

Sector Vulnerability Profile: Agriculture and Fisheries

Supplementary Document to:
The National Climate Change Adaptation
Strategy for Sri Lanka
2011 to 2016

Sector Vulnerability Profile:
Agriculture and Fisheries

November 16, 2010

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We acknowledge and appreciate all support provided by the Climate Change Secretariat, Ministry of Environment, SNC Project Team, Department of Agriculture, Ministry of Agriculture, Department of Meteorology, Disaster Management Center, University of Peradeniya, Ministry of Fisheries and Aquatic Resources and the many other stakeholders who have contributed to this document. Refer Appendix E for the full list of stakeholders consulted during SVP preparation.

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List of Abbreviations and Acronyms

ADB	Asian Development Bank
AGBC	Agbiotech Centre
ARDQIP	Aquatic Resources Development and Quality Improvement Project
BHP	Brown Plant Hopper
CB	Central Bank
CCA	Coast Conservation Act
CCCS	Center for Climate Change Studies
CCD	Coast Conservation Department
CCS	Climate Change Secretariat
CDM	Clean Development Mechanism
CENARA	Capacity Enhancement of NARA
CFE	Caring for the Environment
CIDA	Canadian International Development Agency
CRI	Coconut Research Institute
CRMP	Coastal Resources Management Project
CZMP	Coastal Zone Management Plan
DAPH	Department of Animal Production and Health
DEA	Department of Export Agriculture
DFAR	Department of Fisheries and Aquatic Resources
DMC	Disaster Management Center
DOA	Department of Agriculture
DSD	Divisional Secretariat Division
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization of the UN
FCRDI	Field Crops Research and Development Institute
FORLUMP	Forest/Land Use Mapping Project
GDP	Gross Domestic Product
GMO	Genetically Modified Organisms
HA	Hectare
HORDI	Horticulture Research and Development Institute
IFAD	International Fund for Agricultural Development
IPCC	International Panel on Climate Change
IPNS	Integrated Plant Nutrition Systems
IWMI	International Water Management Institute
LIDAR	Light Detection and Ranging
LMO	Living Modified Organism
MCS	Monitoring, Controlling and Surveillance
ME	Ministry of Environment
MENR	Ministry of Environment and Natural Resources
MEPA	Marine Environment Protection Authority
MFAR	Ministry of Fisheries and Aquatic Resources
MHWL	Mean High Water Line
MLWL	Mean Low Water Line
MM	Millimetre
MOAL	Ministry of Agriculture and Lands
MOFE	Ministry of Forestry and Environment
MT	Metric Tonnes
NAP	National Policy on Agriculture
NAQDA	National Aquaculture Development Authority
NARA	National Aquatic Resources Research and Development Agency
NARESA	Natural Resources Energy and Science Authority
NBRO	National Building Research Organization
NCSA	National Capacity Needs Self Assessment Project
NDMP	National Disaster Management Plans
NEAP	National Environmental Action Plan
NGO	Non Government Organization
NIV	New Improved Varieties

OFC	Other Field Crops
OIV	Old Improved Varieties
PGRC	Plant Genetic Resource Center
RRDI	Rice Research and Development Institute
RRI	Rubber Research Institute
SNC	Sectional National Communication
SRI	Sugarcane Research Institute
TRI	Tea Research Institute
UNDP	United Nations Development Program
UNFCC	United Nations Framework Convention on Climate Change
USDA	The Sri Lanka-US Department of Agriculture
VRI	Veterinary Research Institute

Agriculture and Fisheries

Part I - Agriculture & Livestock

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For more than 2,500 years, Sri Lanka has been an agrarian based society and agriculture still remains a key component of the economy as well as the island's cultural base. Despite the gradually declining economic importance of agriculture and fishery in Sri Lanka over the years, most rural people, who constitute the major segment of Sri Lanka's population, are dependent on rainfall-based sources of income, such as agriculture, livestock production and inland fishery. Consequently, the agriculture sector is afforded high priority in the *Mahinda Chintana 10 Year Horizon Development Framework* and the National Action Plan for the *Haritha Lanka Programme*. Major infrastructure programmes to facilitate adequate irrigation water to optimize agriculture are given in detail in the *Randora National Integrated Development Programme*. As agriculture, livestock and fisheries rely heavily on adequate quality and quantity of water and land resources, development within these sectors should take into account the ramifications of already felt and potential climate change, and strategically adopt relevant adaptation measures in their respective sectoral programmes.

1.0 Introduction

Meeting the Millennium Development Goal 1: Eradication of Extreme Poverty and Hunger also needs ensuring food security for the nation.

Meeting the nutritional needs of the country is prioritized through government policy (see BOX 1). Recognizing the importance of agriculture and livestock for national development, the government developmental policies envisage an agricultural renaissance, with special attention on the paddy farmer. The aim is to achieve self sufficiency in food crops and milk for the people, and also to generate agricultural crops and livestock for the export market. Already 150,000 acres of abandoned paddy fields earmarked to be filled have been readied for cultivation, and a further 150,000 acres are targeted for re-cultivation.¹

According to the FAO, 11% of arable land in developing countries could be affected by climate change, causing a reduction of cereal production in as much as 65 countries, and about 16% of agricultural GDP at the global level.

Source: FAO, 2007²

Projections at the global level indicate strongly that climate change could severely affect agricultural production, with cereal production in developing countries being affected the most.² Therefore, despite Sri Lanka now being self sufficient in rice—the staple food of the people—ensuring national food security for all and at all times, is a key need in the face of projected climate change.

BOX 1: AGRICULTURE AND LIVESTOCK FOR NATIONAL DEVELOPMENT

The *Mahinda Chintana: Vision for the Future*, 2010 envisions:

- An agricultural renaissance under the “*Api Wavamu Rata Nagamu*” scheme.
- Agricultural land with clear titles to be provided for 100,000 farmers; 5,000 ha of new land for cultivation to be provided under the Moragahakanda and Kalu Ganga Development Projects; and free agricultural land to be provided for 100,000 farming families in the Northern and Eastern Provinces.
- Introducing Central Farms for the small farmer to cultivate and to process and export quality food crops of high value, using modern technologies.
- Expanding “Agricultural Export Zones” to cover all parts of the country.
- Further developing the cultivation of subsidiary crops.
- Enhancing water holding capacity of the Dry Zone by rehabilitating and building tanks and canals and promoting drip irrigation.
- Undertaking major water resources development projects that will meet enhanced irrigation for agriculture.
- Modernizing Agro-Research Centres with a view to locally producing all varieties of seeds for agriculture in Sri Lanka.
- Doubling the present strength of 340,000 heads of milch cows.
- Setting up a pool of 50,000 milch cows in plantations owned by state sector plantation companies.
- Increasing the production of animal feed through cultivation of corn and grass for fodder.
- Development of the infrastructure for enhancement of the livestock industry in the North and East, with incentives for acquisition of livestock and the production of animal feed and opening markets for the products.
- Introducing the latest technologies to increase productivity in the livestock sector, modernizing the key institutions and improving their services.

1.1 Economic aspects

At the time of regaining political independence in 1948, Sri Lanka had a predominantly agricultural economy, with nearly 85% of the population living in rural areas and engaged in agriculture or agriculture related activities.³ At the time, nearly 90% of Sri Lanka's foreign exchange earnings were from tea, rubber and coconut.³ Conversely, the contribution of the agriculture sector (inclusive of fishery and forestry) to the national GDP has continued to drop during the past few decades,^{5,6} with the growth of the manufacturing and service sectors (FIGURE 1). Even so, the share of the agricultural sector to the GDP was 12% in 2009,⁵ and the plantation sector comprising tea, rubber and coconut continues to make a significant impact on the national economy.⁵ Furthermore, about 70% of the population still live in rural areas where farming is widely practiced; there were about 250,000 farmers cultivating cash crops such as chilli, onion and potato by the end of the last century;³ and 32.7% of the labour force still work in the agricultural and fishery sectors.⁵

Livestock also plays a considerable role in the agricultural sector (FIGURE 2) and the national economy,^{3,5} and is an important occupation for the rural population.¹

BOX 1 (continued)

Action Plan for the *Haritha Lanka* Programme⁴

Mission 5 deals with responsible use of the land resource, including land use for agriculture. The strategies mentioned include:

- Reduction of land degradation in agricultural areas.
- Development and implementation of programmes for the use of non-cultivated agricultural lands.
- Optimizing soil conservation by making it mandatory and by other means.
- Promoting precision farming, traditional varieties of crops and crops to fit agro-ecological conditions.
- Conserving, restoring and improving important representative agricultural landscapes.
- Improving management of commercial plantations.
- Promoting integrated management of upper watersheds.
- Promoting adaptation to drought conditions.
- Reviewing land related laws.

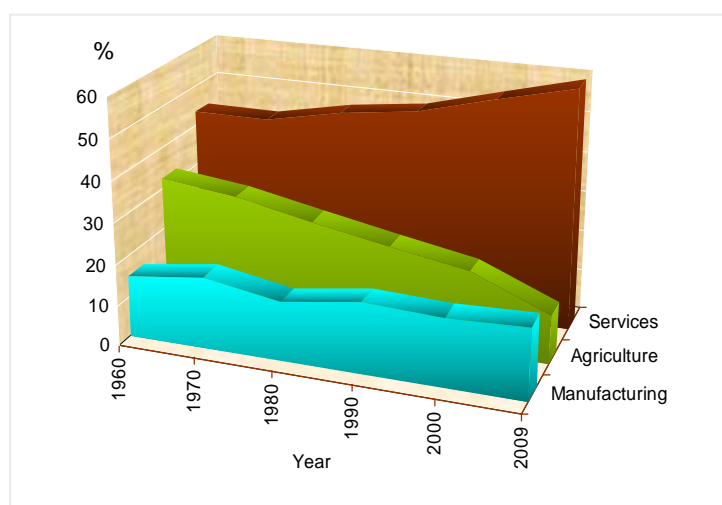
Mission 7 deals with wise use of water that is essential for agriculture and livestock development and includes:

- Strengthening implementation of integrated water management systems.

Mission 3 deals directly with climate change:

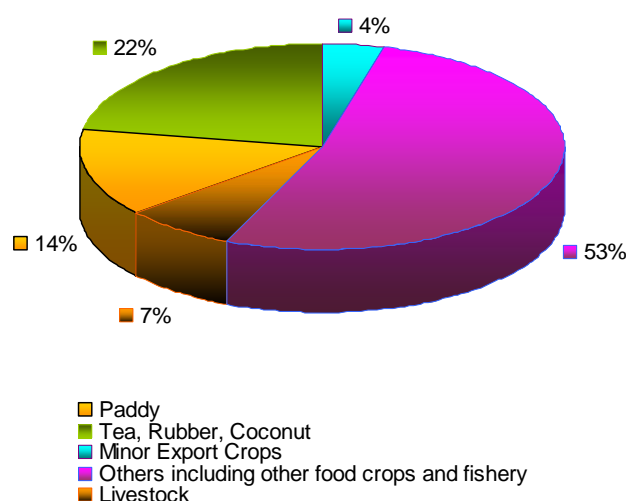
- Establishing food security in the face of climate change threats.
- Developing and adopting energy saving technologies in agriculture.
- Making rainwater harvesting at site level mandatory.

More details on overarching development policies are given in APPENDIX A.



Data Source: Central Bank, 1998, 2001 & 2010

FIGURE 1 Relative Composition of manufacturing, agriculture and services in the National GDP (adapted from MoENR, 2002⁷)



Data Source: Central Bank, 2010

FIGURE 2 Share of agricultural GDP (%)

About 75,000 families are currently involved in the poultry industry, including suppliers^a denoting its importance for the national economy. Furthermore, the present policy framework for development of the livestock sector is guiding the government's strenuous effort to increase national milk production to make the country self-sufficient in milk in the medium term.⁶

1.2 The resource base and environmental concerns

Rice fields, crop plantations, vegetable plots, *chera* plots and home gardens constitute the main agricultural land uses in Sri Lanka.⁷ This includes land under food crops (consisting of rice paddies, horticultural crops, other field crops and spices), plantation crops (comprising mainly tea, rubber, coconut and sugarcane), minor export crops, and other beverage crops such as coffee.^{7,8} The category termed other field crops (OFC) includes over 100 species.^{7,8} Among these are cereals, grain legumes, condiments and oilseeds, onion and potato. Crops such as onion, potato and vegetables generally remain a small farmer activity, though some of these crops are also grown on a semi-commercial scale.^{7,8} Fruits, vegetables (i.e. up-country and low-country vegetables), and ornamental plants also form an important component of agricultural export earnings as they contribute to ensuring food security and national income generation.

• Overall farming systems

Sri Lanka is divided into 46 agro-ecological regions (FIGURE 3) that take into account soil, annual rainfall and its seasonal distribution, and altitude.⁹ Sri Lanka's traditional farming systems have developed over hundreds of years with farmers managing production systems in these regions to best suit local environmental conditions.⁸ This has led to a rich agro-biodiversity in the island in terms of rice, cereals, pulses, vegetables, root and tuber crops, spices and fruits.⁸

Changes in climatic conditions may, however, change the conditions that define the agro-ecological regions, and reduce the productivity of crops and livestock that are adapted to them. Currently, more than 2,000,000 ha are under some form of agriculture in Sri Lanka (Table 1). However, much of the agricultural lands are located in the water deficient Dry Zone where increased productivity of crops (other than paddy) depends entirely on rainfall.

^aDr D D Wanasinghe, President of Sri Lanka Poultry Association. pers. com. at the workshop to discuss the Agriculture SVP.

A positive feature is that the varied climatic conditions in farming systems of the island have given rise to a wide range of crop species and land races that are suited for varied conditions of soils, rainfall and altitude as well as to diseases and insect pests. Genetic diversity is particularly high among rice, cereals, cucurbits, vegetables such as tomato and eggplant,⁸ indicating potential for crop improvement in the face of climate change as an adaptation measure.

TABLE 1 Extent of land under different agricultural uses in Sri Lanka

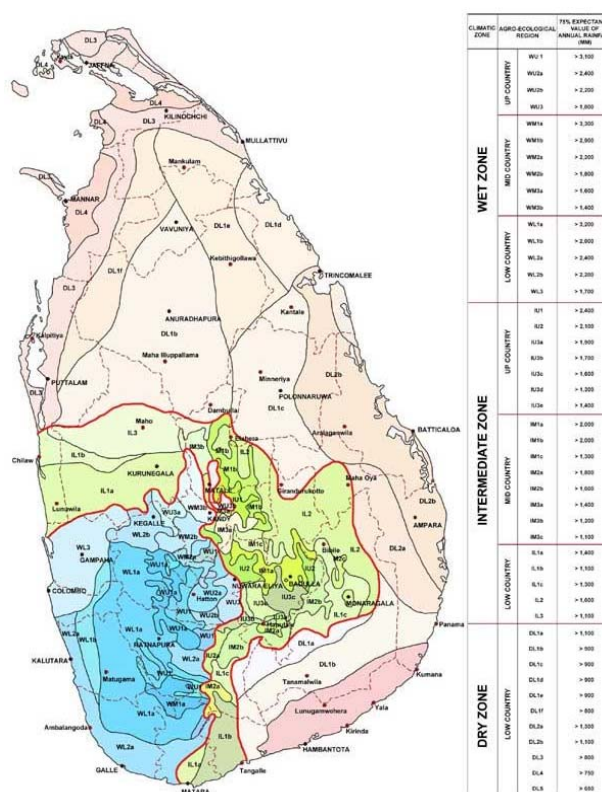
Land use	Area (ha) in 2009
Paddy	977,561
Vegetables (including, root and tuber crops)	85,663
Fruits	85,066
Other Field Crops	130,297
Plantation crops (Tea, rubber, coconut and sugarcane)*	716,320
Minor export crops (coffee, cocoa, cinnamon, pepper, cardamom, cloves, arecanut, cashew, betel)†	119,862

Source: Department of Agriculture unpublished data provided for this report except for composite of data from Central Bank, Sri Lanka, (2010)* and Data from the Department of Census and Statistics (2010)†

● Rice paddies

The gross total extent of land sown for paddy cultivation in 2009 was nearly 980,000 ha during both *Yala* and *Maha* seasons,⁵ including the paddy lands of the North and East. Sri Lanka's paddy fields are both rainfed and irrigated from rainwater stored in tanks, built during the island's hydraulic civilization, and large multi-purpose reservoirs built in recent times. Paddies in the Dry Zone are rainfed from the North-East monsoon during the *Maha* season and irrigated in the non-rainy period or *Yala* season. Paddy fields in the Wet Zone are rainfed and comprise terraced systems in hilly areas, and open systems in flat lowland areas, to suit the local terrain and rainfall.

The national paddy production was 3.65 million MT of rough rice in 2009,⁵ which is adequate to satisfy the country's domestic requirements. However, it is seen that total paddy production in 2009 declined by 5.8% compared to the highest ever production of 3.87 million MT in 2008, mainly due to insufficient water for cultivation during the *Yala* season as a result of delay in the onset of monsoon rains, and the consequent delay in release of water for cultivation.⁵



Source: Department of Agriculture, 2003

FIGURE 3 Agro-ecological regions in the country

This, as well as the increase of paddy production in the 2008/2009 *Maha* season from the previous year's *Maha* season due to an increase in the extent in cultivated and productivity supported by favourable weather⁵ underscores the importance of adopting adaptation measures to mitigate the impacts of adverse weather conditions to maintain consistency of paddy production. Further, the very high genetic variation among indigenous rice varieties is an indicator of excellent potential for varietal improvement for adaptation to climate change. The need for development of different age groups of paddy (short term and long term varieties) to suit unpredictable rainfall regimes—such as delays in the *Maha* season rains—is also recognized by the Department of Agriculture.^b Already several New Improved Varieties (NIV) with varying yield times (i.e. varied age groups) have been developed. They could be produced in sufficient quantities and distributed among farmers through strategic climate change adaptation measures.

