sectors of society. It is widely seen as a form of insurance amongst poorer groups of a community, as a means of spreading risks across different income and sustenance opportunities. However it is also associated with more affluent groups who have better access to skills and opportunities for off-farm incomes (Barrett *et al*, 2001; Ellis, 1999; Niehof, 2004)

In general, livelihood diversification is seen as a positive feature. It balances out the seasonality of agricultural production, spreads the risk of failure or disturbances across different sectors, has the potential to improve assets and environment by enabling investment from extra income, and can improve the potential for women to develop independent means of income. There are potential negative impacts of diversification, including reduction of farm productivity if focus is placed on off-farm employment, association with a disparity in access to opportunities between richer and poorer households, and entrenchment of women in labour roles, with men gaining better access to income. However, on balance the positive effects tend to be widely applicable, with negative effects only occurring where there is already an imbalance of resources and opportunities (Barrett *et al*, 2001; Ellis, 1999; Elmqvist & Olsson, 2006; Niehof, 2004).

3.5 Resilience in agricultural systems

Although conventional Green Revolution agriculture has successfully led to increased yields, analysis of managed systems consistently finds a trade-off between the profitability and resilience of agricultural systems. This section looks at specific studies on agricultural resilience to disasters.

Current theory on ecological agriculture identifies that the multiple functions of diversity increase the resilience of agroecosystems in several ways. Permanent ground cover decreases erosion and improves water retention. Crop and variety diversity act as a buffer against pest and disease attacks and climate fluctuations as different crops and varieties are tolerant to different conditions and resistant to certain pests and diseases. Due to the lack of 'insurance' through diversity, monocultures can be uniformly and completely damaged by changes in conditions, such as climate, pests or disasters (Altieri, 2002; Altieri, 1995; Collins & Hawtin, 1999; Gupta, 1995; Mogina, 2000; Vandermeer *et al*, 1998). However, although biodiversity is widely recognised as an important coping mechanism against agricultural risks and uncertain futures, the theory is currently largely based on 'received wisdom' rather than evidence based knowledge (Jackson *et al*, 2007). There is a clear need for deeper understanding of whole agro-ecosystem interactions and for the substantiatiation of observations of the link between resilience and specific practices in order to establish policy and technical support for locally appropriate practice.

A key study that has influenced this research project has been has been a study comparing the resilience of ecological and non-ecological farming practices in Central America following Hurricane Mitch in 1998 (Holt-Gimmenez, 2002; World Neighbours, 2000). The hurricane caused massive damage to the across Central America by landslides and floods, and destroyed homes, infrastructure and agriculture. The study was initiated after observation that much of the damage from the hurricane appeared to be linked to poor farming practices and deforestation. Farms using ecological agriculture practices seemed to have had a lower impact from the hurricane. Farms were paired as closely as possible according to similarities in aspect, slope, location of watershed, intensity of storm and type of crops, with the only variation being that one used primarily ecological farming methods and one conventional farming practices. Measurements of depth of topsoil, subsoil, moisture content, soil quality, vegetation cover, surface and gulley erosion, landslides, and crop and economic losses and yields were taken at each farm, as an indication of the amount of damage caused by the disaster. The farmers from each plot were involved in the data collection of their neighbours plot in order to maintain a fair comparison and provide training in the analysis methods. A key limitation here is the lack of baseline data by which to assess the impact. The impact was actually measured in comparison to the 'paired' plot, but the pre-disaster differences between the plots were not measured, thus making it difficult to extrapolate the level of damage that was the result of the disaster.

Based on this methodology, the study found that farms using ecological practices such as agroforestry, cover-cropping and terrace bunds had 28-38% more topsoil, 3-15% more soil moisture and 2-3 times less surface erosion than their neighbours who had more intensive conventional cropping systems. Overall there was found to be between 58% and 99% less damage to ecological farms. This was attributed to the increased cover of vegetation and trees that stabilised the soil, and management practices such as bunds which soften the gradient of the slope. In some cases growers that had created bunds actually benefited by the hurricane, as soil that slumped down the slope filled in the bunds.

These physical factors, such as ground cover and management, relate to the level of resistance of the systems. Although overall the resistance of ecological farms was found to be greater than that of non-ecological farms, this impact was found to be limited by specific conditions such as steep gradients, the local storm intensity and management practices such as deforestation up-hill from the farmers plot. The resistance of slopes was significantly reduced at a gradient of 15-30% and then 30-50%, and at high storm intensity. This indicates that there is a slope gradient above which land cannot be cultivated resiliently, regardless of the practices used. The presence of growers on such marginal land links back to social and political circumstances as many of them had been displaced from their original land to marginal areas by larger farms. Where landslides and gullies originated up-hill from the test sites beyond the farmers land, this was usually linked to deforestation, which was beyond the control of the farmers. However this emphasises the importance of integrated catchment basement management with consideration for all land users. It is also notable that there is a level of storm intensity beyond which different agricultural practices are not significant, which indicates that there is an upper cap to the capacity of systems to resist disasters, reflecting the limit to the capacity of local organisations to respond to disasters as found in Batista and Baas (2004).

Social impacts were also observed from the study. Ecological farmers in the area were often part of the Campesina-a-Campesina (farmer-to-farmer) movement, a movement of small farmers who share information and skills. The Campesina-a-Campesina movement already had well developed and strong support and information networks between growers compared to networks of non-ecological growers. At the local level many Campesina-a-Campesina associated community groups readily mobilised in response to the emergency and helped to motivate self-help efforts in their communities rather than waiting for external assistance (Archbald & Richards, 2002; Eberdt, 2003; Sperling & Longley, 2002).

3.6 Chapter conclusions: agricultural systems and resilience

The principles of ecological agricultural systems relate not only to the productivity of these systems, but also their broader ecological functions. The need to feed the growing global population is a significant driving force in agricultural research and development. However the links between the global production of food and access to food is not straightforward, so it is strategically important to consider the relevance of agricultural approaches to more marginal regions of the world, including those frequently affected by disturbances. Technological development has the potential to contribute to agricultural production in more marginal areas, but careful attention must be paid to its accessibility and relevance to populations in these areas.

Features of agricultural systems including agronomic practices and social networks influence the resilience of the systems. However there appears to be a limit to the capacity of these features to impact resilience to very extreme events. Overall improved understanding of the interactions must be found in order to ascertain the appropriateness of different agricultural approaches for marginal areas. It is also important to look at the wider interactions around agricultural systems, including livelihood diversification, the roles of social interactions and wider national and international development in order to identify the most appropriate approaches to building resilient agriculture.

4. The methodology for investigating agricultural resilience

4.1 Introduction

Research, and particularly that in post-disaster situations poses several challenges. Killan (2002) explains that "the methodological problems of field studies in disasters are those common to any effort to conduct scientifically valid field studies in the behavioural sciences. The disaster situation itself, however, creates special or aggravated problems for field studies" (p49). This chapter details the research approach taken in this study to achieve the above objectives.

4.2 The research question origin, evolution and approach

This research question emerged from background literature reviews on the resilience of ecological agricultural systems compared to industrialised agriculture. The research carried out following Hurricane Mitch (Holt-Giminez, 2001; World Neighbours, 2000) was a strong influence on the methodology. Most research on agro-ecological systems has been carried out on component parts of the system, such as soil life, or using computer modelling, rather than real whole systems. There are clear reasons why this is the case, as breaking down complex interactions between ecological, social and political systems to form useful and convincing evidence that can be applied more widely is difficult. The Holt-Gimenez research, and a handful of other studies (eg. Mogina, 2000; Tiffen *et al*, 2004), do look at whole systems, including the interactions between the social, agronomic and political contexts. Whilst the findings from such studies are site specific, corresponding themes and evidence set more specific agro-ecological research in a real-life context.

Although tsunami of the scale of the 2004 Indian Ocean event are not a frequent hazard, tsunami are relatively common around the world and also share impact features with other hazards such as hurricanes, severe storms and flooding. The key differences between tsunami and other similar hazards are that storms and flooding are climate related and generally seasonal, occurring regularly in a given location. Many of the issues relating to the impact of storms on agriculture relate to sloping land, which exacerbates erosion, and thus higher impacts are linked to communities who live on more marginal steep agricultural land. Tsunamis are solely a coastal hazard, and sloped land is barely affected, however, many of the agricultural communities affected included small farms on marginal land.

Funding to carry out this research project was secured shortly before the 2004 Indian Ocean Tsunami. Whilst identifying possible fieldwork locations, I came across the assessment of the Tsunami's impact on agriculture coordinated by the Green Movement of Sri Lanka (GMSL, 2005). The University of Ruhuna, in Matara District, Southern Sri Lanka, who had played a key role in coordinating the assessment, offered collaboration and logistical support. This was thus identified as a fieldwork location as it provided the opportunity to work in an area following a large scale natural disaster with strong institutional support. The research was done in collaboration with HDRA's International Development Programme, where I worked part-time.

4.3 Limitations of the study

Any 'ideal' research design will almost inevitably be limited by external constraints. Research in post disaster situations brings its own additional issues and problems such as the displacement of people, lack of pre-disaster data and issues relating to the subject sensitivity (Pole & Lampard, 2002; Stallings, 2002). Several factors discussed below limited the approach and the amount and type of information that it was possible to collect in the study.

4.3.1 Researcher identity and subjectivity

It is impossible to achieve an objective perspective in research, as the researcher naturally brings with them multiple identities, such as culture and gender, and presumptions, expectations and interests. Interviews are not simply a means to analyse a context, but create a context themselves based on the individuals involved. Interviewees may also bias their responses towards what they think the researcher wants or expects to hear, or based on their impressions of the study's aims. Researcher subjectivity is not necessarily a negative limitation on a study, but should be acknowledged as an integral part of the process (Lofland *et al*, 2006; Sarantakos, 1993).

Different cultures have varying attitudes towards categories such as gender, age and ethnicity, and thus the social identity of the researcher may impact the attitude and responses of interviewees. The field researcher in this study was a young white female. Various different roles and issues that female researchers can meet in cross-cultural research situations include difficulty gaining access to male dominated situations, hustling from male subjects or colleagues, lack of respect or not being taken seriously and paternalistic behaviour (Easterday *et al*, 1991; Warren & Hackney, 2000). During the research, although most of the situations were male dominated, they were not exclusively male and there were no situations required for the research that could not be accessed because of gender issues. However the other situations were all experienced to some degree during the research. Recommendations for minimising and dealing with such issues include dressing appropriately and maintaining a friendly, but professional approach (Easterday *et al*, 1991; Warren & Hackney, 2000) and these were adhered to during the fieldwork.

Most of the interviews and discussions in Sri Lanka were carried out through a translator, and these were different individuals in different locations (see below). This is likely to have created different dynamics due to the multiple interactions between the interviewee, the translator and the researcher. For most interviews in Sri Lanka the research was introduced as a joint project between a British and Sri Lankan university and a British ecological agricultural NGO, and it was made very clear that the research would not lead directly to any material benefit to the household. However the interviews in Ampara district were carried out with a translator from, and on behalf of, a national or an international NGO. The NGOs were running projects in the area including distributions and thus may have encouraged the respondents to exaggerate their needs in the hope of being prioritised for assistance. In support of this bias, the results from interviews in Ampara district did show the highest levels of need, but observation showed clearly that the impact of the tsunami was more severe in that area, so the assumption that respondents were exaggerating cannot be substantiated.