Overall, the extent of paddy lands has increased since the establishment of peace, due to the re-use of a large extent of abandoned paddy lands in the Northern and Eastern provinces.^b

The long history of paddy cultivation in Sri Lanka that spans over two thousand years is closely linked with climatic variations in the region where rice is grown, resulting in a high varietal diversity of rice (Oryza sativa). Among these are several indigenous rice varieties that can tolerate different climatic and soil conditions, and are highly resistant to pests and disease. For example, there are traditional upland varieties well known for their drought tolerance; varieties grown in the coastal areas and floodplains of rivers that possess tolerance of submergence and flash floods; a few rice varieties cultivated at higher elevations (over 1000 m) that grow at low temperatures; and several varieties that show broad-based resistance to serious pests, high salinity and other adverse soil conditions.† Sri Lanka also has five species of wild rice, including one with a rhizome (Oryza rhizomatis) which is perennial.* Among the traditional and wild varieties of rice many have characteristics that are important for varietal improvement. For example, Oryza nivara, Podiwee, Murungakayan and O. eichingeri are resistant to blast; Dahanala and Kalubalawee are resistant to thrips; Rathuheeneti, O. eichingeri, Suduhanditan, Balamawee, Sudurusamba, Mawee and Hondarawalu are resistant to the brown plant hopper (BHP); O. granulata is resistant to drought, and O. rufipogon shows high salinity tolerance.* Some new varietal lines such as LD 183 is expected to be resistant to drought, and LD 183-187 are resistant to high salinity; some New Improved Varieties (NIV) such as At 353 and At 354 also have high salinity tolerance*; BW 361, 363 and 364 are resistant to iron toxicity.***

Sources: MoFE 1999,† MENR, 2009*; data from the PGRC, 2010*; Amitha Benthota, DOA, pers com, 2010 **

• *Plantation agriculture and other export crops*

The Plantation Sector comprises tea, rubber, coconut and sugarcane, which together with other minor export crops such as coffee, cocoa, spices (including cloves, cinnamon, nutmeg, mace, pepper, cardamom, etc.), cashew, arecanut, betel leaves, essential oils and un-manufactured tobacco are important in terms of export earnings.⁷ Around 709,000 ha are under tea, rubber and coconut⁵; 7320 ha are under sugarcane,⁵ and 119,862 ha are under coffee, cocoa, cloves, cinnamon, pepper, cardamom, cashew, arecanut and betel leaves.¹⁰ About 300,000 small scale growers are involved with the cultivation of export crops, of whom the majority are smallholders. Tea and rubber plantations are concentrated in the Central and Sabragamuwa Provinces; coconut plantations are mainly located in the Kurunegala, Puttalam and Gampaha Districts;^c cinnamon and citronella plantations are found mainly in the Southern Province.

Research carried out at the respective Tea, Rubber and Coconut Research Institutions, as well as selection by growers, has resulted in considerable diversification of cash crops from the originally introduced germplasm.^{c,d} This has served to produce high-yielding varieties that are also resistant to pests and disease and adverse climatic conditions.^{c,d,8}

• *Home gardens and horticulture crops*

There are about 1.42 million home gardens in Sri Lanka, accounting for about 76,483 ha.^e They make a substantial contribution to agricultural production in the country, and play a perceptible role in maintaining canopy cover in the island, ameliorating the local climate, and providing timber and wood products.^{8,11} Home gardens constitute a traditional system of perennial cropping for a wide range of valuable crops, and are known to be particularly important for providing construction and industrial

^b Information provided by the DOA during preparation of this report.

^c Information provided by the CRI during preparation of this report.

^d Information provided by the TRI during preparation of this report.

^e Data from the Department of Census and Statistics, 2002.

wood^{11,12} and maintaining high species and genetic diversity of fruit, vegetables and spices⁸ that can be used to improve capacity of such crops to withstand climate change. Forest analogue home-gardens, such as the typical 'Kandyan home gardens' demonstrate diverse agricultural systems, and are the main agricultural holdings for horticultural crops.^{8,11} They are also repositories of indigenous traditional knowledge on agricultural practices that could be of value when formulating adaptation measures for climate change.^{11,13} Home gardens in the Wet Zone, particularly in the Western wet lowlands are, however, now being increasingly fragmented, with the decreasing land-man ratio in the region.¹³ This is leading to considerable localized loss of canopy cover and the erosion of indigenous horticultural crop diversity.¹³ *Chena*, or slash and burn cultivation, though environmentally destructive, is also a major source of cereals and vegetables that have been subject to selection by farmers over time.^{8,13}

The Department of Agriculture is continually engaged in research and development projects, extension services, seed production and quality improvement programmes for development of the horticultural sector, headed mainly by the Horticulture Research and Development Institute (HORDI). These efforts include the release of several hybrid varieties that have qualities to withstand climate change. For example, two new hybrid varieties of tomato, '*Bhathiyaa and Maheshi*', and one variety, (i.e. *KC-1*) that were released are tolerant to high ambient temperature coupled with a high yield.⁶

• *Livestock*

Livestock is an important component of the agricultural sector. At present there are about 1,136,860 neat cattle and 371,790 buffalo, 377,460 goats, 8,000 sheep and 81,310 pigs, 13,615,290 chickens and 15,244 ducks country wide.¹⁰

Most of the livestock comprise imported high yielding breeds to address the increase in livestock production. Sri Lanka also has several local breeds that are well adapted to the local environment and harsh conditions, but are relatively low yielding. These locally adapted breeds now show a significant drop in population size due to the move towards high yielding imported breeds and cross-breeding. This requires special measures to conserve the indigenous livestock breeds with traits that are useful to adapt to climate change.

Among the extant indigenous breeds are a type of locally adapted native cattle (*Bos indicus* var *ceylonicus*) or "Batu Harak" and the white cattle of *Thamankaduwa* that are reared for draught and milk, hardy indigenous goats including a locally adapted breed *Kottukachchiya*, and village chicken that are poor egg producers but are highly adapted to a harsh environment. The locally adapted breeds show traits such as high adaptability to the environment, high resistance to tropical diseases, high fecundity, early maturity, good mothering ability, longevity and low cost of production.

Source: Silva (2010)¹⁴

• *Agro-biodiversity in ex-situ conservation facilities*

Ex-situ collections are important to overcome the overall trend for narrowing of the indigenous crop and livestock genetic base, and thereby to increase options for crop breeding in the future that could help reduce agricultural vulnerability to climate change, pests and disease.

The Plant Genetic Resources Centre maintains *in vitro* collections of all crops, including traditional varieties (Table 2). Currently there are 12,847 accessions of crops from 375 species. All crop research and development institutes under the Department of Agriculture (DoA)^f, and the research institutes for plantation crops (i.e. tea, rubber, coconut and sugarcane) maintain field collections of varieties, cultivars and clones of crops within their purview.^{10,13}

The Department of Export Agriculture (DEA) maintains germplasm of coffee, cocoa, cardamom and clove and other export crops.^{10,13}

The AgBiotech Centre set up under the ADB sponsored Science and Technology Manpower Development Project is linked to the Agricultural Faculty of the University of Peradeniya, and has up-to-date facilities for preservation of both plant and animal germplasm and for biotechnology using genetic resources. Its facilities for biotechnology research include some modern equipment such as the gene gun, confocal imaging system, bioreactor and all the facilities for DNA finger printing. These facilities are, however, under utilized at present.

Source: MENR, 2007¹⁵

The Department of Animal Production and Health (DAPH), and its research centre—the Veterinary Research Institute (VRI), do not have similar organized programmes and facilities for livestock germplasm conservation, although it is mandated to enhance livestock productivity and the use of domesticated animals such as cattle, pigs and poultry. Some facilities that do exist in centres like the

^f The Field Crops Research and Development Institute (FCRDC), Horticultural Crops Research and Development Institute (HORDI) and the Rice Research and Development Institute (RRDI).

AgBiotech Centre (AgBC), University of Peradeniya and at the Veterinary Research Institute, Gannoruwa are underused due to lack of coordination.^g

TABLE 2 Germplasm collection status by crop group at the PGRC in 2010

Crop Group	Number of accessions at the PGRC
Rice and related species	4,507
Other cereals and related species	1,617
Grain legumes	1,948
Vegetables (legumes, cucubits, brassics, allium, leafy vegetables and other vegetables)	2,579
Solanacious vegetables and condiments	1,193
Fruit crops	163
Root and tuber crops	209
Oil crops	414
Medicinal plants	27
Fibre crops	66
Mustard and related spices	124
Wild relatives of crop species	308*

Source: Unpublished data provided by the PGRC for this report in June 2010, and March 2009*

^g Dr Pradeepa Silva, pers. com., 2010.

2.0 Climate Change Related Issues and Vulnerability

The following sections deal specifically with the agriculture and livestock sector with regard to management and enhancement of productivity among crops and livestock. The importance of water availability and irrigation for agriculture is acknowledged, but those aspects of water management are dealt with in detail in the Sector Vulnerability Profile on Water.

According to the IPCC, *vulnerability* is the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change. Vulnerability is a function of the character, magnitude and rate of climate variation and its effects to which a system is exposed, its sensitivity, and its adaptive capacity. *Exposure* means the nature and degree to which a system is exposed to significant climatic variations. *Sensitivity* is the degree to which a system is affected either adversely or beneficially by climate related stimuli. *Adaptive capacity* is the ability of the system to adjust to climate change, to moderate potential damages, to take advantage of new opportunities or to cope with the consequence

Although the potential impacts of climate change on rainfed agriculture *vis-à-vis* irrigated systems are still not well understood, climate change is expected to change the pattern and quantity of rainfall; evapo-transpiration, surface run-off and soil moisture storage; and water availability for irrigated agriculture and public use. The possible impacts of climate change in Sri Lanka are given in BOX 2. The natural hazards currently affecting Sri Lanka are in BOX 3.

In view of the socio-economic and nutritional importance of maintaining adequate agricultural production, the possible impact of changes in rainfall regimes and rising temperature on irrigated and rainfed agriculture and livestock production could have wide ranging and serious impacts on Sri Lanka's food security, nutrition, public health and economic development. As an island nation Sri Lanka is also vulnerable to the risk of sea level rise and increased frequency of storms that can inundate coastal land, cause saline intrusion and result in the loss of low-lying coastal agriculture.

BOX 2: IMPACTS OF CLIMATE CHANGE ON THE WEATHER IN SRI LANKA

Increasing temperature

- Air temperature in Sri Lanka has increased by 0.64°C over the past 40 years and 0.97°C over the last 72 years, which revealed a trend of 0.14°C per decade. However, the assessment of a more recent time band of 22 years has shown a 0.45°C increase over the last 22 years, suggesting a rate of 0.2°C per decade.
- Consecutive dry days are increasing in the Dry and Intermediate Zones.
- Ambient temperature (both minimum and maximum) has increased.
- The number of warm days and warm nights has increased, while the number of cold days and cold nights has decreased.

Rainfall variability

- The precipitation patterns have changed, but conclusive trends are difficult to establish.
- A trend for rainfall decrease has been observed historically over the past 30-40 years, but this is not statistically significant.
- There is a trend for the increase of one day heavy rainfall events.
- An increase in the frequency of extreme rainfall events is anticipated, which would lead to more floods.

Drought

- The increased frequency of dry periods and droughts are expected.
- The general warming trend is expected to increase the frequency of extreme hot days.

Source: Department of Meteorology, Sri Lanka, provided for preparation of this report (2010).

BOX 3: IMPACTS OF NATURAL HAZARDS THAT AFFECT SRI LANKA

"Natural hazards occur due to natural phenomena that have a human element, and result in a large number of fatalities and/or large scale damage to property." (MENR, 2002)⁷

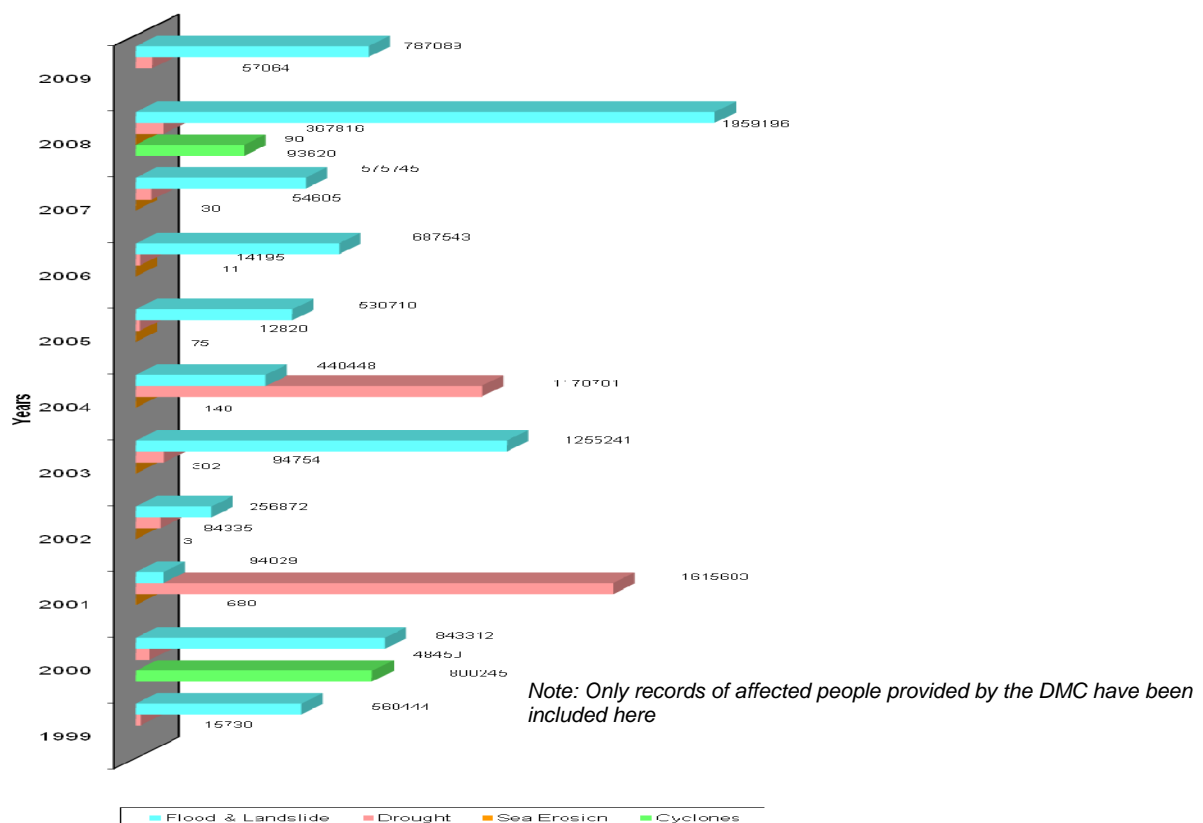
Coastal erosion affects Sri Lanka's beaches and adjacent coastal lands that are constantly subject to erosion, by winds, waves and currents that pound the coast. Available records indicate an average rate of coastal erosion of about 0.5 m/year and an accretion rate of about 0.2 m/year (CCD 2006).¹⁶

Landslides have been a frequent problem in Sri Lanka for many decades, and they generally follow heavy rains exceeding a threshold of 125 within 24 hours (NBRO data provided for preparation of this report, 2010).

Floods are associated with extreme rainfall conditions, and occur in almost all river basins in Sri Lanka. Serious flooding frequently occurs in the Kelani, Kalu and Mahaweli river basins. Floods occur mainly in the Wet Zone, in areas having high rainfall, though flooding may sometimes occur in the Dry Zone as well (Manchanayake and Madduma Bandara, 1999;¹⁷ NARESA, 1991).¹⁸

Drought is the major natural hazard experienced in Sri Lanka, which, despite the lack of a heavy toll on life, has very serious negative impacts on the economic and social life of the country due to considerable expenditure by the government for compensation of crop failure due to drought (Manchanayake and Madduma Bandara, 1999).¹⁷

Cyclones are less felt in the island than the Indian subcontinent as Sri Lanka is situated outside the cyclone belt. However, several serious cyclones have been felt periodically, with most damage occurring in the northern and eastern parts of the island, and to a lesser degree in some areas of the North Central Province (*note: This situation can vary in the future with climate change, and although the frequency of cyclones have remained the same, there is increasing cyclone intensity during the past few decades*).



Source of data for graph: DMC, 2010

Number of people affected by natural disasters

Changes in rainfall regimes, sea level rise, and other features associated with climate change could also increase the prevalence of natural disasters such as floods, droughts, landslides and storms that could have consequent negative impacts on agricultural production, future national food security, and the socio-economic fabric of the country. To minimize these impacts, it is necessary to adopt adaptation measures to ensure that agricultural productivity is not jeopardized. The key climate change-related issues and vulnerabilities relating to the agricultural sector are presented below.

2.1 Climate change induced threats

• *Vulnerability to natural hazards*

Possible impacts of sea level rise and coastal flooding:

- Saline intrusion due to sea level rise and storm surges
 - will be exacerbated with lowered river flows during droughts and by sea level rise.
 - could occur into surface and groundwater in coastal areas, which will affect freshwater availability for farming communities and agricultural activities, and reduce agricultural productivity.
 - could be felt up to considerable distances inland along rivers discharging to the sea, and could degrade arable coastal land, particularly paddy fields, causing them to be abandoned. The paddy lands in Kalutara, Batticaloa and the northern peninsula are most expected to be affected.¹⁹

Projected average temperature increase for Sri Lanka:

- 2025 is 0.4°C
- 2050 is 0.9°C
- 2075 is 1.6°C
- 2100 is 2.4°C

Source: Department of Meteorology, data provided for preparation of this report in 2010

Possible impacts of changes in rainfall regimes and prolonged droughts:

- The higher variability of rainfall due to climate change will adversely affect some agro-ecological regions, and hence affect the crops and livestock that they usually support. For example, high intensity rainfall will affect harvesting and soil erosion in tea lands and reduce the days suitable for rubber tapping.
- High intensity rainfall events could:
 - increase the intensity and frequency of water related disasters such as floods and landslides, which will in turn adversely affect all types of agriculture and livestock production in areas that are naturally prone to these disasters; especially in flood prone areas and steep slopes prone to landslides.
 - cause severe soil erosion and loss of plant nutrients due to heavy surface run-off in agricultural lands located on steep slopes. Soil erosion would also compound flood damage to crops and farming communities, and cause siltation of irrigation reservoirs.
- Rain-fed paddies that comprise over 30% of all rice paddies in the country²⁰ could also be affected by rainfall variability.
- The Dry Zone now shows an increasing number of consecutive dry days due to rainfall variability. As nearly 70% of the paddy cultivated in Sri Lanka is in the Dry Zone,¹⁹ where the annual rainfall is markedly variable temporally, and less than 1,750 mm on average,⁹ this trend can adversely affect paddy yields.
- Droughts that are already a feature of the Dry Zone could become more prolonged, leading to reduction or loss of agricultural productivity in paddy lands that are rain-fed and/or irrigated. As much of the island's irrigated paddy lands are in the rain limited Dry Zone, more prolonged droughts may cause serious socio-economic impacts and imperil the future food security of the country.