4.3.2 Ethics

Ethical considerations are crucial in the design of research projects and can strongly influence the design of the methodology. Social research is, by its nature, a fluid and adaptable interaction between the researcher and the respondents. However, if carried out insensitively the process can have adverse effects on the respondents and the community in general for instance by probing into sensitive issues, exposing private information or generating misleading or inaccurate reports. As such the researcher is obliged to protect the interests of the respondents by ensuring sensitivity and accuracy in data gathering, processing and dissemination (Sarantakos, 1993). De Vaus (2002) identifies five ethical responsibilities towards survey participants: voluntary participation; informed consent; no harm; confidentiality anonymity and; privacy. This research endeavoured to meet these responsibilities.

This research included interviews with people who had been personally affected by the tsunami, many of whom had lost family members, property and their livelihoods. Most had also already been questioned by different organisations carrying out needs assessments, and many had not yet received significant assistance. The research was carried out overtly and the aims of the research were stated clearly at the outset when inviting the householder to take part. As the survey was not offering direct benefits to any respondents this was made clear from the outset. Some respondents questioned what they would gain from giving information, and it was explained that the results would be disseminated to Sri Lankan organisations and may contribute to longer-term rehabilitation approaches. No-one declined to be interviewed.

Confidentiality has been maintained for the information from the interviews, and data that is displayed does not explicitly show the household source. The exception to this is where photographs have been used. Interviewees were asked before photographs were taken of them or their property. Several photographs have been included in this thesis to demonstrate results and key themes, however they have not been associated with any comments or activities of respondents that may be of a sensitive nature.

4.3.3 Translation

All of the grower interviews and around half of the organisation interviews were conducted in Singhalese or Tamil and translated into English by a field assistant. One field assistant helped with the research carried out in Matara and Hambantota districts, and two different translators helped with research in Ampara district. As interviews were based on discussion around guide themes, further discussion was frequently generated, and the need for translation somewhat restricted the opportunity follow the full dialogue. Different translators had different skills and experience of agronomy and knowledge of subject specific vocabulary, which was an occasional constraint to ease of translation and interpretation of the information. The field assistant in Matara and Hambantota was an agriculture student and therefore familiar with agronomic terms. One of the translators in Ampara was also an agriculture specialist, however the other one was not, and there was some constraints explaining the questions, and finding the right English translation for some technical terms. Two of the translators worked for NGOs and may have had some bias as to there interpretation of information relating to NGO activities. In attempt to minimise mis-translation, the questionnaires were discussed in detail with the translator before and following the interview and clarifications made.

4.4 The data collection process and rationale

The research objectives emerged from initial reviews of the literature on agricultural resilience, LRRD and agricultural rehabilitation. The objectives, outputs, methods, data type and timing of the data collected are shown in Table 4.4 below.

Table 4.4 Objectives, outputs, methods, data type and time scale of the data collected

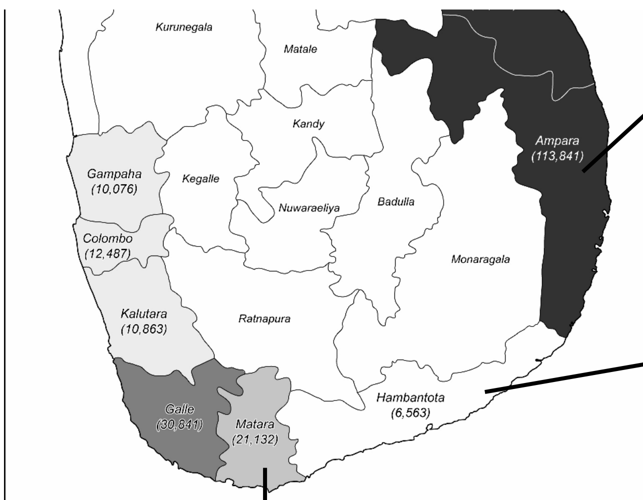
Objective	Output	Approach	Time scale	Data collected
Investigating agricultural resilience to disasters	Identification of factors affecting the resilience of homestead gardens in post-tsunami Sri Lanka.	Semi-structured interviews with individual homestead growers and focus groups, with farm walks where possible.	Matara: May/ June 2005 Hambantota: May/ June 2005 Ampara: June 2005	Interview transcripts with additional discussion, annotated sketch maps, photographs.
		Semi-structured interviews with agricultural rehabilitation and development organisations and observation of meeting minutes	Matara, Hambantota and Ampara: May/ June 2005 and follow up emails August 2005- May 2006.	Interview notes, email correspondence and notes and minutes from meetings.

4.5 Identifying the fieldwork locations

The main part of the research was carried out in Sri Lanka following the 2004 Indian Ocean Tsunami. It was selected as an appropriate and interesting field location based on several criteria. As with most developing countries, agriculture is the basis of the national economy, and the primary income for a majority of people. 45% of the total workforce is involved in agriculture, forestry and fisheries, although this figure may not include the many households that cultivate on a small-scale subsistence level. Although the coastal areas are not the most important in terms of agricultural production for Sri Lanka, agriculture was the worst affected sector after fisheries, this included damage to almost 28,000 homestead gardens, which are vital as a source of food and income to many lower income households (FAO, 2005). In addition English is spoken widely in Sri Lanka, and logistical support was offered by a national University affected by the tsunami, and both these factors were helpful in facilitating successful fieldwork.

The field survey was carried out in three districts of Sri Lanka, Matara, Hambantota and Ampara, which characterise different agro-ecological and political regions. Matara district is in the South West of the country in the wet zone. Hambantota district is in the South East, in the dry zone. Ampara district is on the South East coast, also in the dry zone, and is partially controlled by the rebel independence fighters the LTTE. Official social data to compare the regions is unavailable as there is very little statistical information on LTTE controlled districts in the East and North of the county. However it is generally recognised that Ampara district is impoverished in terms of infrastructure including education, healthcare and transport. Matara is relatively wealthy, with good transport links by rail and road to Colombo and has greater potential for agriculture as a result of being in the wet zone. Hambantota district is more remote from major urban centres and is one of the driest and poorest districts in the country.

All three districts were severely affected by the tsunami as shown on Figure 4.5. Ampara was the worst affected district in Sri Lanka in terms of numbers of fatalities and internally displaced peoples (IDPs), this partly due to the extensive coastline, but also to the high coastal population density and high levels of poverty. Matara had fewer affected people, but still a very severe impact relative to the small stretch of coastline in the district. Hambantota is sparsely populated compared to Ampara and Matara, so the number of affected people is high proportional to the district population (Weligamage *et al,* 2005).



Ampara District:
- Dry agroecological zone
- Relatively low levels of development
- Partially controlled by LTTE
- Highest number of tsunami fatalities in Sri Lanka

Hambantota District:
- Dry agroecological zone
- Relatively low levels of development
- Low population density

Matara district:
- Wet agroecological zone
- Relatively high levels of development
- Densely populated

Figure 4.5 Map showing districts surveyed and numbers of people affected by the 2004 tsunami in Sri Lanka
(full map shown in figure 1.4)
(adapted with kind permission from the Survey Department of Sri Lanka)

4.6 The approach to investigating agricultural resilience

The survey on the damage to and recovery of homestead gardens affected by the tsunami in Sri Lanka was undertaken in May and June 2005 to investigate agricultural resilience to disasters. The survey aimed to identify features of the agronomic system that may have mitigated the impact of the tsunami or supported rehabilitation following the disaster. The survey included interviews, discussion and, where possible a walk around the growers plot.

Interviews were carried out with homestead growers using a crib-sheet of guide questions or points (see appendix a). The crib sheet consisted of open questions or points for discussion, which allowed a breadth information and themes to emerge, whilst maintaining a clear focus on issues around agronomic systems and the tsunami impact. The points included in the crib sheet were based on initial review of literature on agricultural resilience. Information was gathered on the agronomic system (types of crops, methods of cultivation, processing activities); the impact of the tsunami on basic needs, cultivation, food security and income; whether cultivation had been resumed; and any assistance that had been received.

The interviews were piloted on agriculture students at the collaborating university in Sri Lanka and after the first round of field interviews the script was modified to streamline questions where there was repetition of answers. Interviews took between 30 and 60 minutes depending on the time available to the interviewees and the amount of discussion generated.

Observation was a key part of the investigation of homestead gardens. Where possible during the survey, a walk around the homestead plot was made with members of the household. This provided the opportunity to discuss the agronomic system and impact of the tsunami in a more interactive and visual context. An annotated sketch map was made of each plot and crops and vegetation pre-and post-tsunami were marked on and discussed with the household members and photos were taken and have been used in the analysis where appropriate. Issues brought up in the interview were discussed again and clarified or sometimes contradicted, and features in the plots helped to bring out further information on the agronomic systems. This approach proved to be very valuable in terms of brining out additional or contradictory details to those found in the interviews. Plot walks were carried out as part of all of the household interviews, however they were not possible in some of the group interviews. For example one group interview was held in a temporary shelter camp some distance from the interviewees plots. In the other group interviews only 1 or 2 plot walks were made due to time and distance constraints of visiting the plots of all group members. In total 23 household interviews and 4 group interviews and 26 plot walks were carried out.

Several challenges were encountered during the fieldwork, which prevented it being carried out exactly as planned. One focus in the interview was to identify the impact of the tsunami on food and income obtained from the homestead plot. During the survey design it had been planned to use ten counters, such as stones or large seeds, to represent the pre-tsunami production, and for the respondent to reduce the number to represent post-tsunami production, and thus estimate the percentage impact. However this approach proved very difficult to explain to the field assistant in Matara and Hambantota, who was also very reluctant to ask respondents to carry it out and the idea was eventually abandoned and the respondents were asked to estimate verbally instead.

In most of the sites in Ampara district, it was not possible or appropriate to carry out individual household interviews due to the logistical support from NGOs in the district, which was more limited in scope that that from the University for the surveys in Matara and Hambantota districts. In these instances group interviews were carried out. The group participants were gathered by the national or international NGOs collaborating in the research in Ampara district. In one instance the survey contributed to an assessment for project planning for an international NGO. Group interviews have various advantages over individual interviews, for instance providing a large amount of data in a relatively short space of time, and the context is more akin to informal discussion that an interview (Wilkinson, 2006). In the context of this research it did provide a broader overview of the issues relating to agriculture and the tsunami within communities. However, it was a disadvantage in terms of identifying agronomic practices that may have contributed to resilience, as these emerged in greater detail through discussion and tours of the growers plots.

4.7 Selecting the samples

The survey in Sri Lanka included interviews with homestead growers and national and international organisations involved in agricultural rehabilitation. The survey of growers focussed on those engaged in homestead based horticultural production and/ or agro-processing for income or subsistence. Homestead growers are characteristically diverse, however to enable systematic sampling selection criteria based on the size and function/s of the holding were used. The criteria for sample selection for grower interviewees were: the holding was based at, or within walking distance from the home of grower; the size of holding was under 1 hectare (most were half a hectare or less); the cultivated land had been affected by the tsunami; and that the holding was a significant source of food and/or income for the household. While the survey focussed primarily on horticultural and tree crops, the sample included examples of other homestead agro-based industries such as mushroom cultivation, a seedling nursery, and coir production as case studies of alternative activities.

The selection of survey locations was undertaken with the help of the University of Ruhuna and national and international NGOs. Within each of the three districts villages known for their homestead gardens were selected purposefully for the surveys. Figure 4.7 below shows the field survey locations of grower interviews. All the interviews with growers were carried out through a Singhalese or Tamil translator as discussed above. Within each district the grower interviewees were selected on an opportunistic basis so long as they fitted the selection criteria. Twelve growers were interviewed in each of Matara and Hambantota districts, however three interviews were discarded due to insufficient data or not effectively meeting the selection criteria. In Ampara district, due to different opportunities and logistical support, four focus groups of between ten and twenty people, including two CBOs, and two individual interviews were carried out. The field locations are detailed in section 4.8 below.

Interviews with organisations working on agricultural rehabilitation and development activities were also carried out in the three districts. These included international NGOs, national NGOs and government agricultural departments. In Matara and Hambantota districts a total of eight international NGOs, two national NGOs and two government departments were interviewed. In Ampara district there were no official NGO interviews, but information was gathered from one national and one international NGO. Additional information on the activities of national and international organisations working on agricultural rehabilitation and development was gathered from coordination meetings as described in section 4.9.

Organisations were selected to cover the range of types of institutions working in the area. UN agencies and international NGOs largely implemented rehabilitation projects through local NGOs, CBOs and government departments. National NGOs interviewed had district offices and area field officers. They were generally funded for their ongoing and non-emergency project work through international donors. Local NGOs were also used by international NGOs to implement projects in communities. Government agricultural departments carry out an extension service, including training and information, and collect agricultural taxes. They also offered various services such as seed/ tree seedling and input sales and credit for agricultural equipment and services. Community based organisations (CBOs), as compared to local NGOs, are considered here as a network of households within the community without necessarily a physical base. CBOs vary in terms of their cohesion and activities, but they include sharing information, exchanging seeds and accessing bulk quantities of inputs at a cheaper rate. Individual households undertake their own rehabilitation activities and are also the recipients of rehabilitation aid on a household basis or through community interventions.

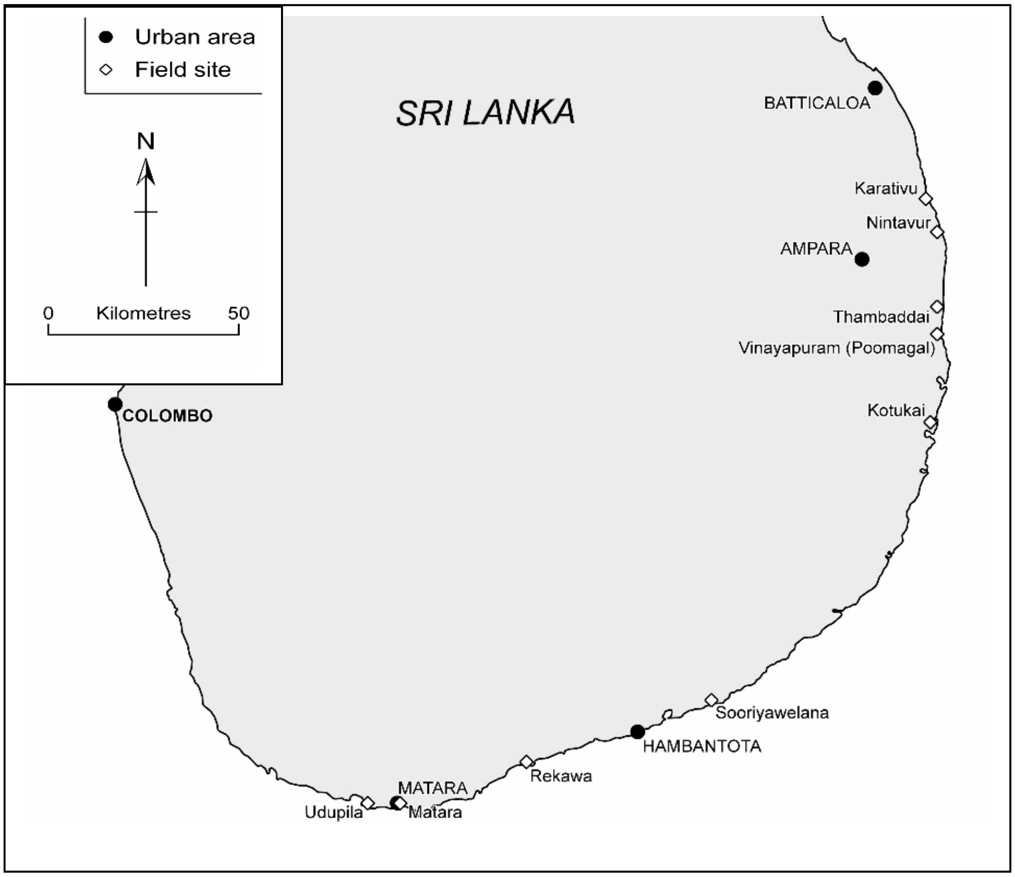


Figure 4.7 Field survey locations

4.8 Outline of field survey locations and pre-tsunami agronomic systems

Homestead gardens were surveyed in ten field locations: three in Matara District, two in Hambantota District and five in Ampara district. Either individual household interviews or group discussions were carried out in each of the sites. The survey approach, location and pre-tsunami agronomic systems are described in detail below and the locations shown on maps. An overview of the sites is given in Table 4.8.

Table 4.8 Overview of field survey locations and pre-tsunami agronomic systems

Field location	Survey method	Pre-tsunami livelihoods	Pre-tsunami agronomic system	Pre-tsunami seed system	Pre-tsunami management	Pre-tsunami networks
Karativu, Ampara District	Focus group with about 20 homestead growers	Main income and food source from cultivation. Occasional additional income from casual labour.	Maha is the main season. Primarily vegetable crops. A few banana plants also cultivated.	Own seed saved to plant in following season.	Cow rented and tethered on land before cultivation. Urea and NPK used. Irrigated by hosepipe from wells.	No farmers group. All knowledge on cultivation learnt from their experience.
Kotukai, Ampara District	Focus group with about 10 homestead growers	Main income and food source from cultivation. Occasional additional income from fishing.	Maha is the main season. Primarily vegetable crops, although one member grew morunga and kept poultry for eggs.	Some bought new seeds every year. Some selected healthy plants to save seeds from. Some exchange of seeds.	Cow rented and tethered on land before cultivation. Urea and NPK used. Compost used by some following training course run by NGO. Drip irrigation introduced by NGO.	Farmers group established by national NGO and implemented training in composting, drip irrigation and organic agriculture.
Nintavur, Ampara District	Focus group in temporary shelter camp with about ten homestead growers	Main income and source of food had been from cultivation. Occasional additional income from casual labour and poultry.	Maha is the main season. Primarily vegetable crops, but some tree crops such as papaya and mango.	Most seeds home saved, and only bought if additional ones needed.	Cow rented and tethered on land before cultivation. Urea and NPK used. Chemical pesticides used. Irrigation from wells.	No farmers group. All knowledge on cultivation learnt from their experience.

Poomagal Farmers Association, Vinayapuram, Ampara District	Focus group with about ten members of the farmers association	All had main income and source of food from cultivation. Some additional income from labour or office work.	Maha is the main season. Primarily vegetable crops, with some fruit trees for own consumption. Money borrowed at the start of the season to buy inputs and repaid at the end.	Most grow commercially bought open pollinated seed varieties, and then save seeds for the next season.	Cow rented and tethered on land before cultivation. Urea and NPK used. Chemical pesticides used. Irrigation from water pits.	Strong farmers group. Activities include sharing information and seed pooling. Some information from government extension service.
Thambaddai, Ampara District	Two individual households interviewed, one in shelter camp and one female headed household.	Both had main income and source of food from cultivation although one had had some other work.	Maha is the main season. Primarily vegetable crops. One household had had 3 cows and income from coconut sales.	They had saved their own seeds, but sometimes bought in a new variety if they heard about a particularly good one.	Cow rented and tethered on land before cultivation. Urea, NPK and chemical pesticides. Irrigation from wells.	Had been a growers group that gave micro-credit loans. Most knowledge from their own experience.
Rekawa, Hambantota District	Six households with homestead gardens interviewed.	Main income of households from various sources: fishing, office work, military. Cultivation provided some food and supplementary income for some of the households, although one household cultivated on a larger scale commercial scale.	Maha is the main season. Most households grew diverse vegetable and tree crops, although two had focused on a limited number of vegetables.	Most saved their own seeds and exchanged with neighbours. The household that cultivated commercially bought in seeds every year.	Most households did not use any method for soil fertility or pest control. The household that produced commercially did use chemical fertilisers and pesticides.	One grower was a member of a CBO that offered credit and supplied seedlings. All had learned from their own experience.

Sooriyawelana, Hambantota district	Six households with homestead gardens interviewed.	Main income and for all households was from cultivation, and source of food for some. Occasional additional income from contract work.	Maha is the main season. Half the households had diverse gardens with a range of vegetable and tree crops. Significant income for several households from coconut sales. The others grew a limited number of crops for commercial purposes. Some also cultivated paddy	All purchased hybrid seeds for some of their crops, but also grew local varieties, and saved their own seed.	All households used chemical fertilsers and pesticides and occasionally manure. Some growers took out loans at the start of the season to buy inputs and repaid at the end. Irrigation from the river.	No farmers group. Several had taken part in training organised by an international NGO. Information sometimes from the Department of Agriculture.
Madihe, Matara District	Two households interviewed	Main income for one household was mushroom production, and for the other, coir processing.	Maha and Yala growing seasons for rainfed crops. Mushrooms grown indoors. Both households had small gardens for some of their own food.	N/A	No chemical inputs used on mushrooms or coconuts.	No farmers groups. Information on mushroom cultivation from specific organisation.

Mirissa, Matara District	One household interviewed	Main income from cinnamon seedling production.	Maha and Yala growing seasons for rainfed crops. Additional spice seedlings grown for sale and garden for own vegetables and paddy cultivation.	N/A	Pesticides used on seedlings when needed.	No farmers group, but worked through government department and gained information from them.
Udupila, Matara District	Six households interviewed	Main income and source of food of five of the households was from cultivation. The other household had various sources including hotel and office work.	Maha and Yala main growing season. Mostly vegetable crops grown by five of the households. The other grew mainly papaya.	All of the growers used a significant proportion of home saved seed of local varieties for their vegetable crops The local growers save seeds of different local varieties and exchange with other growers. Hybrid seeds area also used for some crops, the main selection criteria being high yield.	Chemical pesticides and fertilisers used by all growers.	Strong farmers CBO in the area with about 100 members. Activities include buying bulk inputs to cut costs, sharing home-saved seeds, and information. Some information from government agriculture department. Papaya grower had grown new variety of papaya recommended by government agriculture department.

4.9 Impact assessments and information on agricultural rehabilitation

A survey of the agricultural rehabilitation strategies and practices of organisations involved in agricultural rehabilitation and development was also undertaken. Interviews were carried out with organisations working in post-tsunami agricultural rehabilitation in Sri Lanka with the aim of identifying rehabilitation strategies, possible links to longer-term development and resilience and constraints and opportunities to implementing 'ideal' sustainable interventions.

Interviews were based on a crib sheet, as in the interviews with homestead growers (see appendix b). The guide points addressed several issues including; their overall aims and activities; specific agricultural rehabilitation and development activities; post-tsunami impact and needs assessments; and their work approach and links in the area.Interviews with organisations took between 20 and 40 minutes depending on how much open discussion was generated.