The variability of the North-East monsoon that brings rain for the main Maha season for paddy cultivation in the Dry Zone may increase with climate change, affecting paddy production. For example, erratic high rainfall during harvest time tends to severely reduce the paddy yield.

Source: Second National Communication to the UNFCCC (draft),¹⁹

- Reduced annual rainfall leading to drought conditions could increase evapo-transpiration from the soil and plants, and deplete soil moisture reserves. This will be more apparent in the Dry Zone and the coastal areas.
- Changes in rainfall regimes could cause changes in the length of growing seasons for particular crops.

Possible impacts of a rise in temperature:

The rate of increase for mean air temperature for the 1961-1990 period was 0.016°C (Fernando and Chandrapala, 1995).²¹ This is higher than the global average rate of temperature increase which was 0.60°C±0.20°C over the entire 20th century.

- Heat stress could occur in crops, which will be aggravated by the lack of water due to reduced rainfall.
- Increased evapo-transpiration and pan-evaporation could occur, and this together with dryness caused by droughts, may reduce surface water available for irrigated agriculture, reduce stream-flow and groundwater recharge, and reduce availability of water for crop production, especially in the Dry Zone.
- There could be increased crop respiration, transpiration and photosynthesis, as well as changes in seed quality and quantity.
- Changes could be expected in the quality of agricultural produce that are dependent on specific temperatures for maximum productivity.
- Increasing temperature can adversely affect decomposition of soil organic matter and soil bio-physical and chemical properties, and increase the erosivity of soil.^h
- Changes are expected in the distribution of pest populations in agro-ecological regions due to climate change, including possible introduction of new pests and diseases to crops.
- Increased evaporation of soil water, coupled with less rain, could increase salt accumulation in the soil of the Dry Zone. This can lead to salinization of soil and loss of production in agricultural lands—particularly in the Dry Zone coastal areas.

Tea production is dependent on a critical maximum temperature of 22°C. It is also rain fed and dependant on good availability of soil moisture. Recent research by the TRI has shown that tea production declines at temperatures >25-26°C. Cooler temperatures are necessary for the development of high quality teas at higher elevations which fetch a premium price.^{19, ↑}

Coconut, a rain-fed plantation crop, requires a uniformly spread annual rainfall of >1500 mm, as it is adversely affected by long dry spells and high temperatures expected from climate change.¹⁹ Coconut is expected to be greatly affected by rising temperature, drought, soil fertility decline and new pests and diseases.[†]

Rubber production could be affected by prolonged rain as a result of climate change that precludes tapping.¹⁹

Source: Second National Communication to the UNFCCC (draft)¹⁹ and submissions by the TRI[↑] and CDT

^h Discussion point from the workshop to discuss the Agriculture SVP in May 2010.

2.2 Vulnerability enhancing factors

• *Anthropogenic factors that may increase vulnerability to climate change*

Moving away from the use of traditional varieties of crops:

- New improved varieties and breeds were developed in the past to increase yield. These, though high yielding and fulfilling a national need, are from uniform genetic stock and are more susceptible to pests and disease, have higher nutritional requirements, and lower resistance to adverse climatic conditionsⁱ than traditional varieties.¹³ As such, they can be more vulnerable to climate change than traditional varieties that are acclimatized to varied ecological and climatic conditions.⁹
- The consequent drop in the use of large number of indigenous varieties/breeds^j (including traditional varieties) that are relatively low yielding but can withstand adverse environmental conditions such as low rainfall, drought, high salinity and pests and disease⁸ can reduce future options for crop/livestock improvement in the face of climate change.⁹ However, studies carried out to determine existence of traditional varieties of crops in the country show that several are being cultivated in locations scattered across the country.^k The PGRC has also commenced *in-vitro* conservation of traditional varieties of many crops, and are able to provide limited seed to farmers for propagation.

The RRDI was set up at Batalagoda in 1952 to develop high yielding varieties. With the popularity of New Improved Varieties (NIV) released in the 1960s that were highly sensitive to inorganic fertilizers, the area devoted to traditional varieties of rice declined perceptibly over the years. By the early 1980s, more than 90% of the paddy lands had switched to the NIVs, so that Old Improved Varieties (OIV) and traditional varieties together had declined to less than 10 per cent of the cultivated area.

Source: Central Bank, 1998³

Loss of traditional knowledge in agriculture:

Maintaining agricultural productivity in the face of climate change will need conserving the farming systems that produced the original genetic variation of crops together with the age old knowledge about associated cultivation practices and crop uses that are gradually dying out with the older generation and the disuse of traditional crop varieties.

- With the reduced use of traditional varieties of crops, there will be the inevitable loss of knowledge about their cultivation requirements and associated agricultural practices over time. Such knowledge is recognized as important to adapt to the impacts climate change in the UNFCCC in addition to new knowledge and technologies that are commonly used.
- The present high reliance on artificial fertilizer and pesticides also leads to a loss of traditional knowledge on natural methods for increasing yields, keeping away pests, and other knowledge that would be useful for adapting to climate change.

Loss of agricultural production due to land degradation:

- Land degradation due to soil erosion has impoverished the soil and considerably affected agricultural productivity.
- Home gardens in the highly populous Wet Zone have suffered considerable degradation in the past two decades due to urbanisation and fragmentation—causing loss of horticultural crop diversity. This is addressed to a limited extent by the introduction of urban agriculture.
- The fragmentation of home gardens in the Wet Zone Western lowlands has also eroded canopy cover (shade trees), thereby causing changes in the micro-climate and contributing to higher ambient temperature in rural settlements.
- Land fragmentation which reduces canopy cover, has also affected crop production. For example,

ⁱ Discussion point from the DoA at the MoE workshop to update data in the 4th National Report on Biodiversity to the Convention on Biological Diversity, 3rd June 2010.

^j There was a collection of over 300 cultivated rice varieties in Sri Lanka at the Kandy Agri-horticultural and Industrial exhibition of 1902 as report by. Ranaweera, N.F C (1998). Fifty Years of Agriculture in Sri Lanka. In *Fifty years of Sri Lanka's Independence: A socio-economic review* (ed. A D V de S Indraratna), SLISES. Colombo.

^k Dr D K N G Pushpakumara pers. com. June 2010.

land fragmentation in the Gampaha and Kurunegala Districts is a major problem in the coconut sector.^l

- Land degradation has caused a severe drop in tea production, and is the cause of about 30-50% loss of productivity in mid-country tea lands.^m
- Land degradation due to salinization is induced by sand mining in rivers and flooding as it causes destabilization of river banks and siltation.
- Paddy production has been affected by decreasing soil fertility; salinity increase, iron toxicityⁿ and acidity of soil; threats from weeds and pests (including insects) and scarcity of water in rainfed rice lands.
- Insecure land tenure in a high percentages of agricultural holdings in the Wet Zone, coupled with the small size of these holdings, have resulted in the neglect of soil conservation measures and over reliance on chemical fertilisers and pesticides to increase yield.

In the past, inadequate attention was given to matching crops with physical resource potential, which caused considerable deterioration of soil and water resources in the Dry and Intermediate Zones, due to the encouragement of increasing agricultural activities while ignoring soil and moisture conservation and efficient water management.^{8,20} This issue is now addressed by the DoA.

In the Wet Zone hill country, inadequate management of tea lands and vegetable gardens in the past brought in its wake soil erosion and land degradation,⁸ the effects of which are felt even today.

Source: Dr B U R Punyawardena, DoA, pers com. during preparation of this report in 2010

- Only about 2.9 million ha consisted of arable land in 1998 with a land-man ratio of 0.1 ha,²⁰ which decreased further due to conversion of land to non-agricultural use and soil toxification, curtailing the expansion of agricultural land for increased production.²⁰ However, more recently the re-use of paddy lands in the North and East and the paddy subsidy have served to increase the area under paddy cultivation.^o

● *Threats from invasive species, LMOs and GMOs*

- Climate change is expected to increase the worldwide range of many alien invasive species. Sri Lanka as an island is highly vulnerable to alien species invasions and the severe repercussions they could have on the fishery and agriculture sectors, and hence on the national economy.
- Likewise, the cultivation of Genetically Modified Crops and the use of Living Modified Organisms to increase yield and address climate change impacts could also erode the agricultural resource base for the rural farmer.

● *Socio-economic factors*

- Coconut is a significant crop in the coastal belt, while paddy and several other food crops also contribute to the coastal economy. The loss or degradation of such agricultural land due to sea level rise and resultant saline intrusion could significantly lower national agricultural output and the economy of coastal communities, while mitigatory measures would be long-term and very costly. This increases the need to develop salinity tolerant cultivars^p in crop breeding programmes and to consider the socio-economic and environmental impacts of saline intrusion on low-lying coastal agriculture.

Possible global socio-economic impacts of climate change:

- decline in yields and production
- reduced marginal GDP from agriculture
- fluctuations in world market prices
- changes in geographical distribution of trade regimes
- increased number of people at risk of hunger and food insecurity
- migration and civil unrest

Source: FAO, 2007²

^l Information provided by the CRI during preparation of this report, 2010.

^m Data provided by the TRI during preparation of this report, 2010.

ⁿ This issue has been addressed by the DOA by the release of several NIVs such as BW 361, 363 and 364 that are resistant to iron toxicity (source: Ms Amitha Benthota of the DOA, pers com, July 2010).

^o While there was loss of paddy lands in the past due to conversion to other uses, other cultivable land is now being converted to paddy lands due to the introduction of paddy subsidies (source: submission by the Ministry of Agriculture and Agrarian Services during the preparation of this report).

^p Coconut has high tolerance of salinity so that developing salt resistant cultivars is not required for this crop (submission from the CRI during preparation of this report, 2010).

- Vulnerability of the agricultural community to climate change will be influenced by several socio-economic factors, including status of poverty and food security, insecurity of land tenure, amount of resource endowed, education levels, dependency on agriculture for livelihood, availability of irrigation water, institutional supporting framework and government policies.

Research by the Tea Research Institute (TRI) has shown that tea plantations in the wet country low and mid elevations are vulnerable to impacts of climate change, with loss of productivity being most pronounced at mid elevations. This is of concern as around 60% of natural tea production is from the low country where a majority of tea small holdings are found, and about 1.5 million people are dependant on the tea industry for cultivation, processing, marketing and related employments. However, tea plantations at high elevations are found to benefit from climate change.^q

- Agricultural households account for about 40% of the poor in Sri Lanka,¹⁹ so that increased competition for depleted water resources and deteriorating agricultural outputs due to climate change could have severe impacts on marginalized low income groups in the Dry Zone. They will therefore be most affected by the vagaries of climate change.
- Due to the small size of most agricultural holdings, including home gardens, the farming community is not in control of sufficient land to produce a marketable surplus.⁸ This could make them more vulnerable to impacts of climate change and further reduce agricultural production.

2.3 Mapping climate change vulnerability

A vulnerability mapping exercise, using GIS, was undertaken in order to better understand climate change vulnerability in key sectors in Sri Lanka, building on the IPCC definitions of exposure, sensitivity, and adaptive capacity as defined in section 2.0 above.^r The analysis is intended for use as a macro-level planning tool, to illustrate where sector-specific vulnerability is high in relative terms across the nation, and to guide decisions on prioritization and targeting of potential climate change adaptation responses.

General methods

The basic methodology involved in the GIS mapping was to develop indices for exposure, sensitivity, and adaptive capacity relevant for each given sector. These three indices were then combined to create a composite sector-specific vulnerability index. The analysis is largely based on publicly available data sources including the 2001 National Census. Areas where complete and comparable data sets of relevant indicators could not be obtained (such as the North and East where census data are not available) were not analyzed, and will need to be evaluated at a future stage, perhaps after the 2011 census is completed.

Separate *exposure indices* for floods, drought, and landslide exposure were developed based on historic data on the frequency and scale (i.e. assessed in terms of number of people affected) from the Disaster Management Center (DMC). The index for sea level rise was based on a ratio of the area of land within 2 m above sea level as a percentage of total land area within 5 km from the coastline in each DS Division. Topography data was obtained from ASTER 30 m Digital Elevation Model. These exposure indices are common across all sectors. However only exposure types relevant to a given sector were analyzed and illustrated.

The sensitivity and adaptive capacity indices are unique to each sector and the indicators used in their formulation are given in the following pages along with the vulnerability maps.

It must be noted that the mapping exercise itself is preliminary and limited in scope, and should be refined on an ongoing basis, based on detailed data which may become available from various government agencies. It is also noted that relevant agencies are carrying out detailed hazard mapping at the national or regional levels.^s

^q Submission by the TRI during preparation of this report, 2010.

^r IWMI's Climate Change Vulnerability Index as in Eriyagama *et. al.*, 2010 was used as a starting point and substantially refined for finer grain and sector specific analysis. (see full reference in Part II of this document [ref. 20]).

^s For example, the Disaster Management Centre is currently coordinating a detailed risk profiling exercise for the major disaster types, at a much higher level of detail, in collaboration with the Coast Conservation Department, Irrigation Department, the National Building Research Organization, and several others. The maps generated through the DMC exercise would provide much finer grain information for exposure indices.

What the vulnerability maps foretell

• Vulnerability of the paddy sector

FIGURES 4 - 6 illustrate the geographic distribution of vulnerability to drought exposure in the paddy sector. The indicators considered in developing the sensitivity and adaptive capacity indices are given below. The DSD vulnerability ranking table and the larger scale map is in [APPENDIX B](#).

The sensitivity index for drought and flood includes	The adaptive capacity index for drought and flood includes
Data (at DSD level) on: <ul style="list-style-type: none"> • Area of paddy cultivation (<i>Asveddumized</i> paddy) 	A composite of data (at DSD level) on: <ul style="list-style-type: none"> • Percentage of people employed in agriculture with education below O/L • Percentage of landless paddy farmers • Percentage agriculture share in income (among those employed in agriculture) • Percentage of paddy land not fed by major irrigation
Raw data source: Census of Agriculture 2002, Department of Census and Statistics	

The sensitivity index for sea level rise includes	The adaptive capacity index for sea level rise includes
Data (at DSD level) on: <ul style="list-style-type: none"> • Area of paddy cultivation (<i>Asveddumized</i> paddy) within 5km from the coast line 	A composite of data (at DSD level) on: <ul style="list-style-type: none"> • Percentage of people employed in agriculture with education below O/L • Percentage of landless paddy farmers • Percentage agriculture share in income (among those employed in agriculture) • Percentage of paddy land not fed by major irrigation
Raw data source: Census of Agriculture 2002, Department of Census and Statistics	

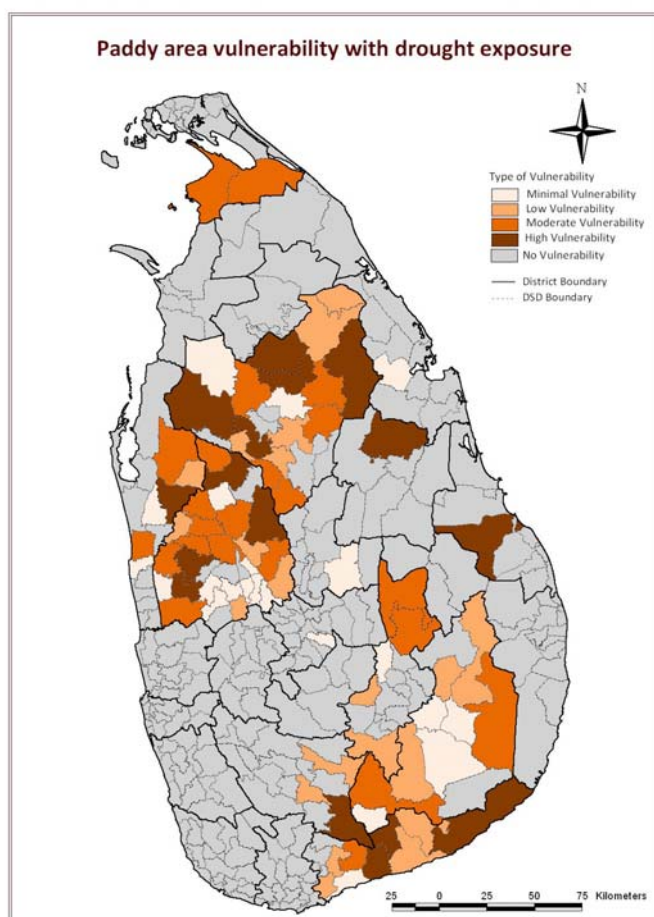


FIGURE 4 Vulnerability of the paddy sector to drought exposure

Vulnerability of the paddy sector to drought exposure:

- Vulnerability to the increase in droughts expected due to climate change is widespread throughout the country and is concentrated in the Dry and Intermediate Zones.
- 16 DSDs emerge as highly vulnerable to drought exposure. These DSDs have:
 - 59,117 livelihoods dependent on agriculture
 - 347,186 ha of agricultural lands of which 176,852 ha (50.9%) are cultivated with paddy
 - 3153 tanks covering a total area of 35,772 ha
- Anamaduwa (Puttalam District), Ambalantota (Hambantota District), and Polpithigama (Kurunegala District) emerge as the DSDs most vulnerable.
 - In these DSDs farmers, on average, earn 62% of their income from agriculture
- A further 23 DSDs emerge as moderately vulnerable to drought exposure. These DSDs have:
 - 76,859 people employed in the agriculture sector
 - 174,839 ha of paddy lands
 - 3,901 tanks covering a total area of 32,648 ha

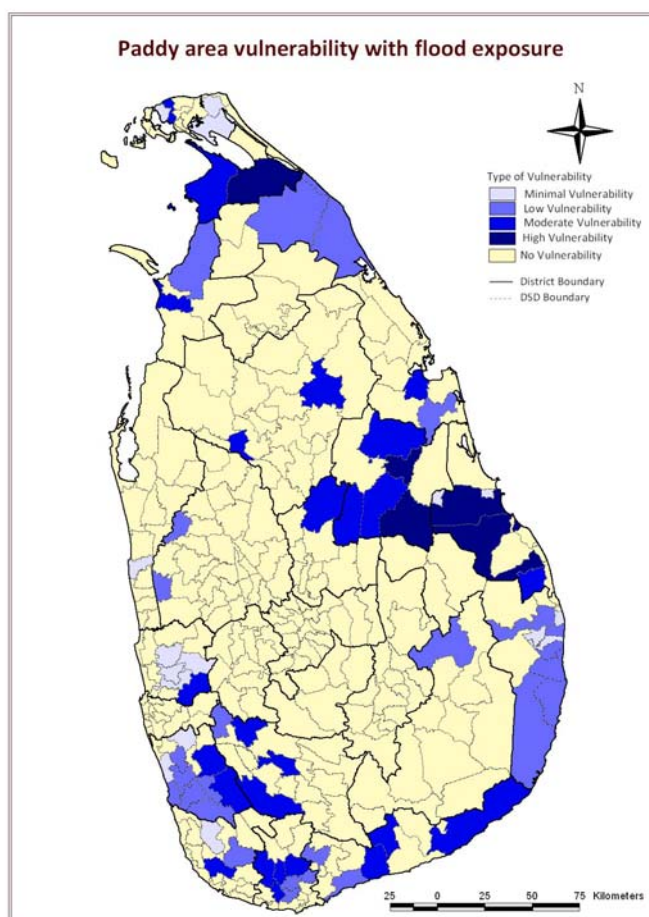


FIGURE 5 Vulnerability of the paddy sector to flood exposure

Vulnerability of the paddy sector to *flood* exposure:

- 6 DSDs emerge as highly vulnerable to the increase in floods expected due to climate change. These DSDs have:
 - 105,401 ha of agricultural lands of which 81,890 ha (77.6%) are cultivated with paddy
 - 14,375 livelihoods dependent on agriculture
 - 283 tanks covering an area of 6,765 ha
- A further 25 DSDs emerge as moderately vulnerable to flood exposure. These DSDs have
 - 56,650 ha of paddy lands, and
 - 39,015 livelihoods dependent on agriculture.

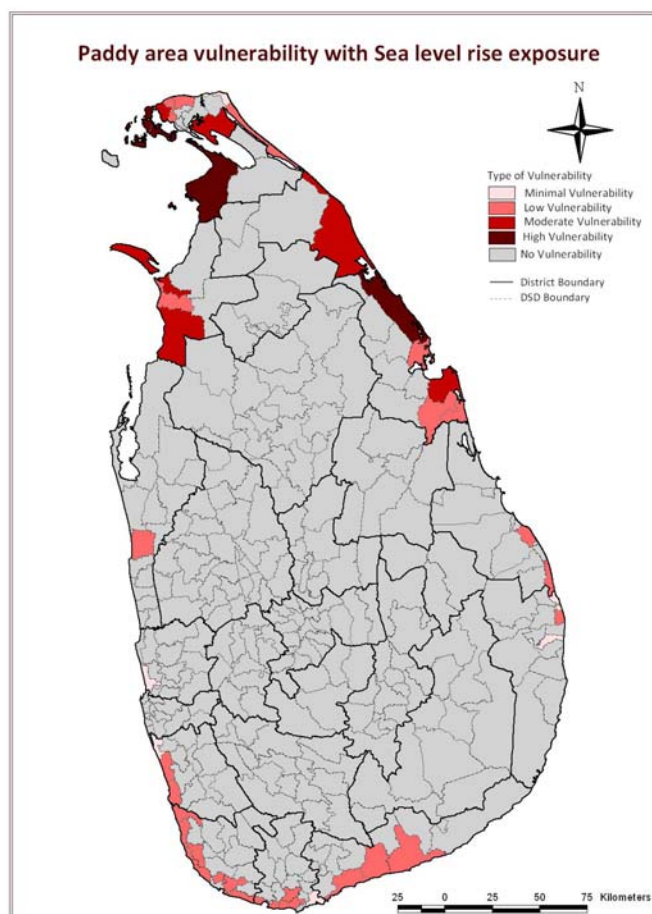


FIGURE 6 Vulnerability of the paddy sector to sea level rise exposure

Vulnerability of the paddy sector to *sea level rise* exposure:

- The highest levels of paddy sector vulnerability to sea level rise exposure appear to be concentrated in the North/Northeast of the island.
- 4 DSDs emerge highly vulnerable to sea level rise, all of which are in the Northern part of the country. These 4 DSDs have:
 - A total paddy cultivation area of 176 ha of which 145 (82%) are located within 5 km from the coastline
 - 2,785 jobs in agriculture
- A further 6 DSDs, also in the Northern part of the country, emerge as having moderate vulnerability. These 6 DSDs have:
 - A total paddy cultivation area of 256 ha of which 160 (62.5%) are located within 5 km from the coastline.
 - 4,394 jobs in agriculture
- The total paddy land within 5 km from the coastline island wide is 112,285 ha. This is 13.45% of the total paddy land in the country, and 31.17% of the total paddy lands in coastal DSDs.

- *Vulnerability of the plantation sector*

FIGURES 7 - 9 illustrate the geographic distribution of vulnerability to drought exposure in the plantation sector. The indicators considered in developing the sensitivity and adaptive capacity indices are given below. The DSD vulnerability ranking table and the larger scale map is in [APPENDIX B](#).

The sensitivity index for the plantation sector include	The adaptive capacity index for rice includes
A composite of data (at DSD level) on: <ul style="list-style-type: none"> • area of tea, rubber, and coconut lands • estate population 	A composite of data (at DSD level) on: <ul style="list-style-type: none"> • Percentage of females who have not completed Grade 5 (among those employed in agriculture) • Percentage of population with less than O/L education (among those employed in agriculture) • Percentage agriculture share of income (among those employed in agriculture)
Raw data source: <i>Census of Agriculture 2002, Department of Census and Statistics</i>	

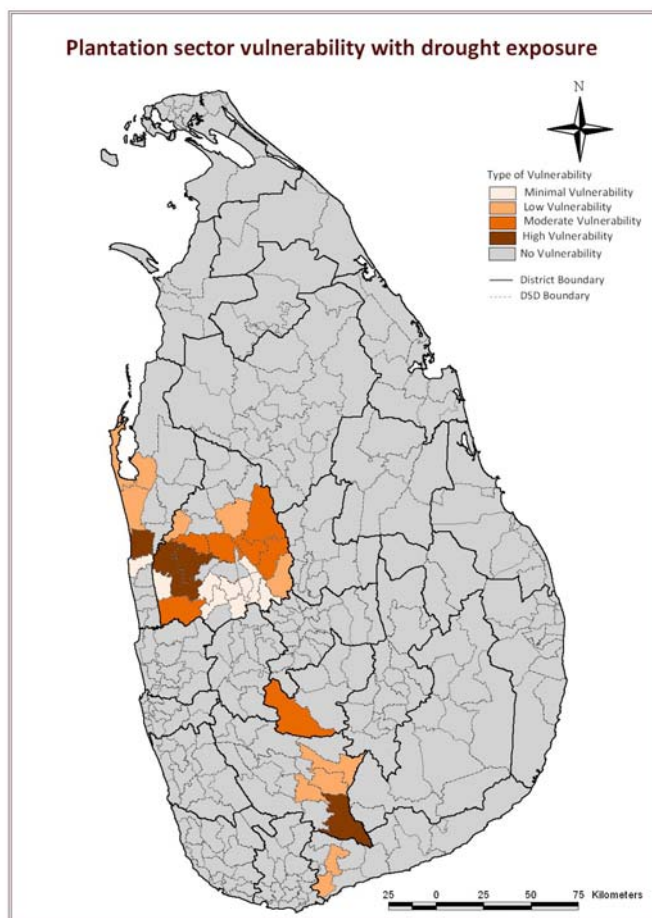


FIGURE 7 Vulnerability of the plantation sector to drought exposure

Vulnerability of the plantation sector to *drought exposure*:

- 5 DSDs emerge as highly vulnerable to drought exposure. These DSDs have:
 - 88,069 ha of coconut cultivations, and negligible amounts of tea and rubber cultivations.
 - A total population of 354,789 of whom 77,656 are below the poverty line
 - 40,172 jobs in agriculture
- 7 additional DSDs are moderately vulnerable. These DSDs have:
 - 108,340 ha of coconut, 2,727 ha of tea and very minimal rubber.
 - A total of 10,522 jobs in agriculture, and an estate population of 32,075
- Of the 12 DSDs with high or moderate vulnerability to drought, 9 are in Kurunegala District. Plantations in these DSDs are primarily for coconut cultivation.

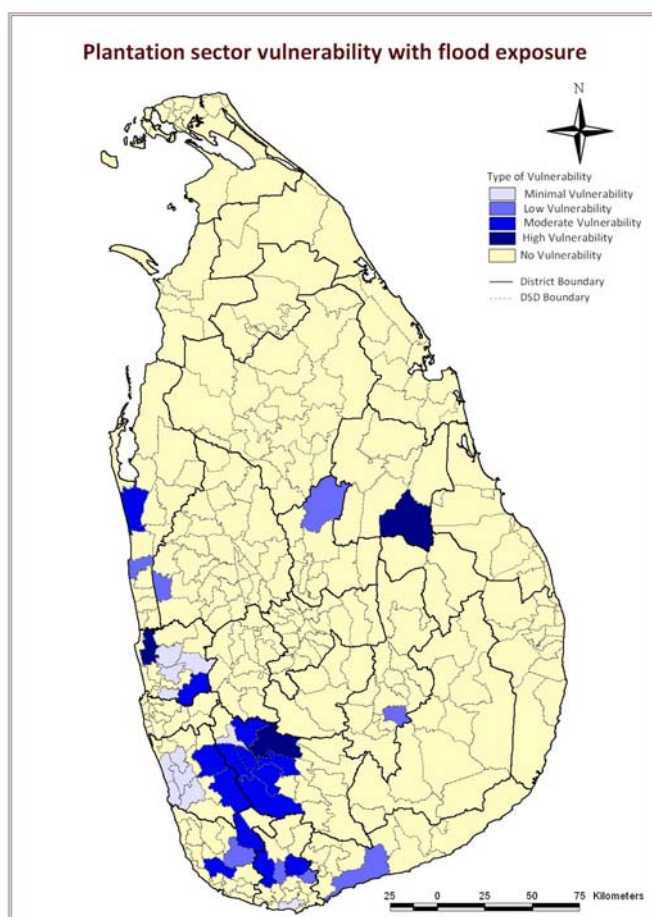


FIGURE 8 Vulnerability of the plantation sector to flood exposure

Vulnerability of the plantation sector to *flood* exposure:

- 3 DSDs emerge as highly vulnerable to flood exposure. These DSDs have:
 - 9,130 ha of tea cultivation, 1,608 ha of rubber, and 14,170 ha of coconut (36.7%, 6.5%, and 56.9% of total plantation area respectively)
 - A total population of 401,255 of whom 51,521 are below the poverty line
 - 35,875 jobs in agriculture
 - An estate population of 4,039
- 14 additional DSDs are moderately vulnerable. These DSDs have:
 - 58,342 ha of tea, 39,305 ha of rubber, and 49,339 ha of coconut plantations
 - A total of 117,982 jobs in agriculture, and an estate population of 13,206

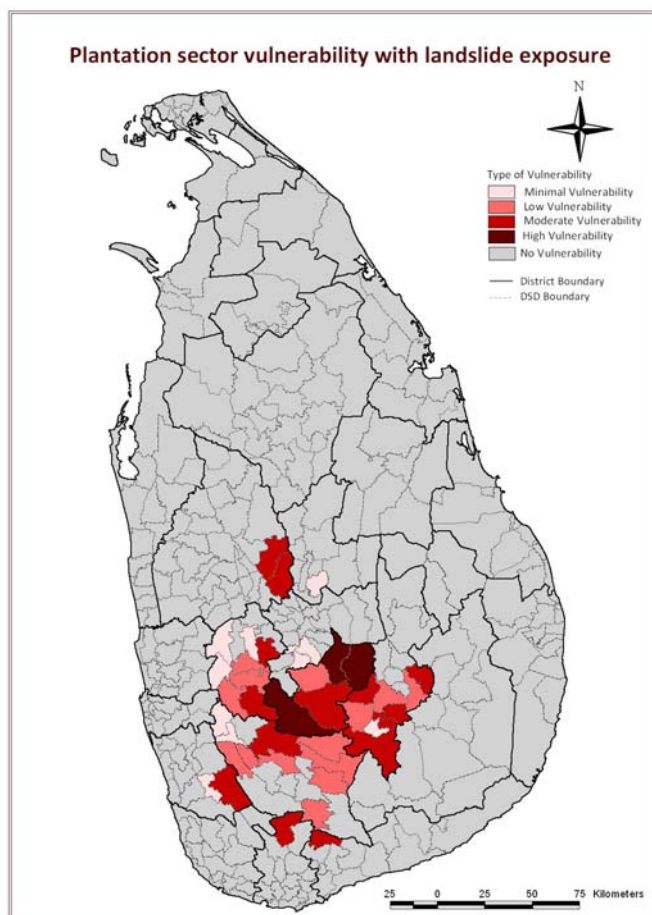


FIGURE 9 Vulnerability of the plantation sector to landslide exposure

Vulnerability of the plantation sector to *landslide* exposure:

- 3 DSDs, all in the Nuwara Eliya District, emerge as highly vulnerable to landslide exposure. These DSDs have:
 - 4,167 ha of tea plantations, and 2,383 ha of coconut plantations, while rubber lands are negligible
 - A total population of 397,911 of whom 102,470 are below the poverty line
 - 100,942 jobs in agriculture
 - An estate population of 44,197
- 14 additional DSDs are moderately vulnerable in this regard. These DSDs have:
 - 33,174 ha of tea, 51,810 ha of coconut, and 12,015 ha of rubber plantations
 - A total population of 993,467 and an estate population of 60,774 (6.12%)
 - 196,292 jobs in agriculture

- *Vulnerability of the livestock sector*

FIGURE 10 - 12 illustrate the geographic distribution of vulnerability to drought exposure in the livestock sector. The indicators considered in developing the sensitivity and adaptive capacity indices are shown below. The DSD vulnerability ranking table and the larger scale map is in [APPENDIX B](#).

The sensitivity index for livestock includes	The adaptive capacity index for livestock includes
A composite of data (at DSD level) on: <ul style="list-style-type: none"> • number of landholdings with cattle/buffalo • number of landholdings with goats and swine • number of poultry (number of birds) 	A composite of data (at DSD level) on: <ul style="list-style-type: none"> • percentage of population employed in agriculture who have completed secondary education • number of landholdings above ¼ acre • % of females with education above Grade 5 (from among the population employed in agriculture) • Percentage of income derived from agriculture (from population employed in agriculture)
Raw data source: Census of Agriculture 2002, Department of Census and Statistics	

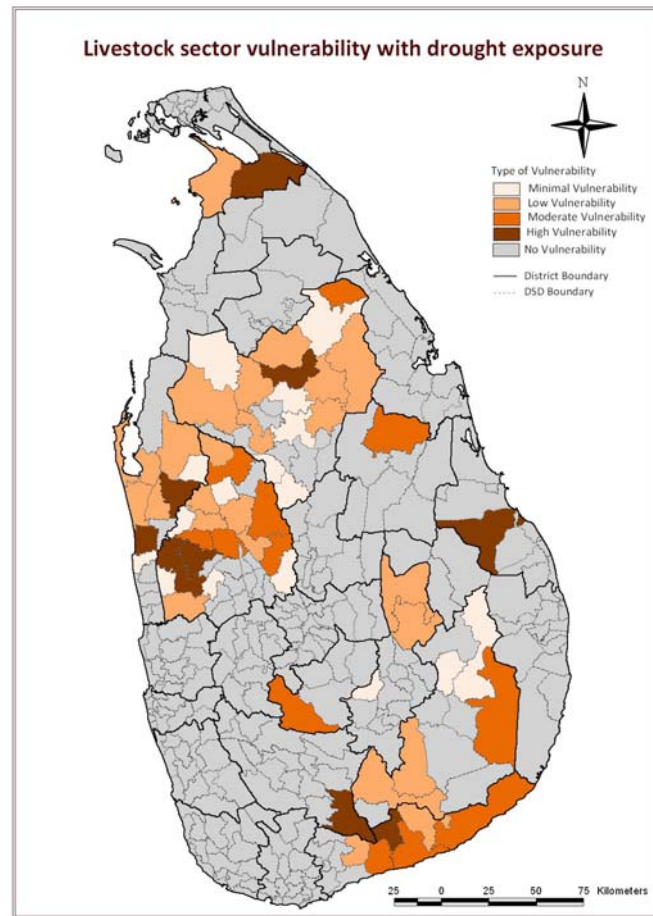


FIGURE 10 Vulnerability of the livestock sector to drought exposure

Vulnerability of the livestock sector to *drought* exposure:

- 10 DSDs emerge as highly vulnerable to drought exposure. These DSDs have:
 - 127,350 land holdings with cattle, and 47,085 land holdings with goats and swine
 - Over 2.5 million heads of poultry
 - 35,878 people employed in agriculture
- 12 additional DSDs emerge as moderately vulnerable. These DSDs have:
 - 146,811 land holdings with cattle, and 70,878 with goats and swine.
 - Over a million heads of poultry

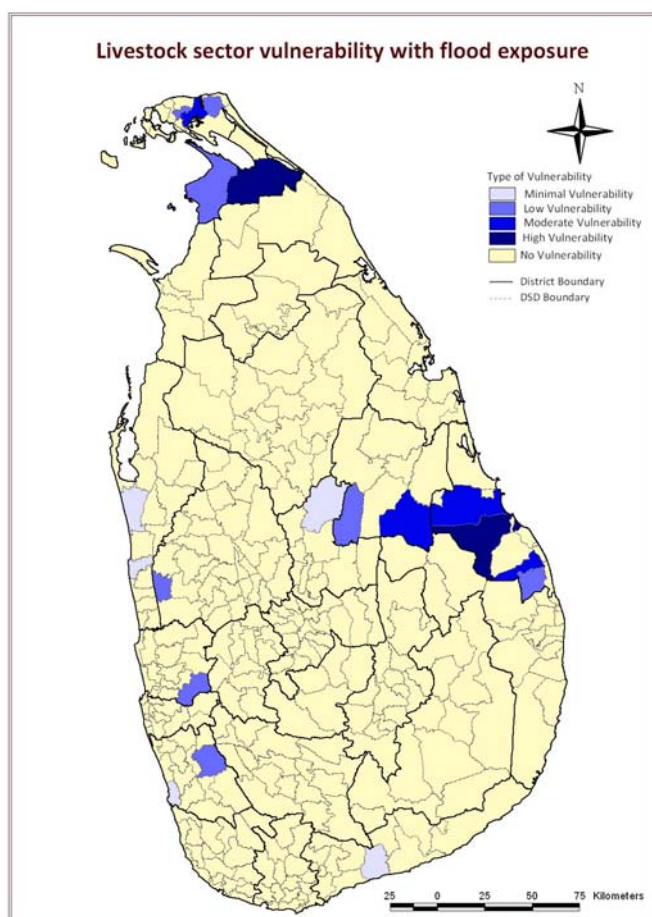


FIGURE 11 Vulnerability of the livestock sector to flood exposure

Vulnerability of the livestock sector to *flood* exposure:

- Vulnerability to flood exposure in the livestock sector is clustered primarily in the North and East.
- 2 DSDs emerge as highly vulnerable and 4 more as moderately vulnerable to flood exposure. These 6 DSDs combined have:
 - 83,826 land holdings with cattle, and 41,906 land holdings with goats and swine.
 - Almost 42,000 heads of poultry
 - 13,878 people employed in agriculture

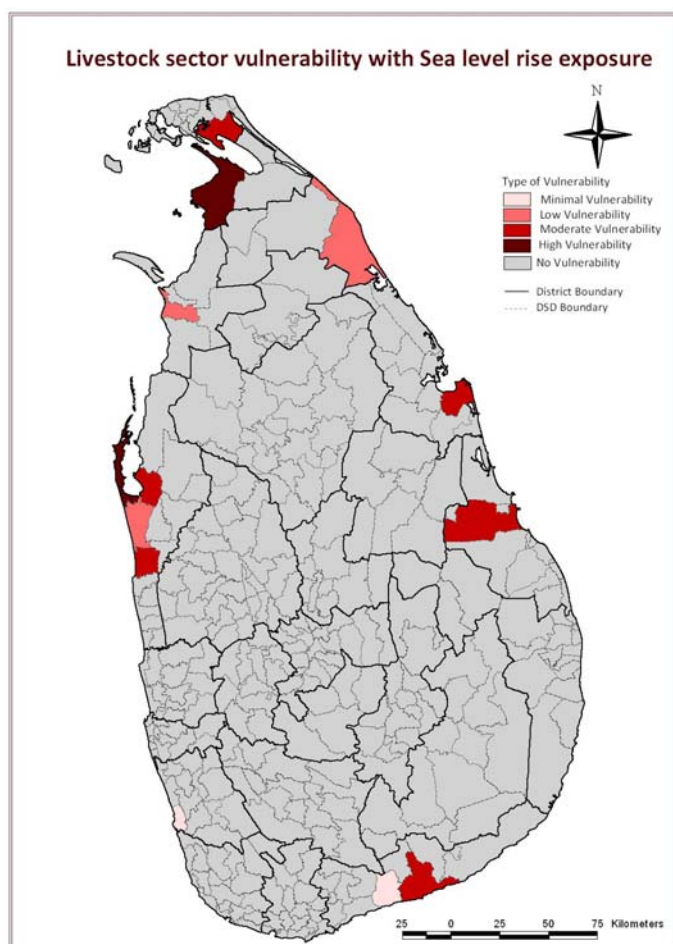


FIGURE 12 Vulnerability of the livestock sector to sea level rise exposure

Vulnerability of the livestock sector to *sea level rise* exposure:

- Livestock sector vulnerability to sea level rise exposure appears to be generally low, and localized in a very few areas.
- 2 DSDs emerge as highly vulnerable in this regard, and 6 more as moderately vulnerable to sea level rise exposure. These 8 DSDs combined have:
 - 52,381 land holdings with cattle, and 41,241 land holdings with goats and swine.
 - Slightly over 701,410 heads of poultry
 - 12,412 people employed in agriculture

3.0 Institutional and Policy Framework

3.1 Institutional set up^t

The main institutions and agencies that have an impact on management of agricultural and livestock production are given in Table 3. See more institutional details in [APPENDIX C](#).

TABLE 3 Institutions and agencies with impact on the agriculture sector

Key Ministries	Key Agencies	Other Agencies with possible impacts
<ul style="list-style-type: none"> Ministry of Agriculture 	<ul style="list-style-type: none"> Department of Agriculture and the institutions under it* Department of Agrarian Development Department of Export Agriculture Sri Lanka Council for Agricultural Research Policy Hector Kobbekaduwa Agrarian Research and Training Institute 	<ul style="list-style-type: none"> National Agricultural Diversification and Settlement Authority (<i>Hadabima</i>) Ceylon Fertilizer Company Ltd. National Fertilizer Secretariat Land Commissioner General's Department The Land Reform Commission National Planning Department Sri Lanka National Freedom from Hunger Campaign Board Institute of Post-Harvest Technology Tea and Rubber Estates (Control and Fragmentation Board) Tea Small Holdings Development Authority Mahaweli Livestock Enterprise Company Ltd. Mahaweli Irrigation Development Programme Department of Meteorology Department of Forests Central Environmental Authority Department of Land Settlement Agricultural faculties of universities Coast Conservation Department Urban Development Authority The Department of National Botanic Gardens The Land Reform Commission
<ul style="list-style-type: none"> Ministry of Plantation Industries 	<ul style="list-style-type: none"> Department of Rubber Development National Institute of Plantation Management Coconut Cultivation Board Coconut Development Authority Tea Research Institute Coconut Research Institute Rubber Research Institute Sugarcane Research Institute Sri Lanka State Plantations Corporation Sri Lanka Cashew Corporation 	
<ul style="list-style-type: none"> Ministry of Livestock and Rural Community Development 	<ul style="list-style-type: none"> Department of Animal Production and Health National Livestock Development Board The Veterinary Research Institute 	
<ul style="list-style-type: none"> Ministry of Irrigation & Water Resources Management 	<ul style="list-style-type: none"> Department of Irrigation Mahaweli Authority of Sri Lanka 	
<ul style="list-style-type: none"> Ministry of Disaster Management 	<ul style="list-style-type: none"> Disaster Management Centre (DMC) 	
<ul style="list-style-type: none"> Ministry of State Resources & Enterprise Development Ministry of Environment Ministry of Lands & Land Development Ministry of Economic Development 	<ul style="list-style-type: none"> Department of Land Use Policy Planning Provincial Councils 	

* See [Appendix C](#) for details

^t This section has been validated at the workshop to prepare the Water SVP and reflect the views of the many stakeholders consulted during the SVP development process.

The National Agricultural System consists of crop production, fishery and aquatic resources development, livestock development and the conservation and sustainable use of natural forests. The crop production sub-sector is divided into plantation crops and non-plantation food crops. The latter sub-sector comes within the purview of the Ministry of Agriculture under which functions the Department of Agriculture (DOA) and the agencies that function under it (see APPENDIX C) and the Department of Export Agriculture. The latter is concerned with the development and preservation of minor export crops such as coffee, cocoa, cardamom and clove germplasm, etc.

The Plantation Crop sector comes under the Ministry dealing with Plantation Industries. In this sector, the Tea Research Institute (TRI), Coconut Research Institute (CRI), Rubber Research Institute (RRI) and the Sugarcane Research Institute (SRI) address research and development of their respective crops and the protection of relevant crop germplasm. The Department of Animal Production and Health and the Veterinary Research Institute (VRI) are concerned with research and development in the livestock sub-sector as well as with the conservation of indigenous livestock germplasm. The latter activity is constrained due to insufficient funds and infrastructure. The Livestock Sector is now under the purview of the Ministry of Livestock and Rural Community Development.

3.2 Key policies and legislation that govern the sector

Key sector policies

The National Policy on Agriculture (NAP) of 2007²²

This policy deals with Food and Export Agricultural Crops and Floriculture with the aim of solving many problems in this sector and facilitating their rapid growth. The objectives stipulated in the policy have been designed to meet the basic needs of the farming community in terms of food security and nutrition, and enhanced employment opportunities and income generation by the adoption of technically feasible, socially acceptable, economically viable and environmentally friendly agricultural production technologies, marketing and related strategies. The policy includes promoting agricultural production, seeds and planting materials, fertilizers, pesticides, agricultural machinery, post-harvest technology, irrigation and water management, land use, soil conservation, traditional agricultural crops, home gardening, and agricultural research. It also deals with providing agricultural credit, agricultural insurance, agricultural extension and education, and promoting marketing, agro-based industries, investments in agriculture, institutional development, sharing of plant genetic resources and youth involvement in agriculture. (see Table 4 for other key policies and laws).

TABLE 4 Legislation/policies/plans/strategies influencing the development of agriculture and livestock

Main legislation governing agriculture	Other legislation having an impact on the agriculture	Policies/plans/strategies
<ul style="list-style-type: none"> • The Agriculture and Agrarian Services Act of 1999 • Irrigation Ordinance No. 32 of 1946; Irrigation Act No.1 of 1951 and its subsequent amendments. • Soil Conservation Act No. 25 of 1951; amended in 1996 • Plant Protection Act No. 35 of 1999 • The Seed Act No. 22 of 2003 • Control of Pesticides Act No. 33 of 1980 • Animals Act No. 46 of 1988 • Animal Disease Act No. 33 of 1992 	<ul style="list-style-type: none"> • The National Environmental Act No. 47 of 1980 and the amendment No. 56 of 1988 • Coast Conservation Act No. 57 of 1981, and amendment No. 64 of 1988 • Felling of Trees Control Act No. 9 of 1951 • Urban Development Authority Law No. 37 of 1978, as amended by subsequent Acts, the recent ones being Act No. 44 of 1984 and Act No. 4 of 1992 • Flood Protection Ordinance No. 4 of 1924. • The State Lands Ordinance No. 8 of 1947 and amendments • The State Lands Ordinance No. 8 of 1947 and amendments • Fertilizer Act No 21 of 1961 and amendment Act No. 68 of 1988. 	<ul style="list-style-type: none"> • The National Policy on Agriculture (NAP) of 2007 • The National Livestock Policy • The National Land Use Policy of 2009

4.0 Current Policies/Plans/Strategies and Actions that Support Adaptation

Adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. To minimize the impacts of climate change, it is necessary to adopt adaptation measures that promote managing the agricultural system efficiently after a comprehensive assessment of potential vulnerability to climate change.

4.1 Enhancing production from agriculture and livestock

Landmark actions taken by the government to address climate change are given in **BOX 4**. Climate change and the variability of climatic conditions that it brings are major challenges for developing countries because of their strong economic reliance on natural resources, rain-fed agriculture and limited management options to reduce impacts. On the other hand, Sri Lanka's long history of agriculture broadens the choice of options for adaptation and underlines the need to strengthen adaptation measures within this sector along with that of irrigation.

Although the exact manifestation of climate change on all crops are not precisely known, the projected changes in intensity and frequency of storms, droughts and floods that could alter hydrological cycles and precipitation can be expected to have major implications for future food availability. Hence adaptation to climate change would require better preparedness to face changing weather patterns, salinization of agricultural lands and natural hazards, such as floods and droughts that are expected to become more pronounced. This would also involve increasing agricultural productivity by counteracting any reduction in productivity associated with climate change and resultant increase in pest and invasive species populations, by maximizing production, crop improvement, land zoning to identify areas suitable for farming, safeguarding farming communities against the increased intensity and frequency of natural hazards by way of early warning systems and institutional support to care for those affected by loss of property and livelihoods.

The government has already taken several measures to ensure sustainable development in the agriculture and livestock sector. The following policies, plans, strategies and actions that follow this ethic are expected to help adaptation to climate change with regard to safeguarding the agriculture (i.e. agriculture and livestock) sector from the very possible negative impacts of climate change. Details of key institutions that could support adaptation programmes in the agriculture and livestock sector are given in **APPENDIX C**.

BOX 4: LANDMARK ACTIONS TAKEN BY SRI LANKA IN RESPONSE TO CLIMATE CHANGE

- Ratification of the United Nations Framework Convention on Climate Change (1992) on 23.11.1993 followed by the Montreal Protocol (on substances that deplete the ozone layer) and the Kyoto Protocol (which commits countries—i.e. mainly Annex I parties) to reduce their collective emissions of greenhouse gases.
- Establishment of a Climate Change Secretariat (CCS) within the MoE to facilitate, formulate and implement projects and programmes at national level with regard to climate change.
- Preparation of an inventory of greenhouse gases (2000) followed by an update which is ongoing.
- Establishment of a separate Climate Change Division within the Ministry of Environment.
- Establishment of a Centre for Climate Change Studies (CCCS) in 2000 under the Department of Meteorology, to conduct research, monitor climate change, and provide the general public with current information on climate change and allied issues.
- Preparation of the Initial National Communication on Climate Change under the UNFCCC in 2000 by the MOE, which indicated the sectors most vulnerable to climate change and subsequent impacts, the sectors that most contribute to climate change, and the required mitigation options and adaptation responses.
- Initiation of the second National Communication on Climate Change under the UNFCCC which is ongoing.
- Addressing national capacity needs to implement the UNFCCC through the National Capacity Needs Self Assessment Project (NCSA) and preparation of the NCSA Action Plan based on a thematic assessment of existing capacity to address climate change by the then MENR (i.e. the MoE).

- *Support from policies and plans*

The National Agricultural Policy²² promotes:

- Production and utilization of organic and bio-fertilizers to gradually reduce the use of chemical fertilizers through Integrated Plant Nutrition Systems (IPNS)
- Minimizing the use of synthetic pesticides through promoting bio-pesticides and Integrated Pest Management (IPM)
- Conservation of water resources, efficient water management and soil moisture retention techniques
- Prevention of water pollution from agriculture
- Adhering to the National Land Use Policy when allocating land for cultivation purposes
- Land conservation within watershed areas
- Enforcing the provisions of the Soil Conservation Act
- Conservation of traditional agricultural crops and methodologies relating to organic farming, pest control, preservation and processing of food for nutritional and medicinal purposes, and facilitation of the exchange of such knowledge among the farming community
- Home gardening and urban agriculture to enhance household nutrition and income

The National Livestock Sector Policy:²³ The livestock development policy deals with developing the Dairy sub-sector, the Poultry Sub-Sector, and Animal feed resources. The Dairy sector is regarded as the priority sector for public sector investment in livestock development. There is no direct government involvement or support in the meat sub-sector, but private sector activity is permitted and the government takes responsibility for ensuring public health safeguards and quality standards in the meat industry.

The policy goals and targets are:

- The achievement of sustainable and equitable economic and social benefits to livestock farmers
- Increasing the supplies of domestic livestock produce at competitive prices to the consumers
- Achieve increased self-reliance, of at least 50 percent, in domestic milk by 2015.
- Double the current domestic production of poultry products by 2015
- Domestic livestock products to be competitive with the imported livestock products.

National Environmental Policy:²⁴ This policy provides the direction and framework for managing and caring for the environment in Sri Lanka. The implementation of the policy needs recognition of the impact of human activity on individual natural resources and on the environment as a whole. It spells out the directions needed in relation to the basic natural resources of land, water, atmosphere and biological diversity, and the environmental strategies to be followed by key economic sectors. Under the management of the land resource, it recognizes the need for providing interventions to increase agricultural productivity and sound agricultural practices in all cultivated land in the island, especially where land degradation is most serious. It also states that environmental changes that affect land resources will be monitored and the real costs of environmental damage from misuse of land will be continually assessed, on the basis of recognized priorities.

Caring for the Environment -- The National Environmental Action Plan 2008-2012:²⁵ The CFE contains the National Environmental Policy, development linked environmental strategies for implementing the policy and a comprehensive set of actions for managing the environment so as to make the development process more sustainable. This document devotes a chapter on Climate Change, and discusses the related issues and responsibilities in Sri Lanka. Under this, Strategy 6 deals with making changes in agricultural practices to suit the changing climate. Among these are selection of crop varieties that are responsive to elevated CO₂, short term varieties that tolerate biotic and abiotic stresses, adjusting rain-fed farming to rainfall variations, adjusting cropping practices to avoid climate induced biotic constraints, establishing surveillance and forecasting systems, selecting rubber genotypes to suit different environments, and adopting suitable crop management technologies and cultivation timings, including home garden cultivation. A range of actions have been identified under adaptation strategies covering changing agricultural practices, use of naturally occurring organic manure and biogas to replace chemical fertilizer, and promoting green procurement and promoting rainwater harvesting.