Two coordination meetings for livelihoods were attended as part of the study; one national meeting and one district level meeting in Ampara. Coordination meetings were held for representatives of organisations working in the relief and rehabilitation process. Their objective was to coordinate the activities of different organisations to ensure even and fair delivery of aid and to share information and resources. Attendance was voluntary but they were open to all government departments and national and international NGOs. They were held at district and national level. The minutes for other coordination meetings, available from the Sri Lanka Humanitarian Information Centre (HIC) website[1], were also looked at in terms of issues relating to impact assessments, intervention plans, implementation and coordination.

Several regional and national impact and needs assessments for the agriculture sector were carried out and made available for general access on the HIC website. Two of these, the Food and Agriculture Organisation (FAO) 'Assessment of tsunami damage on crop production, land and irrigation water resources and suggestions for short and medium term activities in general agriculture' (FAO, 2005), and the Green Movement of Sri Lanka (GMSL) 'Post-tsunami assessment for recovery of livestock and agriculture sectors in Sri Lanka' (GMSL, 2005), were the only assessments relating specifically to the agriculture sector. They were both on a national scale, but included differing methodological approaches. The international NGO, the International Water Management Institute (IWMI) also carried out a consolidated livelihoods assessment for Hambantota district: 'Bringing Hambantota back to normal'

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[1] See: Agriculture and fisheries/ livelihoods coordination meetings minutes, Humanitarian Information Network, http://www.humanitarianinfo.org/srilanka/catalogue/Catalogues.aspx?CatID=34

(Anputhas *et al,* 2005). This related generally to livelihoods is several communities in Hambantota district, but included agriculture. All three assessments were analysed as part of this study to demonstrate different approaches to impact/ needs/ capacities assessments. However they are not necessarily representative of the overall distribution of approaches to assessments.

4.10 Analysing agricultural resilience

The analysis of the data is key to generating concepts and knowledge from research; "without analysis the research process … can achieve little in terms of explaining social phenomena" (Pole & Lampard, 2002). It is apparent that analysis is carried out after the data collection, but it is also an integral part of the research process and is undertaken at every stage. For example during semi- or un-structured interviews emerging themes may be noticed, and questions spontaneously added to further investigate the issue. The final analysis is that from which conclusions are drawn, but relies on the quality of prior analysis and on careful data collection (Pole and Lampard, 2002; Silverman, 2001).

The data from interviews with tsunami-affected homestead growers in Sri Lanka comprised of twenty-one household interviews and six focus groups, including wider discussion, and several annotated sketch maps. During the surveys the field notes were transcribed on the same day as the interviews. For the first stage of analysis the data were put into a spreadsheet with the relevant questions as headings. Additional headings were created for information linked to additional unexpected themes gathered from further discussion and the plot walks.

At the second stage of analysis the data were sorted according to emergent key themes and re-organised under these new headings. Some additional information and comments from interviews with organisations, relating to psychosocial impacts, were relevant to and thus were included in the analysis of agricultural resilience. The data and headings were sorted through several times to allow the key themes to emerge. Findings are presented in terms of themes supported by overall findings and specific case studies. These are described and illustrated in chapter 5.

5 The resilience of homestead gardens after the tsunami in Sri Lanka

5.1 Introduction

Whilst the focus has been on the resilience of small-scale agriculture systems, the themes that emerged from the survey have demonstrated the breadth of influencing factors at different levels. These range from the specific agronomic methods, to the broader livelihood systems, social capacity and networks and the influence of national and international development. The approach of this study has been to draw out key themes from the interview transcripts, several specific case studies and wider data. One of the major challenges of this research has been to incorporate and make sense of the aspects of the whole social, ecological and political systems that have become apparent. This chapter details the four overlapping themes that were identified as influencing the resilience of homestead gardens, both in terms of their resistance to the impact of the Tsunami, and their capacity to recover following the impact. Section 5.2 describes the themes, detailing the examples and case studies from which they are drawn. Section 5.3 summarises the themes and discusses their links and interactions.

5.2.1 Theme 1: Agro-ecological practices

Although none of the growers defined themselves as ecological, some of them practiced agro-ecological methods as described in chapter 3. These included intercropping trees, bushes and ground crops, using manure and compost, cultivating local varieties, and pest management such as hand picking and growing pest deterrent plants. Some are illustrated in the pictures in Figure 5.2.1a below. Many of the growers interviewed also used conventional agricultural inputs including pesticides and fertilisers to varying degrees. The survey of growers identified links between agro-ecological practices and reduced impact from the Tsunami in several of the gardens plots surveyed.

Grower in Udupilla holding up dried ridge gourds of a local variety for seed saving

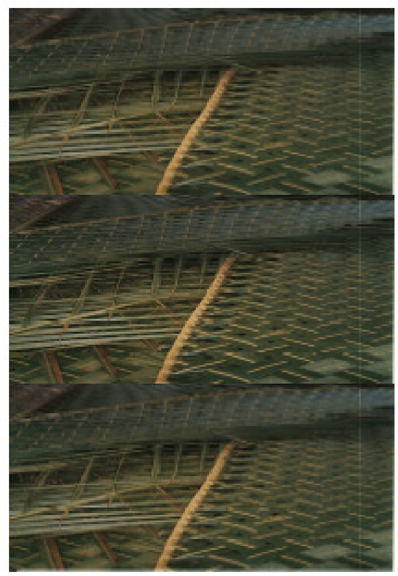
Tagetes marigolds in a plot of amaranth, planted to deter pests

Typical homestead garden with diverse crops and with multiple layers of vegetation only 4 months after it had been inundated by the Tsunami

Figure 5.2.1a Some of the agro-ecological approaches used by the growers interviewed (photos removed)

Trees were found to be vital in the home garden ecology in terms of improving resilience. Following the tsunami coconut palms (*Cocos nucifera*) were one of the few crops to consistently survive the inundation. Coconut palms grow abundantly along the coast and are a key feature in many of the plots surveyed. However, whilst some growers interviewed actively managed and harvested them, others had cleared areas of their land to plant more ground crops. Coconut palms are superbly adapted to coastal conditions being salt and drought tolerant and with flexible trunks, which absorb the energy of wind and waves. Although some trees were uprooted, most withstood the impact. A survey of the impact of the Tsunami on homestead garden vegetation (Hitinayake, 2005) also identified this pattern. All of households interviewed who had coconut palms in their plots and for whom a significant proportion of their income had come from coconut production, were still making this income following the tsunami. For several households this meant that they were still earning about half of their pre-tsunami income. The coconut is fundamental to life in Sri Lanka, and has been so historically. They are a truly multi-purpose tree with the flesh used for oil production and as a cooking ingredient; the husk fibre, or coir, for making for rope, bags and mats; the timber for construction; and the leaves for fuel, fencing and roofing. Some of these uses are illustrated in Figure 5.2.1b below. The coconut industry employs 135,000 people formally in plantations and processing, and countless more in informal production, sales and processing. The domestic consumption of nuts is almost 2, 000 million per year and the industry represents almost 15% of total agricultural GNP (CDA, 2003).

Timber

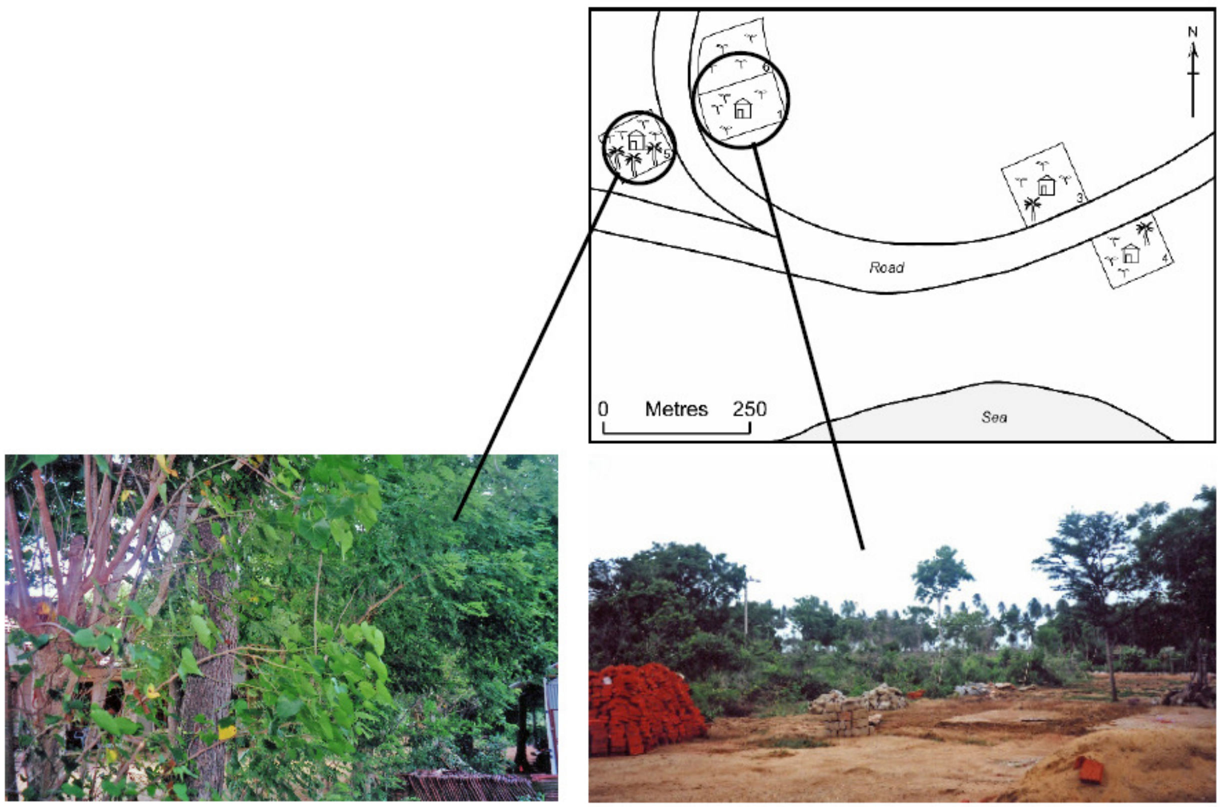


Woven leaves for roofing or fencing

Coir fibre ready to be spun to yarn for making bags and rope

Figure 5.2.1b Some of the many uses for coconut palms

Another case study of two neighbouring plots also highlighted the value of trees as protection from the impact of the Tsunami. The large-scale protection provided by natural coastal buffers such as mangroves and other natural coastal vegetation has been confirmed by countless examples following the 2004 tsunami. This was clearly demonstrated by two adjacent holdings one of which had been protected by a living fence and vegetation, whilst the other more exposed neighbouring household had been severely damaged shown in the pictures in Figure 5.2.1c below. Another household also mentioned living fences and vegetation as a mitigating factor to the tsunami impact.



Living fence that helped to protect this household from the Tsunami impact

Household exposed to the coast and badly damaged by the Tsunami

Figure 5.2.1c The impact of the tsunami on two neighbouring households, one with a living fence, and one exposed to the coast

Living fences in Sri Lanka comprise a variety of species, often including leguminous (nitrogen fixing) species such as *Gliricidia* and *Leuceana.* They are particularly beneficial for tropical soils as they enhance soil fertility, provide shade from intense heat, and the leaves of many species can be used as a mulch to add organic matter to the soil, or as animal fodder (Altieri, 1999 & 2002; Ranasinghe, 2006). These species also seem to have been resilient to the impact of the tsunami, with many surviving sea-water inundation and, in one plot, numerous *Leuceana leuceophala* appearing spontaneously and growing vigorously. A UNEP (2005) study found that stretches of dense mangrove and vegetated sand dunes appeared to protect the land and infrastructure behind them. However the tsunami did cause significant damage to some areas of mangrove and other coastal vegetation across the tsunami affected region. This study found that, even on a small scale, natural barriers such as living fences planted as part of an ecological farming system lessened the force of the wave, protecting the land and infrastructure behind.

Another aspect of ecological agriculture is the lower financial outlay of not buying inputs. Several of the growers surveyed experienced debt as a result of borrowing money to buy inputs. One grower explained that before the 1970's no agrochemicals were used in the village and growers produced their own seed of traditional varieties. High input 'Green Revolution' approaches were introduced and promoted by extension workers in the 1970s, but several growers found that the profit is similar in both systems as the higher yield from using modern technologies is offset by greater spending on inputs. The high spending on inputs had caused considerable debt problems in several households that had borrowed money to buy inputs at the start of the season and lost not only all their crops, but also the investment in inputs.

There were mixed opinions and understanding about the benefits of ecological agriculture practices amongst the growers surveyed. Members of one focus group expressed concern that living fences would shade out their crops, and there was a lack of knowledge about their benefits, for instance providing shade to prevent the water evaporation and fixing nitrogen. The labour intensive nature of many ecological approaches was considered to be a significant constraint by many, although in some cases their benefits were recognised. One grower commented that his father used manure instead of synthetic fertilisers and achieved about a much longer consistent yield from his crops. However, although the interviewee used to use manure and paddy straw, he had stopped due to the greater labour demand as compared with synthetic fertilisers. Growers in Ampara district generally used manure to improve soil fertility, but growers in Matara and Hambantota districts seemed to rely on synthetic inputs. Overall traditional crop varieties were widely valued. Most growers saved at least some of their own seeds of traditional varieties for reasons including cost saving, taste and that there is a consumer preference and a price premium for them. Hybrid seeds were also grown in most gardens, primarily on the basis of yield.

Looking at the reasoning behind which agricultural practices are used and how they are learned, most growers had learned their practices from their own experience or other family members. There were several examples where growers had adopted practices promoted by extensionists and NGOs. These included both ecological and conventional methods, composting and the use of plants for pest control. However a major factor in the uptake of innovations was their labour intensity. For example, as mentioned above, one group of growers had not planted living fences although it was suggested by extensionists, because it would take a considerable time to implement and they thought that the trees would compete for light and water with their crops. With respect to this it appears that training and information provision on appropriate ecological methods can play a significant role in building the resilience of homestead gardens in Sri Lanka. However it should also be noted that the uptake of methods is less likely to be successful if there are perceived disadvantages to them, such as additional labour requirements or decreased yields. These issues must also be set in the context of wider development. Several of the growers interviewed mentioned that they were not able to employ casual labour due to competition for workers from the garment industry, which has become a major export production in Sri Lanka, and has raised wages for unskilled workers. As a result growers were less able to carry out more labour intensive work such as hand weeding or composting, which required them to hire additional labour. This had led to the increased use of less labour intensive agrochemicals. In another location a grower had planted a whole plot with a new variety of papaya, promoted by the Department of Agriculture for its storage qualities. However it had turned out to be very susceptible to virus attack and the grower had spent a lot of money on pesticides for this, before losing many of them in the tsunami, which had left him in considerable financial difficulties.

5.2.2 Theme 2: Livelihood diversification

Diversification of income generating activities and off-farm employment in rural communities is widely recognised as an integral part of rural livelihoods (Barrett *et al,* 2001; Christoplos *et al,* 2004; Niehof, 2004). Many of the interviewees in this survey were engaged in off-farm employment, such as office work or contracted farm labour, and non-land based agricultural activities, such as coir processing, mushroom cultivation or seedling production, shown in the photos below. All of the interviewees who had diversified sources of income, had continued to gain some earnings following the tsunami. Many jobs such as office work, had not been severely affected by the Tsunami, as the impact was so localised. Non-land-based, and non-seasonal agricultural activities, such as mushroom and seedling cultivation could be re-established quite easily. Several aid programs were supporting this, although not everyone had had access to funding. Some of the livelihood approaches found in this survey are shown in the pictures in Figure 5.2.2.

Mushroom cultivation

Cinnamon seedlings

Coir processing machinery

Figure 5.2.2 Diverse livelihood approaches amongst growers interviewed (photos removed_

The coconut processing industry had been affected by the disaster because much equipment had been lost or damaged. A coir fibre-processing mill had suffered a significant decrease in demand for raw fibre due to the loss of many coir-spinning machines. Relief and rehabilitation efforts responded quickly to the industry with widespread distributions of coir spinning machines, and grants available for the repair of coir mills. This traditional industry is ingrained in Sri Lankan culture, but its continuation is threatened by the increasing use of plastic rope and woven plastic sacks for tea collection. One national institution interviewed was eager to work on the revitalisation of the various coconut related industries, introducing appropriate new technologies to make processing more efficient (personal communication, 2005). Given the vital and resilient role that the coconut industry has played in maintaining incomes post-tsunami, there is a strong case for its strengthening, revitalisation and modernization.

5.2.3 Theme 3: Social capacity

Where they were observed or discussed, it was apparent that some community groups had been well mobilised before the tsunami to access and share information and inputs such as seeds. After the tsunami many communities worked together in formal and informal groups to make land rehabilitation and cultivation possible, for instance clearing land, accessing inputs and applying for assistance. Of the communities visited that had re-formed their community based organisations (CBOs) following the tsunami, they had all re-started, or had put considerable effort and motivation into to re-starting cultivation and working out the challenges for themselves. Some of the achievements of these groups are shown in the pictures 5.2.3a below. These included applying for assistance as a group, replanting shared gardens, and collectively having soil tests done to find out if the land was ready for cultivation. They were aware that they had a greater capacity and better chance of being responded to as a group than as individuals. Family and friendship networks also played a vital role in the rehabilitation of livelihoods for many households. Some growers had replanted their crops on the strength of loans from family or friends and without any NGO or government aid towards rebuilding agriculture. Further, many households demonstrated remarkable personal motivation and innovation to resume cultivation without any external aid. For instance one household had planted a $10m^2$ plot to test for soil suitability, as shown in one of the pictures 5.2.3a below.

One published post-tsunami livelihoods assessment for Hambantota (Anputhas *et al,* 2005) commented on the roles of CBOs such as farmers' organizations, fisheries cooperatives, coir manufacturing societies etc. It identified a large variation pre and post-tsunami in terms of the effectiveness of CBOs, some being well managed and effective and some being ineffective and suffering from lack of funds, poor management and internal conflicts. The report did find that, despite lack of resources and facilities, or non-presence of CBOs "all communities have shown positive signs of cohesiveness and solidarity" (p27).

Overall in the survey psychosocial issues were found to have a significant impact on households' capacity to resume agriculture. Evidence for this came from both householders themselves, and many of the aid organisations interviewed. Lack of motivation and issues such as depression and 'dependency' on aid were a considerable constraint to some households. Many people had lost family members and were in mourning. Many were also living in temporary accommodation and in situation of great uncertainty, which posed both practical constraints to starting cultivation again, such as lack of land, and psychological issues. There were also numerous comments in various contexts that people had become dependent on aid, which had brought expectancy for handouts and diminished their motivation for rehabilitation, although there is insufficient evidence to confirm this.

Members of Poomagal Farmers Association

Garden cultivated after the tsunami in Karativu

Crops growing after the tsunami in Kotukal

Bitter gourd trelice in Sooriyawelana garden after the tsunami

Trial garden in Thambaddai

Figure 5.2.3a Examples of community group and individual rehabilitation efforts (photos removed)

Agricultural and other livelihood activities were also found to have a potential role in the improvement of psychosocial wellbeing. Several examples were found where support and training for homestead gardens and coir processing was introduced with the primary aim of providing activities and community building to lift their spirits, with the improvement of livelihood options being only a secondary outcome. The pictures below (Figure 5.2.3b) show coir processing activities with a group of women, which was to culminate in an exhibition of the products they had made. The link between natural resource based psychosocial activities and post disaster recovery was observed during this study in relation to effects observed in Aceh, Indonesia (Bradbury *et al*, 2005), and the activities of several aid agencies in Sri Lanka, which had established home garden and coir processing community support activities.

Figure 5.2.3b Coir craft making with a group of women, leading towards an exhibition of their work

5.2.4 Theme 4: The wider context of development

Development and natural inappropriate resource management has frequently had unprecedented negative effects on communities' livelihoods and resilience. In the case of the 2004 Tsunami, the unsustainable harvesting of coral reefs and mangroves has been found to have increased the impact of the wave (UNEP, 2005). Other impacts of development, such as the destruction of forests, increased dependence on external markets and the development of settlements in hazard-prone areas, has also served to increase vulnerability across the globe (Abramovitz, 2001; Adger, 2003; Wisner, 2003; Vandermeer *et al,* 1998).

The impact of development was noted in several cases in the survey on homestead gardens. One situation was found in one of the villages as an unintended consequence of an upstream dam construction in Hambantota district. The village is situated along the river Kirinde Oya. All growers interviewed remarked on a dam that had been built about 15 years previously. This was part of an Asian Development Bank (ADB) funded project, which aimed to increase irrigated land in the district and create a location where communities from other congested parts of Sri Lanka could settle to farm, and thus to create employment opportunities, increase food production, enhance foreign exchange and improve nutritional standards and income in one of the driest regions of Sri Lanka. The central focus of the multi-million dollar project was the construction of the Lunugamvehera dam for irrigating the watershed. It had been the largest irrigation project undertaken in the southern part of the country.

Although the aims of the project were commendable, faults in the project design and implementation resulted in the project achieving none of the primary aims. A detailed hydrological analysis was not carried out, and as a result water availability was over-estimated. The cost of dam construction increased five-fold from original estimates as the project went on longer than planned. There was also a general failure in considering alternative sites, consulting with local communities or adequate attention to their multiple needs, including those of women. Though poverty reduction was the projects stated overall goal, in reality it has seen the regions poor become poorer and its rich richer. The improved infrastructure and services, such as roads and schools, was a positive outcome, however there were issues over their maintenance after project completion. Due to the overestimation of water availability, four townships were constructed, however two have since been abandoned, largely because of the lack of water, and therefore economic viability. Overall, having displaced almost 1500 families, with many fields abandoned due to lack of water, and few benefits, the project was described, by the ADB itself as “less than successful” (ADB, 2000; GMSL, 2000).

An additional impact was that it had stopped the seasonal flooding of the river that also brought fertile sediment to the land. This was mentioned by all of the growers surveyed and it was stated that they had had to use additional fertiliser and that there were fewer coconut palms growing following the development. The interviewees unanimously mentioned the change in river flow since the dam construction and the end of the seasonal flooding that had brought fertile sediment. Interviewees mentioned that since the dam construction they had had to increase their fertiliser use and there were fewer coconut trees. Another aspect of development that was discussed by many of the growers was the high cost of inputs, the use of which had been widely promoted in the 1970s. This had resulted in debt for several households and severe financial hardship following the tsunami as they had not only lost their crops, but also still had the debt incurred from purchasing the inputs. One household was using the government relief grant to repay their loan and were planning to take out another loan to purchase inputs for the coming season. Figure 5.2.4 below shows a hypothetical flowchart showing links between ‘development’ and increased vulnerability to the tsunami in Sooriyawelana village.