BOX 5: SUPPORT FOR AGRICULTURAL DEVELOPMENT WITHIN THE NATIONAL DEVELOPMENT POLICY FRAMEWORK

- *The Mahinda Chintana-Vision for the future (2010 Presidential Election manifesto)¹ and the Mahinda Chintana 10 year Horizon Development Framework 2006-2016.²⁶*

The Mahinda Chintana-Vision for the future (2010) envisages an agricultural renaissance and spells out activities to develop the agricultural sector and to ensure future food security. Likewise, the Mahinda Chintana 10 year Horizon Development Framework provides commitment for the rehabilitation of degraded agricultural lands, establishment of a drought early warning system and strengthening drought relief, strengthening rainwater harvesting systems, promotion of sustainable agriculture and adoption of an integrated management system for the land resource, among the many aspects of work to be undertaken to conserve and sustainable use of land in the country.

- *The Action Plan for the Haritha Lanka Programme⁴*

This programme directly addresses climate change through Mission 3 under which it addresses Establishing Food Security in the face of climate change threats. It also indirectly supports measures needed for adaptation in the agriculture and livestock sector through Missions 5 (land) and 7 (water). This Action Plan has short-term, medium-term and long-term targets spanning 2009-2016 that are relevant for adaptation to climate change.

• *Support from projects and institutional programmes*

Some of the key projects and institutional programmes that could support the adoption of adaptation measures are given below:

□ Enhancing agricultural production

Conservation and use of traditional and wild varieties of crops and livestock: There have been considerable efforts to build capacity for biotechnology research based on genetic resources, which is essential for crop improvement programmes. Examples of projects for capacity building for biotechnology are:

- The ADB sponsored Science and Technology Manpower Development Project
- The Sri Lanka-US Department of Agriculture (USDA) Germplasm Development Programme from 2001-2007
- The Agricultural Products and Biosafety in Asia (funded by FAO) project of the PGRC
- The Crop Wild Relatives Project carried out by the PGRC and MENR

Use of indigenous crop varieties with resilient features for crop improvement: In the paddy and horticulture sub-sectors, several hybrid varieties that can weather adverse environmental conditions, including less rain, have been introduced, based on research conducted by the DOA. Likewise crop improvement is carried out at all the plantation crop research institutes.

Over the years the Rice Research and Development Institute (RRDI) of Sri Lanka has worked on varietal improvement to produce rice that is resistant to salinity, drought, pests, and bacterial leaf blight by introducing desirable characteristics of traditional rice varieties (such as *pokkali*) to high yielding rice varieties in order to produce new varieties, of which some may meet the impacts of climate change.

Likewise the TRI has developed new cultivars such as TRI 3000 and 4000 series that have pest, disease and drought tolerance, which will assist adapting to climate change. Current work is being done to identify new cultivars based on agro-ecology and to promote better planting practices that will enable soil conservation. Initiatives for promoting cultivation based on land suitability has facilitated converting of marginal tea lands to energy, timber and fruit plantations that are better adapted to climate change.^u There have also been many crop improvement programmes by the CRI and RRI that can help adaptation options relating to climate change in the plantation sector.

^u Submissions from the TRI during preparation of this report, 2010

Livestock development: Overall there has been a growth of total neat cattle milk production in 2009 through better management practices and upgrading of animals in line with the government's strenuous effort to increase the national milk production under the present policy framework to make the country self-sufficient in milk in the medium term. The principles of the national livestock sector recognizes that . . . "native livestock species of the country have several traits of technical importance which has helped them to survive in very hostile environments and on low quality feed, . . . so that . . . "genetic merit of these species should be preserved for future use in animal breeding activities."²³ The relevant agencies are now engaged in use of local breeds for livestock improvement, but still lack coordination to ensure adequate conservation of livestock genetic resources.^v Several indigenous wild species are also believed to have potential in the livestock industry. Examples are the wild boar, wild buffalo, the jungle fowl, the Sri Lanka Spur fowl, the common Moorhen, the purple swamp hen, the wild hare, wild ponies ("Delft ponies"), and two types of wild donkeys.²⁷

Local breeds have been crossed with high yielding Indian Zebu cattle and Bos taurus var ceylonicus. Breeding studies have also been carried out to cross local breeds with Indian breeds and European breeds. Similarly the indigenous buffalo is being crossed with the Indian Murrah and Surti, and the Pakistani breed Nili-Ravi. There have been long-term studies to cross the local 'Kottukachchiya' breed of goats with the Indian breed Jamnapari, and more recently with the Boer breed to increase meat production. Among the poultry as well local poultry breeds are being used to create better backyard poultry breeds.

(MoENR, 2009)¹³

Maintaining crop gene banks: Facilities have been strengthened for biotechnology to be used in crop improvement in the research and development institutions of this sector. Institutions such as the PGRC, HORDI, FCRDI and RRDI under the DOA are maintaining field gene banks of indigenous varieties of food crops (APPENDIX C). The PGRC maintains seeds of traditional rice varieties and provides limited seed to farmers who request them. The other research institutions of the DoA carry out field trials of new improved varieties as do all other crop research institutes (e.g. TRI, CRI, RRI and SRI). Studies carried out on the use of traditional varieties of crops in farming systems have revealed their continued but scattered existence in various parts of the country.

□ Promoting organic agriculture

Field trials: There has been concerted action by the DOA to decrease dependency on chemical fertiliser in farming systems, including in paddy fields. These include field trials and field exhibits to promote organic agriculture and for pilot testing them with farmers. A special project of the DOA promotes organic agriculture for the export market, but currently most of the marketing of organic produce is done locally by NGOs.

The Integrated Plant Nutrition System (IPNS): This has been initiated to reduce the use of artificial fertiliser during agricultural production. Integrated plant nutrition is also promoted by the TRI to reduce the application of artificial fertilizer in tea plantations.

Integrated pest management: This is also promoted by the DOA, especially for vegetables and rice. Dissemination of this knowledge to farmers is constrained to some extent by the fact that the extension services are decentralised and under Provincial DOAs while the research institutes are under the Central Government.

□ Protecting agriculture from alien species and LMOs

National quarantine procedure: The agricultural sector is responsible for quarantine activities and the prevention of alien invasive species entering the country as per legal provisions at the national level. The Plant Protection Act No. 35 of 1999 makes provision for prevention of the introduction of weeds, insects, pests and diseases that would pose a threat to plants, particularly to crops. All imported plants and animals, or their parts, are thus required to be declared at the point of entry to the country and should be subject to quarantine regulations. All imported seed should be certified by the National Plant Quarantine Service and the Seed Certification and Plant Protection Centre of the Department of Agriculture prior to release or use in the country.

^v Dr Pradeepa de Silva, pers com, 2010.

The National Biosafety Framework Development Project (May 2003-2005): This was carried out by the Ministry of Environment to ensure that the risks due to modern biotechnology and its products (i.e. GMOs and LMOs) will be minimized and that biodiversity, human health and environment will be protected adequately; and that the transboundary movements of GMOs would be regulated through formulation of relevant policies, regulations, technical guidelines and the establishment of management bodies and supervisory mechanisms. This resulted in the preparation of a comprehensive National Biosafety Framework (2003) and a national policy on biosafety.

□ Enhancing efficiency of rainwater use

It is recognized that considerable amounts of water in the country is wasted as surface run-off, and that the run-off water can be stored in home gardens and used for plants during water shortages. Rainwater harvesting has already been tested in the Dry Zone. The project on rainwater harvesting conducted by World Vision Lanka at Tanamalwila is an example of what has been particularly successful.



Rainwater tank



Pathahas

In some parts of the Dry Zone, small ponds called *Pathahas* have been used to collect and store rain water. Such water collecting systems 'on farm' would enable farmers to cultivate crops during the dry seasons.¹⁹

A study has also been carried out in a village in the Anuradhapura District to harvest/collect run-off rainwater in tanks from the *Maha* rains. The water collected was used during *Yala* for crop production. As a result the incomes of the families in the study increased substantially.¹⁹

Photos are credited to the draft SNC document¹⁹

4.2 Addressing natural disasters and land degradation

• *The Natural Disaster Management Plan (NDMP) of 1999*

This plan covered the major phases of Disaster Management by addressing preparedness, mitigation and preventive action; recovery, relief, rehabilitation and reconstruction; control of floods, landslide hazards and cyclones; and improvement of meteorological observations, forecast and warning systems. After the formation of the ministry dealing with disaster management in 2005, a new NDMP was drafted by the Disaster Management Centre (DMC), and it is currently pending cabinet approval.

• *The Forest/Land Use Mapping Project (FORLUMP)*

This project, carried out in the 1990s, offered valuable information for planning soil conservation in the country. It dealt with land-use and vegetation mapping of the Upper Mahaweli Catchments (UMC) and other selected forests, enabling monitoring through satellite imagery. Much of this information was made available using GIS, and maps on rainfall erosivity and erosion hazard were produced for the entire UMC to enable soil conservation initiatives.

- *The Landslide Hazard Mapping Project of 1990*

The Landslide Hazard Mapping Project commenced in 1990 and was carried out by the National Building Research Organization. This project provides vital information on the location of landslide prone areas in the districts of Badulla and Nuwara Eliya, Ratnapura and Kegalle to regulate the development of housing and infrastructure on a sustainable basis. The landslide prone areas were mapped and identified through the project, and important information is obtained for prevention and mitigation of earth slips and landslides and to enable the relocation of people away from such vulnerable areas.

- *The Risk Profile of Sri Lanka*

The Disaster Management Centre in collaboration with the UNDP is playing the lead role in this process and will provide inter-agency coordination and monitoring. The disaster risk profile of Sri Lanka would provide decision makers and planners to identify locations, frequency and impact of main hazards affecting the country, as well as the elements at risk. This knowledge would enable policies and strategies to be formulated for hazard mitigation, preparedness and preparation of contingency plans, and will also enable risk reduction strategies to be incorporated into development plans and projects.

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Agriculture and Fisheries

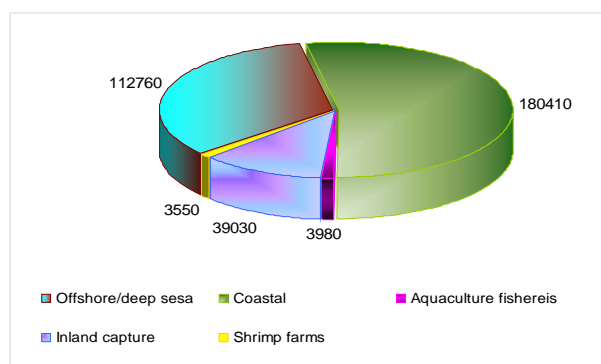
Part II-Food Fishery

Part II - Food Fishery

The fishery sector earns valuable foreign exchange through the export of marine and aquaculture products, and provides direct employment to 208,731 island wide, while sustaining over 2.5 million people. Fishery constitutes the major economic activity in the coastal region which contains 25% of the island's population. Due to its importance as a livelihood of a considerable segment of Sri Lanka's population, and its importance as a source of protein for the people of this country, the fishery sector has received much attention in the national development agenda as shown by its recognition in the *Mahinda Chintana 10 Year Horizon Development Framework* and the Action Plan for the *Haritha Lanka* Programme. The fishery industry is mainly dependant on coastal and marine fishery, while inland surface freshwaters are the source of the inland fishery. Both are heavily dependent on conducive environmental conditions for sustainability and productivity. This makes it critically important that development of the fishery sector should take into account the ramifications of climate change, including sea level rise, and take steps to strategically adopt appropriate adaptation measures to ensure the continued sustainability of the fishery industry.

1.0 Introduction

The fishery sector is divisible into several sub-sectors, namely: coastal fisheries, offshore (deep sea) fisheries, and inland capture fisheries, aquaculture and shrimp farming (FIGURE 13).² The various subsectors and their current contributions to the fishery sector are given in Table 5. Fish also provides about 70% of animal protein consumed in Sri Lanka.³



Source: MFAR, 2009

FIGURE 13 Fish production in 2009 by sub-sectors (tonnes)

BOX 6: FISHERY SECTOR AND NATIONAL DEVELOPMENT

The *Mahinda Chintana: Vision for the Future, 2010*¹:

- Enhancement of the potential of the deep sea fishery resource, including provision of fishing craft with new technology.
- Setting up of factories for fish processing and canning, particularly in the Northern and Eastern Provinces.
- Latest technologies will be introduced to maximize the fish harvest for fishers.
- The mother ship method will be introduced for those involved with the deep sea fishery to bring ashore the catch with least delay.
- More speedy harvesting of resources in the Northern and Eastern seas will give the fishery industry and related industries a new lease of life.

Continued on the next page . . .

The resource base for the coastal and marine fishery of Sri Lanka comprises mainly the Exclusive Economic Zone, which includes the territorial sea (FIGURE 14).⁴ There are about 45 major estuaries and 89 lagoons along the island's coastline that are also important components of the coastal fishery.⁴ While much of the current fish production is from the coastal sub-sector (FIGURE 13), the fishery potential in the offshore/deep sea and international waters, and inland fisheries and aquaculture, is increasingly recognized as important for enhancing the total fishery production in the future.^{1,3} Sri Lanka's inland surface waters^w including freshwater bodies, perennial reservoirs, seasonal tanks and *villus*, which cover about 520,000 ha,⁵ offer considerable potential for the inland freshwater fishery. Opportunities also exist for brackish water aquaculture in a total extent of around 6,000 ha.³ It is expected that the fisheries sector should play a key role for increasing national per capita income from US\$ 2000 to US\$ 4000, and to achieve the expected 10% growth rate in the national GDP.^x Consequently development of the fishery sector is prominent in many of Sri Lanka's overarching policies and plans that further national development (BOX 6).

^w Climate change impacts on water resources have been specifically discussed in the SVP on Water.

^x Input from the discussions for preparation of Part II of the Agriculture and Fisheries SVP with key state sector stakeholders.

Territorial sea and EEZ for Sri Lanka

- The continental shelf around the island is about 22 km wide on average, and covers an area of 30,000 sq km.⁶
- The coastal zone as defined in the CCA of 1981 as the area lying within a limit of 300 m landward of the Mean High Water Line (MHWL) and a limit of 2 km seaward of the Mean Low Water Line (MLWL); in the case of rivers, streams, lagoons, or any other body of water connected to the sea either permanently or periodically, the landward boundary extends to a limit of 2 km measured perpendicular to the straight base line drawn between the natural entrance points of the relevant waters.⁴
- Sri Lanka's territorial sea extends seaward to a distance of 12 nautical miles from the mean low water line and covers an extent of 21,500 sq km. Here the country has sovereignty over all living and non-living resources lying in the water column, seabed and subsoil as well as air space.⁴
- The Exclusive Economic Zone (EEZ) of 517,000 sq km surrounds the island and includes the territorial sea. It extends up to the Maritime Boundary between Sri Lanka and India in the Gulf of Mannar, Palk Strait and Palk Bay, and to a distance of 200 nautical miles at other points.⁴
- Throughout the EEZ the country has sovereign rights to all living and non-living resources lying in the water column, seabed and the subsoil. It also exercises exclusive rights and jurisdiction to authorize, regulate and control marine scientific research, and other rights recognized by International law.⁴
- Sri Lanka is to gain an additional seabed area of 1,000,000 sq km through the claim submitted under the Law of the Sea.⁵



Source: CCD, 2006⁴

FIGURE 14 Territorial sea and EEZ for Sri Lanka

BOX 6: (continued)

The National Action Plan for the *Haritha Lanka* Programme⁷

Mission 4 of the *Haritha Lanka* Programme promotes wise use of the coastal belt and the seas around. Among the actions recommended that would benefit the fishery are:

- Development of the marine and inland fisheries in an ecologically sustainable manner.
- Promoting inland fisheries to reduce pressure on the marine habitats.
- Creating awareness among fishers and other stakeholders to conserve endangered species.
- Conserving fishery resources through establishment of closed seasons and closed areas for fishing.
- Conducting fish stock surveys periodically to ensure sustainability of the resource.
- Introducing co-management of inland and coastal fisheries to induce those involved in the fishery to adopt responsible fishing practices.
- Promoting the adoption of technologies that are non-destructive.
- Prevent exploitation of coastal waters by encouraging use of multi-day boats.

Mission 7 deals with wise use of water - essential for inland fishery, among which is:

- Strengthening implementation of integrated water management systems.

Mission 3 which deals directly with climate change addresses:

- Establishing food security in the face of climate change threats.

The National Physical Planning Policy and Plan (NPPP&P) which includes plans for⁸:

- Expanding the fishery sector by
 - encouraging deep sea fishing, and
 - providing fishery harbours and anchorages at appropriate locations.
- Encouraging industries that support the fishery sector, such as ship building and secondary processing of fish products.
- Identifying and managing inland fisheries.
- Identifying and protecting areas for aquaculture.