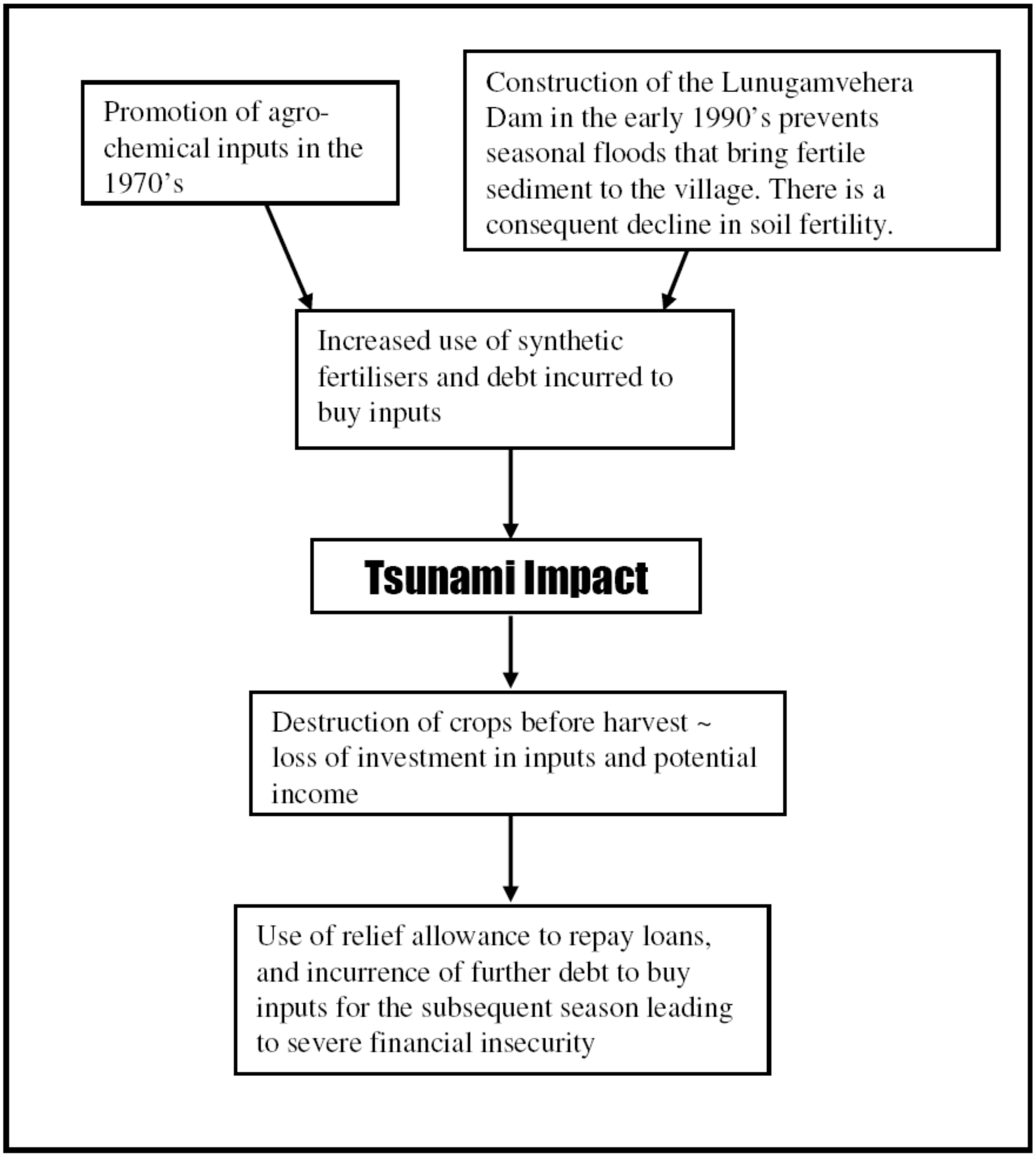


Figure 5.2.4 Hypothetical flowchart linking inappropriate development with increased vulnerability in Sooriyawelana, Hambantota

Approaches to cultivation were also impacted by development. Most of the growers interviewed had received advice or training from an organisation in some form, either from the government agricultural extension service or NGOs. A wide range of practices have been promoted by extensionists, including Green Revolution technologies, pest deterrent plants, living fences and composting. In most cases the recommendations had been taken up, but this seemed to depend on the trade-off between the cost and labour intensiveness, and the immediate benefits of adopting the practice. For example many people used chemical fertilisers as there was an immediate improvement in yield, but the labour requirements for making living fences, and lack of clear benefits meant that the growers to whom this had been recommended did not do this.

The success of taking up recommendations varied. For example, one grower had planted a whole plot with a new variety of papaya, promoted by the Department of Agriculture for its storage qualities. However it had turned out to be very susceptible to virus attack and the grower had spent a lot of money on pesticides for this, before losing many of them in the 2004 Tsunami. Some growers mentioned that they were not able to employ casual labour due to competition from the garment industry, which has become a major export production in Sri Lanka. As a result growers were less able to carry out more labour intensive work such as hand weeding or composting, and using agrochemicals instead incurred associated financial and environmental costs. Many discussed the use of improved commercial crop varieties.

5.3 The intersection of the themes

The four themes described above emerged as distinct issues relating to the impact of the Tsunami on gardens, and their capacity to recover following the disaster. They are based on different levels of association with homegarden systems: the agronomic practices; the whole household livelihood system; that of the human capacity and networks; and that of overall national and international markets, and development policy. In addition to impacting the homestead garden system, there are significant interactions between the different levels.

In terms of agronomic practices, the key factors influencing them that came out of the survey were the training and experience of the growers, the cost of labour, access to materials including inputs, credit and other materials such as irrigation equipment, and environmental factors such as soil fertility. Most growers stated that they used methods that they had learned from their family or their own experience, but where growers had received extension information or training there was a clear uptake of practices, including the use of fertilisers and pesticides, and composting. The uptake of methods was also influenced by the labour intensity of the activity and the cost and availability of labour. Most households used labour only from their own household, and the increased cost of labour was an influential factor in the decision to take on additional seasonal help. The cost of labour was, as a specific example, influenced by the growth in the garment industry, which is in turn influenced by international markets. There appeared to be wide access to inputs, and capacity or credit available to purchase them. Where there was good access to cattle, as was the case in Ampara district, manure was used widely to improve soil fertility, based on a system of growers renting a cow for a period to manure their land.

Features of the growing environment, such as soil fertility also influenced agronomic practices. In Sooriyawelana village, before the construction of the dam, fertile sediment that had come with the seasonal floods, had improved the soil. Since the dam, and stopping of the floods, the growers had noted a decline in fertility levels and started adding synthetic fertilisers, based on the extension advice at the time. The priorities and approaches of training and extension are in turn influenced by national and international policy and markets. Seasonality had a considerable impact on the rehabilitation of cultivation following the Tsunami. Many of the growers and aid agencies in Hambantota and Ampara districts, where they have only one wet season, were waiting for the following wet season before resuming cultivation and distributing rehabilitation aid, although, some growers had started cultivation on a small, or trial scale.

Where they were identified, factors influencing the broader livelihood options for households were their own and family experience, and the training or extension available to them. For example, the mushroom growing household had taken up the activity following free training offered by the government, whilst the coir processors had taken over a family business. These industries are also impacted by broader national and international markets. For example, the coir processors and Coconut Development Board (personal communication) identified that the increase in popularity of synthetic ropes and alternative timber and building materials, were adversely affecting the market for coir and coconut palm based produce.

The human capacities identified in the study included the knowledge, skills, motivation and material resources of the growers, and social capacities include their families, friends and support networks. The motivation of household members is central to the rehabilitation of their livelihoods, and a full analysis of this is another study in itself. There were clear examples of how individuals and community groups had used their own capacities to resume their livelihoods, either through experimenting with potential cultivation or through re-establishing agro-processing industries. Also of interest here is that one of the major reasons for lack of rehabilitation were psycho-social issues, including depression, loss of motivation and bereavement. This was highlighted by both the growers and aid agencies interviewed. Lack of motivation was linked to, not only the direct psychological impacts of the disaster, but also the impact of aid and reliance on handouts of some households. There is an additional link between resuming livelihoods and the psychosocial wellbeing of affected people, which this study was not designed to investigate. It was observed that livelihood and home-garden rehabilitation methods were used as a phsychosocial activity, for example coir processing and home garden rehabilitation. Figure 5.3 below details a conceptual web of the interactions found in this research linking the four key themes described above.

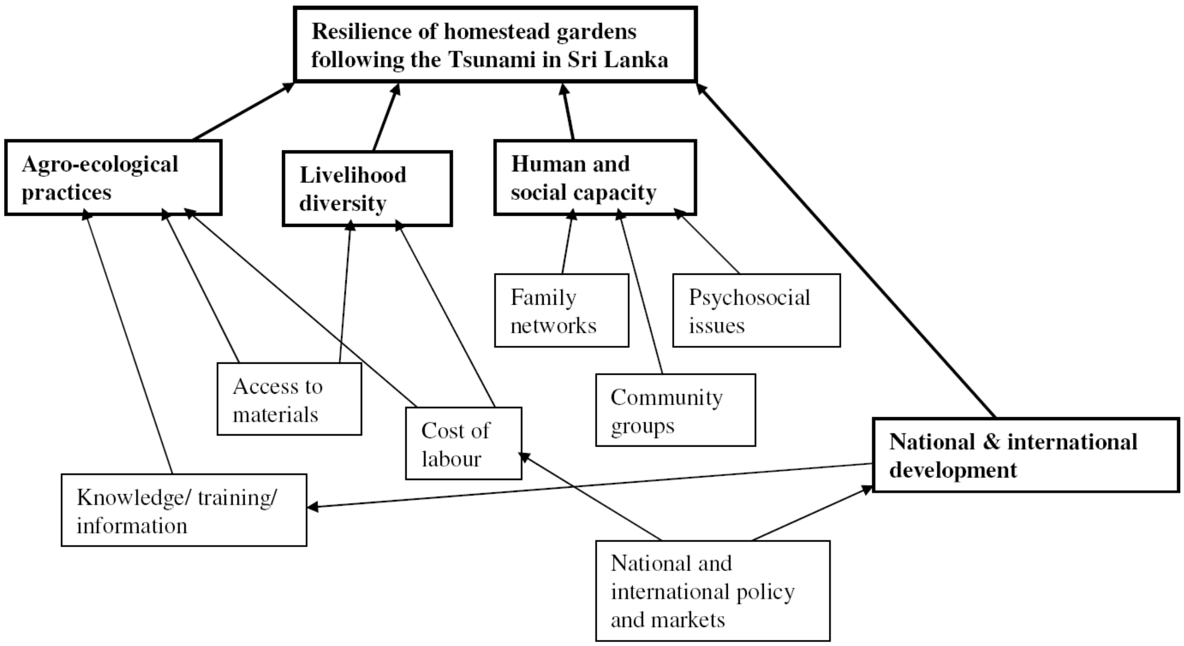


Figure 5.3 The four key themes found to influence the resilience of homestead gardens to the Tsunami, and the web of interactions found in this study linking them

The next and final chapter looks at the research approach and these interactions that have been found to impact the resilience of homestead gardens, considering the wider relevance of findings for research and development relating to agricultural resilience.

6 Cultivating resilience

The overall aims of this research were:

i) To investigate, through the example of homestead gardens in Sri Lanka affected by the tsunami, conditions impacting the resilience of agriculture to disasters.

ii) To consider the potential wider applications of this analysis for agricultural development and rehabilitation approaches that build resilience as well as meet immediate needs.

A web of features and issues that affect the resilience of homestead garden systems to the Tsunami in Sri Lanka have been found through this research. These ranged from specific agronomic practices to much broader issues that are also likely to affect overall household and community resilience beyond just the homestead garden. Analysis of the themes not only identified important issues related to the resilience of homestead gardens, but also highlighted the fact that different methods of research allow different issues and biases to emerge. This chapter looks at the findings of the study and their broader relevance and application. The first section is a critique of the methodology, which considers the challenges and advantages of the approach taken in this study, and the ways in which it impacted the findings. The next section looks at what the findings demonstrate about the resilience at the level of homestead garden systems, and then at a broader household and community level. The final section looks at the findings in the wider context of theories of resilience, and examines the broader application of findings from this research topic.

6.1 The methodology

The aim of this research was to look at the resilience of homestead gardens. The Holt-Giminez study, which compared the resilience of more and less ecological plots following Hurricane Mitch in Central America (Holt-Gimmenez, 2000 & 2002; World Neighbours, 2000) was an important influence for this study. However there are significant differences between the research approaches and results that have brought out some interesting observations about approaches to agricultural research in general. The Holt-Gimenez study focussed on the physical resistance of agro-ecological farms in comparison to more conventionally cultivated plots. The methodology involved physical analysis of the plots and comparison of paired plots. This study looked more broadly at the overall resilience of homestead garden systems, which included features that affected their resistance to the Tsunami impact, but also broader features that impacted their capacity to recover following the disaster. The key differences between that and this research project were the scale - hundreds of researchers and analysed plots, compared to one researcher and several helpers, and around 20 plots; language and communication - the Holt-Gimenez study was carried out by local researchers, whilst this survey was conducted through translators; the pairing of sites; and the quantitative aspects of the research approach. As plots were not paired in terms of more and less ecological approaches, other than the one case study found, it was not possible to measure and compare impacts on a quantitative basis.

The methodology used posed specific challenges in terms of making sense of the range and forms of information gathered. Whilst the key theory was based on agronomic approaches, the issues that emerged as being significant covered a full range of scales, and making sense of these and relating them back to the resilience of homestead gardens has yielded very different types of results to measurement based research, yet the results are valuable in the breadth of issues that they cover.

A key difference between this survey and the Holt-Gimenez study is that this study was not designed to quantify the impact of practices, unlike the Holt-Gimenez study, which measured the differences in soil erosion, moisture content and vegetation. The differences in impact in this study were based on observation, from both the researcher and households involved in the study. The quantification of impacts is a valuable tool in order to provide convincing evidence for different methods. However, even in the Holt-Gimenez study, it was not possible in most cases to pin impacts causally to specific agro-ecological practices. The findings from this study were greatly enhanced by the case study of neighbouring households, which had very different impacts from the Tsunami for which the best explanation was the difference in vegetation cover, and specifically tree crops. The finding of this example was a lucky coincidence and highlights the challenges and the scale of the Holt-Gimenez study to find up to 1000 pairs of plots.

The research approach for this study included a combination of interviews with homestead garden owners and plot walks. Although measurements were not taken, the plot walks included observation and discussion of the impacts of the Tsunami. The plot walk proved essential to bring out issues and features relating to the impact of agronomic approaches on the resilience of the gardens, and established some solid examples of where agro-ecological approaches contributed to the resilience of the plots, in terms of protecting buildings, and the survival of viable tree crops even when ground crops had been washed away. These findings were supported by discussion with the plot holders and neighbours, and other impact assessment documents. There were several cases where it was not possible to conduct a walk, for instance where people had been displaced from their gardens. The interviews held with growers thus played a significant part of the results, and this worked to bring out much broader issues & larger scale than only the agronomic approaches. Although the Holt-Gimenez study also included interviews and some analysis of results including the economic and social impacts of the disaster, the results and themes from this study are based more in narrative and discussion. This approach has highlighted a significantly wide range of issues both agronomic and social.

The wider issues to come out of the survey included the debt incurred by growers through buying inputs, the role of individual motivation, community groups and networks in facilitating rehabilitation, and the impact of broader development. The impact of development included the cost of labour, and physical impacts such as the change in flooding patterns because of the upstream dam, which impacted the downstream soil fertility. Although more detailed research into each of these issues is needed to fully understand them and their consequences, their apparentness from this research is valuable to demonstrate the different levels of influence on the agronomic practices and resilience of homestead gardens.

In terms of the actual research location, whilst the homestead gardens are fairly typical of rural systems in the tropics, the Indian Ocean Tsunami was an unusual disaster in terms of the scale of impact across many different countries and the very localised impact along the coast. Tsunami are relatively rare in most of the affected counties, including Sri Lanka, and there is little reason that there would be local adaptation to this type of disaster, as such adaptation requires repeated exposure to events. Despite this, the themes relating to the resilience of homestead growers in Sri Lanka reflect broader theory on agricultural resilience as detailed in chapter 3, which indicates that certain good practice can lead to resilience that is transferable to different hazards.

6.2 What contributed to the resilience of homestead gardens?

The resilience of socio-ecological systems, as described in chapter 2, can be defined by the following three qualities:

1. The amount of disturbance a system can absorb and still retain the same controls on function and structure;
2. The degree to which the system is capable of self-organisation;
3. The capacity of the system for learning and adaptive management.

(Walker *et al*, 2002)

Based on these qualities, this section looks at the findings from this research and how they impact the resilience of the homestead garden systems. In this context the functions are taken as that of the whole household, such as providing sufficient food, income and shelter for the members, rather than only production in the garden. For example, in most cases farm production was greatly reduced, but many of the households had other sources of income and food provision and were able to maintain the overall household functions.

6.2.1 The amount of disturbance the systems could absorb

The resistance of many of the systems looked at was enhanced by various agro-ecological practices. Firstly, looking at the physical properties of agro-ecological practices, the amount, and diversity of ground cover clearly had an impact on both the resistance of households to the impact of the Tsunami and their capacity to recover following the disaster. Tree and shrub cover and fences mitigated the force of the water and protected buildings. Holt-Gimenez similarly found that the physical properties of ecological agriculture approaches enhanced the resistance of the plots to the hurricane. These included the barrier and soil stabilising effects of trees and their root systems. Additional effects were found by Holt-Gimenez from other practices such as terracing and bunds, which specifically worked to stabilise steep slopes

The Holt-Gimenez study identified the need for the integrated management of the whole slope and watershed, as landslides were frequently found to start beyond the farmers' boundaries. The loss of mangrove forest was widely observed to have aggravated the impact of the Tsunami in many of the countries affected, including Sri Lanka. Similarly the enhanced resistance to a variety of disasters from tree cover beyond grower managed systems, was supported by feedback from interviewees in this study, and is also echoed in a range of different examples from other studies, including coastal and mountainous areas (Anputhas *et al*, 2005; Climate Change, Vulnerable Communities and Adaptation, 2003; UNEP, 2005). The dam described in one of the villages surveyed represented a development beyond the boundaries of growers holdings which impacted their resilience through the loss of soil fertility, and consequent reduction in trees growing and, indirectly, through the increased purchase of inputs.

The other aspect influencing the amount of disturbance that could be absorbed by the households surveyed is their capacity to recover their key functions following the impact. A knock-on effect of the increased resistance to the impact of the Tsunami is the enhanced capacity to recover following the disaster. Lower levels of damage to buildings and infrastructure meant that it was possible to return to the land relatively soon after the disaster. The fact that many of the tree crops remained productive meant that households with trees were able to access them as food and for income.

Coversely there was a level of impact beyond which systems were damaged so severely as to have lost their key functions. For example, where peoples' homes and gardens had been damaged to the point that they were in temporary shelter camps, or people were severely psychologically affected by the disaster recovery of the key roles of their livelihood system, their food security, income and the environmental and human well-being, needed considerable extra support. In many situations the localised impact of the Tsunami meant that people had lost their land, homes and support networks regardless of their farming practices and skills. In such cases support was provided in the form of temporary shelter and training in new skills, but recovery was likely to take some time. This links to findings from other research relating to the upper capacity of systems to absorb extreme impacts regardless of the system structure, for example the capacity of local institutions to support communities (Batista & Baas, 2004), and specific regions which had received a particularly severe impact following Hurricane Mitch, where the level of resistance was found to be low, regardless of farming practices (Holt-Gimmenez, 2002).

The debt associated with the use of externally sourced inputs was a significant issue to come out of this study, especially in one area surveyed, where there was clear evidence of debt cycle related to the purchase of inputs. It was also considered by households surveyed that lower input approaches would have the same profits as the lower yields would be offset by the lower costs on inputs. This is an issue identified more broadly in agricultural development research, however the economics of the holdings require a greater depth of analysis before any conclusions can be drawn. The opinions regarding the cost of inputs in are contrasted by findings in another survey location, where the cost of labour was identified as the reason for not using ecological approaches, and using less labour intensive inputs instead. The results from this study were not sufficient to draw conclusions on the economic benefits of lower input approaches as compared to the use of inputs. However the study clearly highlights the complexity of agronomic systems, and the influence of different levels of knowledge, resources and markets.

6.2.2 The degree to which the systems are capable of self organisation

At the time of the survey there had been very limited livelihood interventions from aid organisations so the findings were based primarily on households own capacities for organisation and recovery, although most households interviewed were receiving financial assistance from the government. Alternative livelihood options were an important feature which enabled many households to recover activity and income generation following the disaster. Households access to alternative income options enabled them to re-organise their means of livelihood. The fact of diverse livelihoods amongst small rural households has been widely recognised (Barrett *et al*, 2001; Ellis, 1999). This study found that households with a variety of livelihood options were better able to recover at least some of their activities, and thus income, following the disaster. These included outside paid work, agro-processing and non-seasonal agricultural activities such as mushroom cultivation and tree seedling production. The reasons for access to livelihood options was not looked at in great depth in this research, but is pertinent to development strategies that aim to improve the resilience of rural households. Factors mentioned in the survey that facilitated the diversification of livelihoods included individual innovation, access to outside employment and the provision of training in new skills.

Another issue that was significant to the recovery of households affected by the Tsunami was their human and social capacities. In terms of individuals, there was evidence that their access to support networks and psychological state had a profound effect on their capacity to recover following the disaster. The psychological problems experienced by people following a disaster are considerable. In this study depression and lack of motivation were the most common reason identified by householders and aid agencies for not returning to livelihood activities. Although not specifically looked at in this study, a relationship between improved psychological health and the return to normal livelihood activities was observed. The link between psychological health and livelihood recovery is an important issue in post-disaster situations and, although it is beyond the scope of this study, is one which merits further investigation.

The role of community groups and networks was another factor that emerged as being crucial to the capacity of households to re-organise their activites following the Tsunami. Many community groups had formed strong networks for support, activity and accessing resources, which helped them to resume cultivation even in the absence of external aid. Several households had been able to recover their livelihoods through their own capacities – ideas or savings - or through help or loans from family members. This emphasises the value of supporting communities in development and rehabilitation, and the implementation of interventions that do not undermine the capacity and strength of community groups, institutions and networks.

The level of damage experienced by households did enforce a limit to their capacity to self-organise. This related to both damage to mental health and to property and resources. Severe emotional trauma, for example from the loss of family members, was widely recognised as an obstruction to adaptation to the new circumstances. The loss of material assets, including housing and access to land, was also a limiting factor to recovery. Households that had moved to temporary shelter camps were severely limited in their capacity to recover their livelihoods.