TABLE 5 Contribution of Sri Lanka's fishery sub-sectors to total production

Fishery sub-sector		Location	Share of total production in 2009 (%)
Coastal fisheries		Over the continental shelf	53.1
Offshore (deep sea)		From the continental shelf to the edge of the EEZ and high seas	33.2
Inland and aquaculture	Fresh water capture fishery	In surface waters including irrigation tanks of the Dry Zone	11.5
	Aquaculture fisheries and shrimp farming	Shrimp culture in coastal areas, farming of food fish in seasonal freshwater tanks and production of fish seed for stocking	2.2

Source: Ministry of Fisheries and Aquatic Resources Fisheries Statistics for Sri Lanka, 2009²

Table 6 below shows the targeted increase in fish production in the Ten Year Development Policy Framework of the Fisheries and Aquatic Resources Sector, 2007.⁶

The last comprehensive survey of the coastal waters done in 1979-80 (by Dr Fridtjoff Nansen) indicated a possible annual harvestable yield of 250,000 MT of fish from the coastal inshore area. Estimates of possible annual yield from the rest of the EEZ vary from 90,000 to 150,000 tonnes.⁶

TABLE 6 Summary of past performance and targets set for the fishery sector in the Ten Year Development Policy Framework of the Fisheries and Aquatic Resources Sector, 2007

Year	Fish production (t)	Per capita availability of fish and fish products based on local production (kg)	Export earnings (Rs. Mn)	Export volume (Mt)	Contribution of fisheries to GDP (Rs. Mn)	Employment (no.)	Expansion of HS/Offshore fishing fleet
2004	286,370	14	9,176	13,680	33,812	655,000	1581
2007	335,466	19	19,321	21,300	67,540	685,500	2464
2012	450,782	21	27,011	29,788	106,821	692,512	2881
2016	461,959	22	41,147	45,432	138,587	795,000	3243

Source: MFAR (2007). Ten Year Development Policy Framework of the Fisheries and Aquatic Resources Sector⁶

1.1 Economic importance of the fishery sector

• Overall fishery sector

The annual total fish production in Sri Lanka for 2009 was 339,730 t, with the coastal and marine fishery contributing over 86%.² Fishery products also contributed 2.6% to all export earnings in 2009.² FIGURE 15 indicates the changes in fish production according to commercial groups between 1995-2007. The food fishery is also one of the most dynamic export sectors in the economy through the export of various aquatic products such as prawns, lobsters, crabs, chank shells, beach de mer, molluscs, fish and fish maws and shark fins.² Rising foreign exchange earnings through the export of marine and aquaculture products (FIGURE 16) and the contribution of 2.6% towards Sri Lanka's

total value of all export earnings in 2009² indicate the importance of the fishery sector to the national economy. Further, the direct involvement of 164,870 males and 10,353 females in the marine fishery and 32,758 males and 750 females in the inland fishery² underlines the importance of the fishery sector in terms of livelihoods. 'Fattening of crabs for export' is also now gaining importance among fishers in the North Central province.⁹ Overall the fishery industry provides direct or indirect employment to 475,000 persons, while fishing and related activities (including those working in boat building, fish processing and equipment manufacturing) sustain about 2.5 million people.² In the post-war scenario in Sri Lanka, it has also been recognized that development of the fishery industry offers excellent potential for providing livelihoods to those affected by the war.^y As such, there is a move to encourage non-traditional farming of sea cucumbers, oyster, sea bass, and seaweed in the sea off the North and the East coasts for which good water quality is a critical requisite.^u The need for catch certificates by the European Union according to their new fishery regulations also confers responsibility on the government to ensure the use of environmentally friendly fish collection methods,^u especially as many of the fish exports are to member countries of the EU.⁵

● *Coastal and deep sea fishery*

Estimates from surveys in 1979-1980 have shown a maximum annual harvestable sustainable yield of 250,000 t from the coastal area comprising 170,000 t of pelagic fish and 80,000 t of demersal fish.

Source: Ministry of Finance and Planning³

Overall the coastal region covers only 24% of the country's land area and accommodates about 25% of the total population.⁴ Despite the drop in contribution from the fishery sector to the national GDP after the tsunami to 1.03%,^{3,6} it had climbed to 1.2%^z of the GDP in 2009.¹⁰ The growth in the marine fishery sector in 2009 was primarily driven by coastal fishing which expanded due mainly to post-war relaxation of restrictions on fishing off the

Northern and Eastern provinces.¹⁰ Further, the entire contribution to the post-tsunami national GDP of 2005 and 2006 from the coastal region,^{aa} where fishery forms the foremost economic activity,¹⁰ is estimated to be 43% and 44%.¹¹ The coastal and deep sea marine fishery contributed respectively 180,410 MT and 112,760 MT of fish amounting to a collective 86.3% of the total fish production in the island in 2009.² Accordingly the coastal and marine fishery forms an important national economic activity.

Due to over-exploitation of the coastal waters in the past, efforts will, however, be made to maintain stability of the coastal fishery at the present level, while management efforts will be concentrated for growth of the offshore and deep sea fishery and aquaculture.³ This can be directly linked to adaptation measures for the fishery sector in view of climate change that may cause significant changes in the coastal environment.

In terms of commercial groups in the deep sea and coastal fishery, pelagic marine fish contribute the most to fish production (FIGURE 15), but the brackish water (estuary and lagoon) fishery—which includes shrimps, lobster and crab fishery—also constitutes an important component of the country's export earnings (FIGURE 17).

Example of the importance of coastal lagoon and estuarine fishery at the turn of the century:

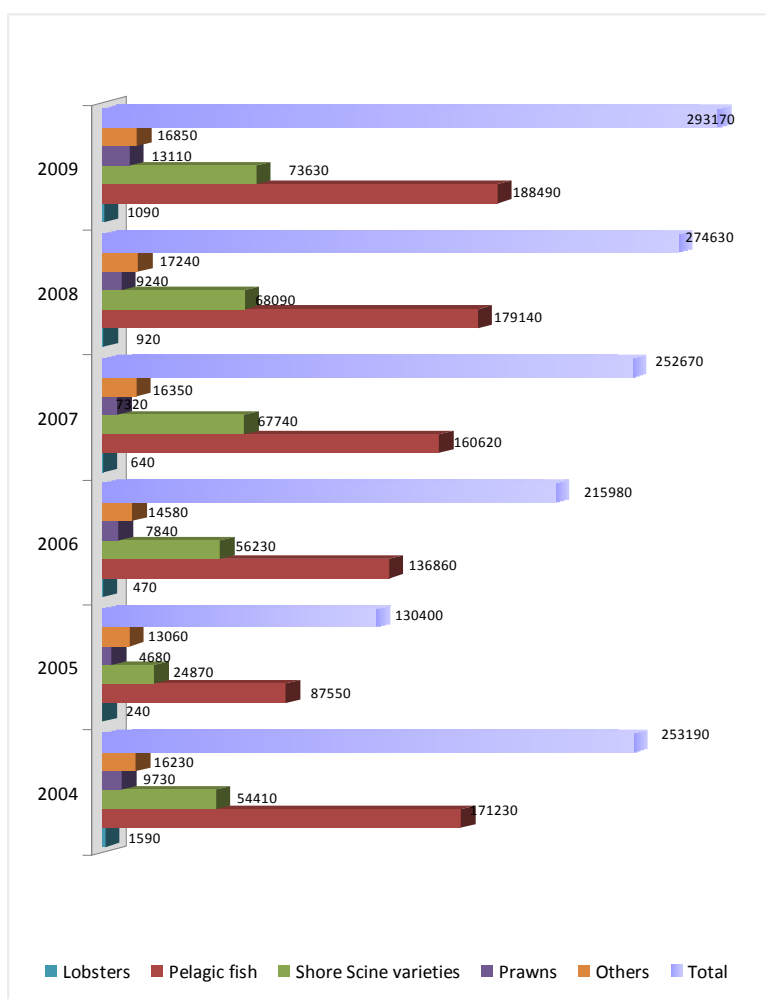
The Negombo estuary yielded 1,024 t of shrimp in 1999 and the Puttalam estuary provided 4,800 t of fish annually during the period 1990-1991. Studies conducted in 1988 indicated that there may be around 30,000 part-time and full-time fishermen engaged specifically in the lagoon fishery, while shrimp farming in the coastal zone provides employment to around 8,000 persons.

Source: CCD, 2006⁴

^y Discussion with fishery sector stakeholders for preparation of this report, 2010.

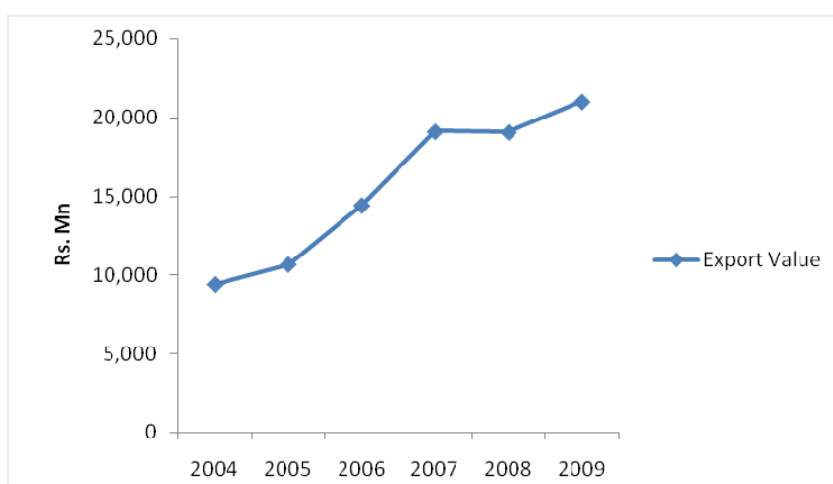
^z MFAR Fisheries Statistics Sri Lanka, 2009 gives this as 1.5% for marine fishery and 0.2% for the inland fishery.²

^{aa} The coastal region defined here is the Divisional Secretariat Divisions with a maritime boundary along the coast.



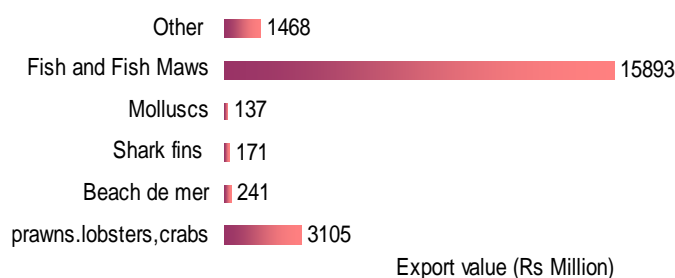
Source: MFAR 2007⁵ and 2009²

FIGURE 15 Fish production by commercial groups in metric tonnes (MT)



Source: MFAR 2007⁵ and 2009²

FIGURE 16 Value of total export earnings from fishery products 2004-2009



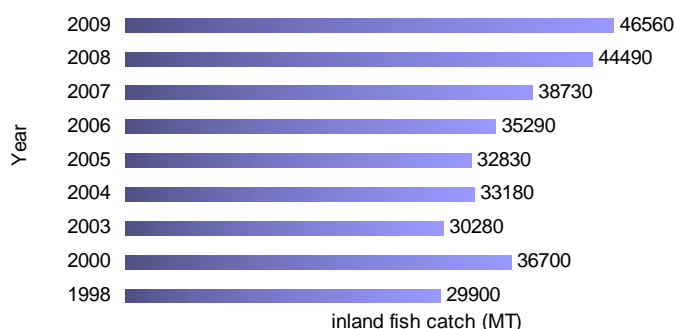
Source: MFAR 2009²

FIGURE 17 Export value of selected fish and fishery products in 2009

- Inland food fishery and aquaculture**

About 11.5% of total food fish production is from the inland capture fishery.² Throughout history, the inland fishery has been a secondary use of waters in many man-made tanks built for irrigated paddy cultivation. In more recent times the larger multi-purpose reservoirs are also used for development of the inland fishery (*note: details of inland waters are discussed in the Water SVP*). The inland fishery provides cheap protein, incomes and employment for many rural people.⁶ Generally the large (> 800 ha) and medium (200-800 ha) reservoirs are used for capture fisheries; the small (1-200 ha) irrigation reservoirs and seasonal tanks which hold water for 6 - 8 months a year are used for culture-based fisheries.⁶

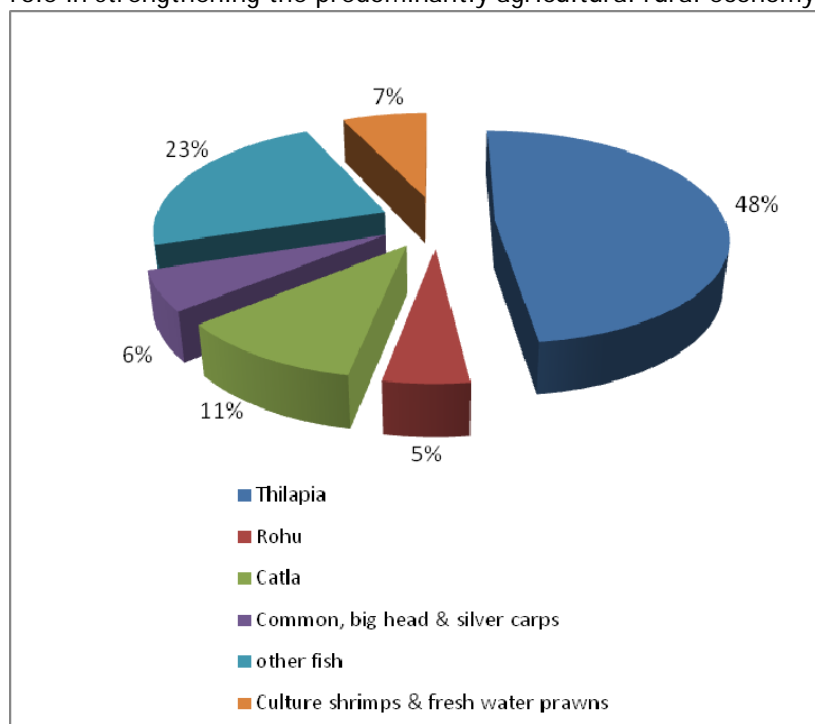
There was a setback in the inland fishery during the early 1990s due to the withdrawal of state support, but the inland capture fishery and aquaculture were rejuvenated with the re-establishment of the Inland Fisheries Division of the Department of Fisheries in 1994, and the setting up of the National Aquaculture Development Authority in 1999.⁶ FIGURE 18 shows the trend for growing production from the inland food fishery since 2005. Among the species contributing to the inland fishery are the cultivated tilapia, rohu, catla, common carp, big head carp, silver carp, *mirigal*, *hiri kanaya*, *lula*, cultured shrimps, fresh water prawns and some wild fish.² Tilapia, which is an introduced species, is the most important food fish in the inland fishery, comprising 56.5% of the inland fish catch in 2009 (FIGURE 19).



Source: MFAR, 2007⁵ and 2009²

FIGURE 18 Inland fish catch by major species in the inland fishery

The inland capture fishery provide an important protein food supplement to rural communities at an affordable price, and opens up alternatives for supplementary livelihood opportunities - thus playing a major role in strengthening the predominantly agricultural rural economy.^{3,6}



Data source: MFAR, 2009²

FIGURE 19 Inland catch estimates by major species (MT) in 2009

The Asian Development Bank funded Aquatic Resources Development and Quality Improvement Project (ARDQIP) supported NAQDA to develop freshwater capture fisheries and aquaculture up to 2009. The main interventions of the project had direct impact on increasing production in culture based fisheries within minor reservoirs and seasonal tanks, and fish seed production. Through the implementation of these activities, total carp and tilapia production was expected to increase up to 45,223 t at full development of the ARDQIP by 2009.

Source: MFAR, 2007⁵

1.2 Environmental aspects of the fishery sector

• Marine and coastal fishery and related ecosystems

There are about 146 species of marine bony food fishes that are of high or medium value in Sri Lanka¹² among the 1,800 species of marine pelagic fish found in Sri Lankan waters.⁴ Sri Lanka also has many types of coastal wetlands including marshes, mangroves, sea grass beds and mud flats that are important to maintain the coastal fishery.^{3,4} Any damage to estuaries and lagoons, coral reefs or coastal wetlands (Table 7) would lead to reduced feeding, breeding and nursery habitats for commercially important coastal and marine finfish and shellfish used in the food fishery.³ Species in estuaries

A stock assessment of sea cucumber, chanks, marine aquarium fish and lobsters as well as a habitat quality assessment was carried out in 2008-2009 by NARA with funds from CIDA and IFAD. This revealed a drop in populations of these groups due to over-harvesting and the poor condition of the southern coral reef habitats.

Source: Input from the discussions for preparation of Part II of the Agriculture and Fisheries SVP with key state sector stakeholders.

and lagoons that contribute significantly towards the food fishery include clupeids, mullet, milkfish, rabbit fish, and many species of shrimps and mud-crabs.^{4,9,13} Many species of shrimp, crabs and lobsters are currently fished in lagoons and estuaries and the sea,¹⁴ and there are several edible species among the 28 species of sea cucumbers found in Sri Lankan waters,^{bb} and several species of edible oceanic squid.^(ibid)

TABLE 7 Extent of marine habitats that are important in the coastal fishery

Habitat	Area (ha)
Estuaries and lagoons	>1,29,075*
Mangroves	6,080*
Salt Marshes	23,819*
Coral Reefs	68,000 [†]
Sea grass beds	NA

Sources: CCD, 2006*; Rajasuriya, 2007^{†15} NA=Data not available

• *Inland food fishery and aquaculture*

Sri Lanka has one of the highest densities of inland surface freshwater bodies in the world.¹⁶ In addition to the island's abundant natural surface water; ancient tanks dot the Dry Zone, while the more recently built large multi-purpose reservoirs are located in the wet uplands. In addition, the network of bunds, small streams, or irrigation canals and sump ponds that are associated with rice paddies are home to many freshwater food and ornamental fish species.¹⁴ This offers high potential for the island's inland food fishery which is mainly dependant on about 260,000 ha of freshwater bodies, 155,000 ha of perennial water bodies and 100,000 ha of seasonal village tanks⁵ that hold water for 6-8 months of the year.⁶ Currently fingerling stocking has been carried out in 38, 65 and 250 major, medium and minor water bodies respectively; 250 minor perennial tanks; 375 seasonal tanks and 300 aquaculture ponds.²

Overall brackish water aquaculture in Sri Lanka covers approximately 6,000 ha in extent.³ At present, this fishery consists mainly of shrimp culture, which has expanded considerably since the late 1970s when commercial shrimp farming commenced in the country.⁴ A large number of shrimp farms are currently located in the Western and Northwestern coastal belt, mainly between Maha Oya and Puttalam/Kalpitiya.⁴ Shrimp farming on the East coast has now re-commenced, particularly in the Batticaloa lagoon area, and the possibilities of expanding brackish water aquaculture to Hambantota, Galle, Mannar, Jaffna, Trincomalee and Mullaitivu are being explored.³ A declining trend in the productivity of shrimp farms of the Northwestern Province has been discerned due to diseases (e.g. white spot) and other environmental factors. The need for zoning coastal areas to sites suited for aquaculture and other development is recognized in the Coastal Zone Management Plan (CZMP);⁴ zoning plans for aquaculture has been carried out for Batticaloa and Trincomalee, and is ongoing for other coastal areas.^x

^{bb} Input from the discussions for preparation of Part II of the Agriculture and Fisheries SVP with key state sector stakeholders.