6.2.3 The capacity of the systems for learning and adaptive management

The measurement of this system quality requires data from different periods so couldn't be assessed in this study. However evidence of adaptive management was shown in several cases, including households that had savings that they had used to rebuild their livelihoods, where community groups had changed their activities and carried out local impact assessments in anticipation of being able to apply for funding, and where a household had set up a trial garden to ascertain which crops would grow. Conversely, mal-adaptive management was demonstrated by households that were in a debt-cycle, which had been aggravated by the disaster.

The capacity of systems to learn and adapt their management also applies to approaches to relief, rehabilitation and development. Many organisations involved in the process have a wide range of valuable experience from different situations and countries and the storage learning from this knowledge is a fundamental basis for developing approaches that support more resilience communities. A key feature of learning is the transfer of information and reflection. It is hoped that this research will contribute to the pool of knowledge on the impacts of the Tsunami and feed into the adaptive development of policies.

6.3 The wider context: planning-in resilience

The second objective of this research is to consider the potential wider applications of the findings for agricultural development and rehabilitation approaches that build resilience as well as meet immediate needs. One aspect of this is the findings relating to the methodology used, as discussed in section 6.1 above. The research approach of interviews and observation through plot walks brought out a breadth of information, which exposes the multiple levels of influence relating to the resilience of homestead gardens. Whilst this is a valuable collection of information, it has also raised a series of questions, which were not anticipated, for example the role of agriculture in psychosocial rehabilitation. Such issues can only be addressed through more focused research methodologies.

The findings in the four themes from this study do however tie in with other research and theory on resilience, which provide starting points to identify how resilience can be planned into future development. The following sections detail these starting points along with suggestions for significant lines of further investigation.

6.3.1 Agronomic approaches

Although the focus has been somewhat diverted from specifically agro-ecological approaches in the findings of this research, the agronomic approaches used are fundamental to the both the resistance and the latitude, or capacity to recover, of homestead agriculture systems. The contribution of agro-ecological approaches to the resilience of systems should not be overlooked. Although the appropriate agroecological approaches are, by their nature, site specific, overall principles, including diversity, ground cover and trees, are universal.

In terms of the adoption of these approaches, whilst they are integral to much traditional agriculture, the influence of extension and training on agronomic practices has been clear. This has been both in terms of the uptake of conventional inputs, and in the adoption of more ecological approaches. In the light of this it is important that extension and training services deliver appropriate and balanced information and training. However the decision to take up specific practices was based on growers understanding of financial and labour trade-offs. In order to make fully informed decisions on such issues balanced information on the costs and benefits of different approaches is needed. In addition it may be necessary to provide specific material or labour support to promote the adoption of approaches without obvious immediate benefits, but clear resilience advantages.

6.3.2 Nurturing diverse livelihoods for resilience

This study supports the overall link between diversity at different levels. Here diversity is seen in terms of crops, networks and livelihood options. Diversity provides an insurance against uncertainty and allows for re-organisation to adapt to changes. Looking specifically at livelihood options (the other issues being looked at in other sections) more research is needed on the factors that influence the diversification of livelihoods. From this study the factors that emerged included opportunities for re-skilling, and work opportunities. Training is helpful to enable people to take up work that is new to them, whether that is a private enterprise or gaining employment. The provision of training opportunities should be a consideration in resilience-building development policy.

6.3.3 Supporting human capacities

The role of local capacities for facilitating rehabilitation at the individual and community levels has been identified as fundamental to the resilience of homestead gardens. Both contribute to the capacity for self-organisation and adaptation to a changing situation. Again further research is necessary in order to ascertain the dynamics that contribute to these capacities. On an individual level the capacities identified include personal motivation to restart cultivation and having savings to facilitate rebuilding livelihoods.

On a community level the capacities noted include organisation and motivation to carry out needs assessments and working together to develop plots and access inputs. It is crucial that development or rehabilitation approaches support these qualities that form a strong basis for resilient households and communities.

Different approaches to agricultural rehabilitation, some of which are discussed in chapter 3, can support or undermine local systems. In order to build resilience, interventions should build on capacities and at least not undermine them. The basis to reinforcing local institutional capacities in the context of development or rehabilitation is an equal partnership between organisations, and community-based and led response. Theory on resilience and adaptive capacity identifies combining knowledge systems as crucial to building resilient systems. The literature on agricultural rehabilitation also emphasises the importance of sharing information on situation assessments, interventions and evaluations in order to maximise the efficiency of interventions, avoid duplication of efforts and learn from others experience. Information sharing between different stakeholders is also crucial to facilitate the development of appropriate policy.

The psychosocial impact of disasters on the capacity of individuals and their ability to resume their livelihoods is considerable. The implementation of appropriate and effective interventions contributes to local capacities and the resilience building potential of interventions. It is also clear that there is a limit to people's capacities to recover and make use of support, which can be based on the level of psychological or material impact they have experienced during a disaster. It is thus crucial that rehabilitation approaches can identify the level of capacity and provide appropriate support for basic needs.

6.3.4 Resilience building development

The role of development is fundamental to all of the issues discussed above, as it sets the context for the physical, social and economic landscape in which households act. The impacts of development found in this study demonstrate importance of factoring resilience into development policy. The forms of development looked at in this research include those with a direct physical impact, such as the construction of a dam or the promotion of inputs, and those with an indirect impact, such as the cost of labour increasing as a result of the garment industry.

The unpredictable breadth of the impacts of development projects or the introduction of new technologies demonstrates the importance that any new projects or developments should take a holistic approach, and include environmental impact assessments. The management of the wider landscape has also been shown to impact the resilience of households, and conservation and sustainable management of natural habitat is crucial to the resilience of surrounding land. In terms of agriculture, there may be a role for new technologies such as drought resistant varieties, but these must be evaluated in terms of the specific environmental context. The use of frameworks as discussed in chapter 3, can bring about the opportunity to actually plan resilience building into new developments. What actions can be taken to influence development? Individual action is important, but political action, in the form of voting, campaigning and the adoptions of international frameworks is also crucial to bring about an overall context which allows for equitable information, education and decisions to be made based on the best interests and resilience of households affected.

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Appendix a

Guide questions for farmers

Location:

Date/ time:

1. Farm system background information
2. Tsunami impact
3. Coping strategies and assistance
4. Interviewee background information

1. Farming system background information

1a. Is this their only income? If not, what proportion of income comes from the farm?

- Most, more than half, half, less than half, very little
- Where/ how is it sold
- Other sources of income

1b. Farm size, number of contract workers, do they have land other than this land,

1c. Description of crops, processing activities:

- Fruit/ trees, vegetables, seedlings, livestock, processing
- Identify the most important crops if any

1d. What proportion of own food comes from the farm?

- Most, more than half, half, less than half, very little

1e. How long have they been there? What did they do before?

1f. Soil fertility

- Urea, NPK, compost, manure, green manure

1g. Pest control

1h. Seeds and varieties

- Own saved or bought
- Variety selection criteria

1i. Any other hazards in the area

- Drought, flooding, storms

1j. Member of CBO, farmers group etc

1k. Sources of information on farming

- Govt extension, family, neighbours, farmer groups, radio, commercial companies
- Exchange information with other farmers
- Type of information eg training, crop varieties, products

2.Tsunami impact

2a. Height of water

2b. Duration of water cover

2c. Distance of farm plot (s) from sea

2d. Impact on basic needs

- Housing, water, food, health, kitchen equipment

2e. Crops lost

2f. Agricultural and agro-processing equipment lost

- Food stores, tools, seeds, other inputs

2g. Other immediate impacts

- Soil erosion, deposition, salinisation, trees uprooted, crops washed away, loss of infrastructure, land now unavailable for planting

2h. Which trees or other crops were affected or died later?

- What impact did they show?

- Change in yield pattern from surviving crop.

2i. If have not begun replanting, what are the constraints?

- Lack of planting material, plants not growing, basic needs not met

2j. If they have replanted, how well have the plants grown?

- Change in growth rate to usual/ expected rate

2k. What, if anything, have they harvested, since the Tsunami? How does this compare with equivalent time last year?

2l. Have they tried any different practices to assist re-planting?

- Different crop varieties
- Different cultivation practices
- Where did they get the idea?

2m. Any unusual things noticed in the garden

- Volunteer plants growing,
- Different pests or weeds?

2n. Any aspects of practice/ environment that appear to have accentuated or decreased the damage?

3. Coping strategies and assistance

3a. Have they had help with basic needs

- Shelter, food, ration card
- From whom: CBO, Farmer network, NGO, INGO, Govt. Military

3b. How have you managed economically?

- Development of other sources of income, savings, family support, government support, insurance
- Specify what

3c. Have they had any agricultural assistance?

- Information, inputs, equipment, training.
- From whom: individual, CBO, Farmer network, NGO, INGO, Govt. Military

4. Household background information

4a. Number in household, male or female headed, gender, age, education (specify whether interviewee is head of household)

4b. Name and address

Carry out farm walk and develop map of different crops and changes to the garden topography and plants.

Also observe distance from the coast/ rivers - ask
Elevation of land/ barriers/other features

Appendix b

Guide questions for agricultural rehabilitation organisations

Name of organisation
Name of interviewee(s)
Location
Date

1. Organisation information
2. Agricultural rehabilitation

1. Organisation information

1a. Type of organisation

- NGO
- Community group
- International NGO organisation
- National organisation
- Government
- Relief
- Research
- Donor
- Policy
- Education
- Development

1b. What fields do you work in in this location?

- Agriculture
- Communications
- Construction
- Education
- Mental health
- Fishing
- Gender
- Health
- Housing
- Infrastructure
- Livestock
- Resource management
- Sanitation

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1c. How long have you worked / been established in the area?

1d. What are your links in the area?

- Locally based organisation
- Have local office
- Work through local partners
- Work with other organisations

1e. How is your work funded?

2. Agricultural rehabilitation

2a. How have you assessed the impact /needs of agriculture?

- Own assessments
- Based on other assessments . which?

2b. What have you identified as the impact on the agriculture sector?

- Agronomic
  - Crop loss
  - Deposition
  - Erosion
  - Input losses . what? Seeds, tools, fertilisers, seedlings…
  - Land losses
  - Salinisation

- Economic/ infrastructure
  - Road to market
  - Village market/ fair
  - Input supply
  - Processing infrastructure

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- Food security
  - Availability of food
  - Affordability of food
  - Variety of food

- Lack of basic needs meeting
  - Food
  - Housing
  - Health
  - Sanitation

2c. What have you identified as the needs for the agriculture sector?

- Alternative incomes
- Inputs / seedlings, fertiliser, seeds, tools
- Irrigation
- Land rehabilitation: debris clearance, desalinisation
- Training in new appropriate techniques

2d. What agricultural rehabilitation activities are you carrying out?

- Access to inputs
- Alternative income development
- Credit
- Distribution of inputs – what, where are they sourced
- Food/ cash for work
- Infrastructure: markets, roads
- Irrigation
- Tools
- Forestry
- Livestock
- Marketing
- Training
- Organisational capacity building

2e. What has the impact been of this so far?

- Yield improvements

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- Amount of land rehabilitated?
- Trees planted?
- Provision of basic needs to enable agriculture
- Alternative livelihoods

2f. What will the long term impact of these interventions be?

2g. What are your longer term plans for agricultural assistance in this area? Do you think there is a need for long term agricultural development?

2h. What are the opportunities/ constraints to agriculture development in the area?

- Availability of appropriate inputs
- Information
- Land
- Land quality
- Training