2.0 Climate Change Related Issues and Vulnerability

According to the IPCC, *vulnerability* is the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change. Vulnerability is a function of the character, magnitude and rate of climate variation and its effects to which a system is exposed, its sensitivity, and its adaptive capacity. *Exposure* means the nature and degree to which a system is exposed to significant climatic variations. Sensitivity is the degree to which a system is affected either adversely or beneficially by climate related stimuli. *Adaptive capacity* is the ability of the system to adjust to climate change, to moderate potential damages, to take advantage of new opportunities or to cope with the consequences.

General methods

As an island nation, Sri Lanka is vulnerable to the risk of sea level rise and increased frequency of storms that can have major impacts on coastal ecosystems that nourish the marine food fishery. The analysis of climate data for Sri Lanka clearly indicates increasing variability of rainfall regimes and temporal and spatial distribution of rainfall as well as a trend for increasing air temperature. All of these can also have impacts on coastal areas and inland waters that are important for the food fishery industry.

The key climate change-related issues and risks relating to the fishery sector are explained below. (See **BOX 2** on Impacts of Climate Change on the Weather in Sri Lanka and **BOX 3** on Impacts of Natural Hazards that Affect Sri Lanka in Part I of this document).

2.1 Climate change induced threats

- *Vulnerability to natural hazards*

Possible impacts of sea level rise, frequent storm surges and coastal flooding:

Impacts on marine habitats: (i.e. loss or changes in coastal habitats and species distribution)

- Landward migration of coastal wetlands, resulting in the loss of freshwater and brackish water habitats important for the coastal and marine fishery and coastal aquaculture.
- Net loss of wetlands in areas where coastal wetlands are unable to migrate to keep pace with sea level rise due to infrastructure or other forms of land uses.
- Adverse impacts of sea level rise on mangroves and coral reefs that are important breeding grounds for the marine food fishery.
- Damage to coastal habitats such as near shore coral reefs, mangroves and sea grass beds due to climate change associated increased incidence of natural disaster events (e.g. storm surges, coastal flooding, and coastal erosion). This will affect the availability of fish stocks for the marine fishery as these habitats are feeding and breeding grounds for food fish. Damage to reefs from storm surges can also lead to more serious coastal erosion and saline intrusion due to sea level rise.
- Changes in salinity of lagoons and estuaries that may affect fish and crustaceans important for the food fishery due to saline intrusion and coastal flooding.

Predicted impacts of sea level rise

The forecasts for global sea level rise in this century vary considerably, but the Inter-governmental Panel on Climate Change (IPCC) has provided a central estimate of 0.2 m and 0.5 m rise by the years 2050 and 2100 respectively. The forecasted sea level rise for 2050 is expected to cause a general shoreline retreat of 10 m along all sandy coasts assuming a mean slope of 1:50 for a typical coastal profile. Over the 50 year period this will correspond to 0.2 m of shoreline retreat per year. By 2100 a general shoreline retreat of 25 m is expected, corresponding to an average retreat of 0.25 m per year. These values are valid for sandy coasts.

Source: CCD, 2006⁴

Impacts on coastal communities:

- The beach seine fishery is affected by changes in the beach environment, so that loss of beach area due to sea level rise will affect this fishery, which is already adversely affected by anthropogenic factors that reduce beach access for fishermen. Further loss to this traditional fishery can have a negative impact on fishers engaged in this occupation and their social systems, necessitating alternate livelihoods and assistance to change lifestyles.

The impact of beach loss on the beach seine fishery

Beach seining, which is conducted in bays and calm waters requires fairly large tracts of beach area for hauling the net manually by about 40-100 people, and for drying the nets and fish. The Department of Fisheries has designated sites for the operation of beach seine nets. The revenue from this fishery accounted for over 40% of the total national fish landings until the early 1950s before the advent of motorized fishing crafts, but had dropped to a mere 5% of the total fishery by the late 1980s. Already beach seine operations have dropped due to many factors, particularly due to loss of beach areas for tourism related activities and coastal erosion.

(Source: CCD, 2006)⁴

- Loss of beach area will also affect access to natural beach landing sites used by fishers who use traditional boats and day boats.

Impacts on coastal structures:

- Several anchorages and 14 more fishery harbours (in addition to the 12 presently in use) are to be constructed,¹⁷ which may be adversely affected by storm surges, flooding and inundation due to sea level rise, so that adaptation mechanisms would be required. Seven of the new harbours will be established on the Southern and Eastern coasts.
- Increased intensity of storm surges will cause more coastal erosion as well as damage to structures built to protect against erosion and sea level rise. This in turn will also affect the beach seine fishery and traditional fishers due to loss of fish landing sites.

Possible impacts of changes in rainfall regimes and prolonged drought:

Impacts on inland surface waters:

- Changes in rainfall regimes and more prolonged droughts in the Dry and Arid Zones could lead to greater evapo-transpiration which could impact on the inland fishery.
- Increased flooding due to increasing number of high rainfall events will affect inland aquaculture and capture fishery due to pollution, sedimentation and any adverse changes in water quality parameters of surface water bodies (mainly tanks) that sustain this fishery.

The variability of the north-east monsoon from November-February annually may increase with climate change, and prolong drought periods.

Source: Second National Communication to the UNFCCC (draft).¹⁸

- Drought would lead to lower yields in seasonal tanks, and thereby have severe impacts on the inland fishery as investments for aquaculture may not yield adequate returns.

Impacts on rural communities:

- Reduced production from the inland fishery would affect rural nutrition and incomes for those dependent on this activity.

Possible impact of rising temperature:

Impacts on marine habitats:

□ Coral reefs

- The rise in ocean temperatures calculated by model projections indicate that thermal tolerances of reef building corals may be exceeded within the next few decades, with heat stress and resultant damage caused to coral reefs.
- Rising ocean temperatures and El Nino events could systematically bleach and impoverish entire coral reef systems.
- As coral reefs act as nursery grounds for coastal and marine fish species important in the food fishery as well as the ornamental fishery, adverse impacts on them may be expected.

Projected average temperature increase for Sri Lanka:

- 2025 is 0.4°C
- 2050 is 0.9°C
- 2075 is 1.6°C
- 2100 is 2.4°C

Source: Department of Meteorology data, provided for preparation of this report in 2010

- Temperature rise induced changes in coral reefs, sea grass beds and other coastal habitats (such as mangroves) may affect distribution and composition of marine and coastal species, and have adverse impacts on fish stocks.
- Acidification of oceans due to global warming and increased atmospheric CO₂ will affect coral reefs and other shell forming organisms, with adverse effects on ecosystems.
- Inland wetlands important for the food fishery may be adversely affected by temperature anomalies with resultant changes in water quality that could cause fish kills.
- Changes in ecosystems can increase impacts of invasive species into coastal and marine habitats. For example, coral reefs in Weligama that were affected earlier by the El Nino bleaching event have now been invaded by *Halimeda* sp. causing further degradation of the reef system in this area.^{cc}

Impacts on marine and inland fish stocks:

- El Nino effects will have adverse impacts on fish stocks. For example, coral bleaching events have long term impacts on reef structure, and major changes in reef structure will have impacts on demersal fish such as groupers and snappers. The drop in quantity of such food fish will affect production in the food fishery, supply chains and export value of the fishery industry. More research is therefore required on temperature related changes on the food fishery.
- A temperature rise of about 2°C may have substantial impacts on the distribution, growth and reproduction of fish stocks - in both marine and inland waters.
 - Rising temperatures may also lead to changes in spawning areas and distribution patterns of commercially important marine fish stocks.
 - Temperature changes may affect migratory routes of marine fish species such as tuna.
- Decreased primary productivity caused by temperature anomalies can affect the abundance of species higher up in the food chain in the long-term.
- Rising temperatures may also lead to greater evapo-transpiration/pan evaporation in irrigation tanks which may have impacts on the inland fishery and aquaculture.

^{cc} Arjan Rajasuriya (NARA), pers. com. 2010.

- There could be temperature related sex change in some fish species, with resultant gender imbalance and resultant depletion of fish stocks. This could especially affect aquaculture.

2.2 Vulnerability enhancing factors

• *Increased threats from invasive species*

Sri Lanka's indigenous fish species are believed to be already threatened due to the introduction of alien invasive aquatic organisms, that have also brought in new diseases into freshwater systems. It is believed that currently there are many species of introduced food fish in the inland freshwaters. Some, such as Tilapia, are believed to be the direct cause of population decline among indigenous aquatic fauna.^{13,19}

- Climate change is expected to increase the worldwide range of many alien invasive species. Sri Lanka as an island is highly vulnerable to alien species invasions and the severe repercussions they could have on fishery and agriculture, and hence the national economy. Some introduced freshwater species are believed to compete or consume indigenous species. Some brackish water indigenous species introduced to freshwaters could also become invasive in the future in the face of climate change, posing a threat to the indigenous freshwater biodiversity and fishery.

The alien invasive Clown Knife Fish (Chitala ornatus) was introduced to Sri Lanka as an ornamental aquarium fish, with breeding populations established in streams and reservoirs in the Wet Zone that harbour most of the threatened endemic freshwater fish. The population reductions of many species of endemic fish have suspected subsequent to the introduction and spread of C. Ornatus.

Source: Gunawardane, 2002 cited in MoENR, 2009¹⁴

• *Socio-economic factors*

- Vulnerability of the fisher community to climate changes will be influenced by several socio-economic factors, including status of poverty and food security, education levels, amount of resources they are endowed with, alternative livelihoods, institutional support frameworks, and government policies.

• *Anthropogenic factors that lower fishery productivity*

- Use of unsustainable fishery practices (e.g. light fishing, blast fishing [which is banned] and large scale purse seining) and fishing gear (e.g. purse seine nets) that reduce fish and shell fish (i.e. lobster) catch.^{dd}
- Over-fishing of near-shore waters have depleted coastal fish stocks and resulted in loss of income in the long-term for fisher families dependant on the coastal fishery.
- Threat of oil pollution from boats and ships. (note: Addressing the danger of a major oil spill due to the heavy shipping traffic in Sri Lankan waters has been identified for marine pollution management by the Marine Environment Protection Agency).
- Damage to mangrove and coral reef habitats due to over-use of mangrove resources, blasting of coral reefs, anchorage of boats near coral reefs and dragging of nets, have already caused loss of feeding and breeding habitats for commercially important coastal and marine finfish and shellfish.
- Haphazard construction and expansion of some piers and fish landing points in lagoons have interfered with water flow, and led to siltation of coastal waters and habitats.

^{dd} E.g. Use of bottom set nets and purse seining in Kalpitiya has had adverse impacts on the fishery resources and habitats. Of concern is that banned fishing gear are freely available in the market (source: Inputs at discussions with state sector stakeholders for preparation of this document, 2010).

- Adverse human activities inland such as release of over-flows from inland reservoirs, and sedimentation caused by inland soil erosion and land degradation - partly due to poor agricultural activities, have caused changes in the salinity of lagoons and estuaries.
- The reclamation, sedimentation and dumping of garbage in lagoons and estuaries reduce productive aquatic area of these habitats.
- The construction of coast protection structures that alter patterns of sand movement along the coast over time leads to degradation of many traditional coastal fish landing sites and beach area required for beach seining. (note: but some coastal protection work/structures are considered favourable as they form beachfronts and are used as new fish landing sites).
- Increased demand at certain localities may lead to an increase in the overharvesting of fish stocks and unsustainable fishery practices as bans are not very effective. For example, tourism development at Kalpitiya can have significant impacts on fish production, and should be addressed to ensure benefits to the industry.^{ee}

2.3 Mapping climate change vulnerability

A vulnerability mapping exercise, using GIS, was undertaken in order to better understand climate change vulnerability in key sectors in Sri Lanka, building on the IPCC definitions of exposure, sensitivity, and adaptive capacity as defined in section 2.0 above.^{ff} The analysis is intended for use as a macro level planning tool, to illustrate where sector-specific vulnerability is high in relative terms across the nation, and to guide decisions on prioritization and targeting of potential climate change adaptation responses.

General methods

The basic methodology involved in the GIS mapping was to develop indices for exposure, sensitivity, and adaptive capacity relevant to each given sector. These three indices were then combined to create a composite sector-specific vulnerability index. The analysis is largely based on publicly available data sources, including the 2001 National Census. Areas where complete and comparable data sets of relevant indicators (such as the North and East where census data is not available) were not analyzed, and will need to be evaluated at a future stage, perhaps after the 2011 census is completed.

Separate *exposure indices* for drought exposure were developed based on historic data on the frequency and scale (assessed in terms of number of people affected) from the Disaster Management Center (DMC). The index for sea level rise was based on a ratio of the area of land within 2 m above sea level as a percentage of total land area within 5 km from the coastline in each DS Division. Topography data was obtained from ASTER 30 m Digital Elevation Model. These exposure indices are common across all sectors, but only exposure types relevant to a given sector were analyzed and illustrated.

The sensitivity and adaptive capacity indices are unique to each sector and the indicators used in their formulation are given in the following pages along with the vulnerability maps.

It must be noted that the mapping exercise itself is preliminary and limited in scope, and should be refined on an ongoing basis, based on detailed data which may become available from various government agencies. It is also noted that relevant agencies are carrying out detailed hazard mapping at the national or regional levels.^{gg}

^{ee} Inputs at discussions with state sector stakeholders for preparation of this document, 2010.

^{ff} IWMI's Climate Change Vulnerability Index as in Eriyagama *et. al.*, 2010²⁰ was used as a starting point and substantially refined for finer grain and sector specific analysis.

^{gg} For example, the Disaster Management Centre is currently coordinating a detailed risk profiling exercise for the major disaster types, at a much higher level of detail, in collaboration with the Coast Conservation Department, Irrigation Department, the National Building Research Organization, and several others. The maps generated through the DMC exercise would provide much finer grain information for exposure indices.

What the vulnerability maps foretell

• *Vulnerability of the marine fishery sector*

FIGURES 20-22 illustrate the geographic distribution of vulnerability to sea level rise exposure in the fishery sector. The indicators considered in developing the sensitivity and adaptive capacity indices are shown below. The DSD vulnerability ranking table and the larger scale maps are in APPENDIX B.

The sensitivity index for marine fisheries includes	The adaptive capacity index for marine fisheries includes
A composite of data (at DSD level) on: <ul style="list-style-type: none"> • number of fisheries landing sites • percentage of livelihoods dependent on fisheries • average fishing yield over the last four years 	A composite of data (at DSD level) on: <ul style="list-style-type: none"> • percentage of population above the poverty line • percentage of population who have completed secondary education • percentage employed in sectors other than fisheries
Raw data sources: Population & Housing Census, 2001; Department of Coast Conservation; Ministry of Fisheries and Aquatic Resources	

The sensitivity index for inland/brackish water fisheries includes	The adaptive capacity index for marine fisheries includes
A composite of data (at DSD level) on: <ul style="list-style-type: none"> • Percentage of employment in fisheries within GN divisions with no coastal frontage • Average inland/brackish water fisheries yield over the last four years • area of water bodies (tanks, lakes, lagoons, mangroves) 	A composite of data (at DSD level) on: <ul style="list-style-type: none"> • percentage of population above the poverty line • percentage of population who have completed secondary education
Raw data sources: Population & Housing Census, 2001; Ministry of Fisheries and Aquatic Resources	

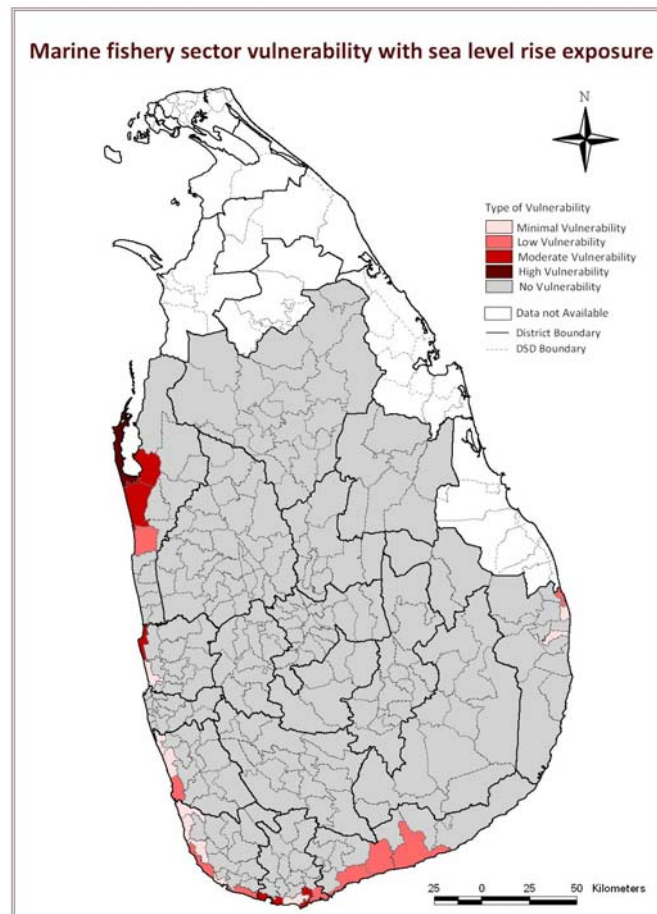


FIGURE 20 Vulnerability of the marine fishery sector to sea level rise exposure

Vulnerability of the marine fishery sector to *sea level rise* exposure:

- Kalpitiya (Puttalam District) emerges as the DSD that is highly vulnerable to sea level rise exposure in this regard. Kalpitiya has:
 - 5,938 jobs in the fisheries sector, which is more than 25% of its total employment
 - 43 fisheries landing sites
- An additional 5 DSDs are moderately vulnerable. These DSDs have:
 - 10,408 jobs in fisheries
 - 115 fisheries landing sites

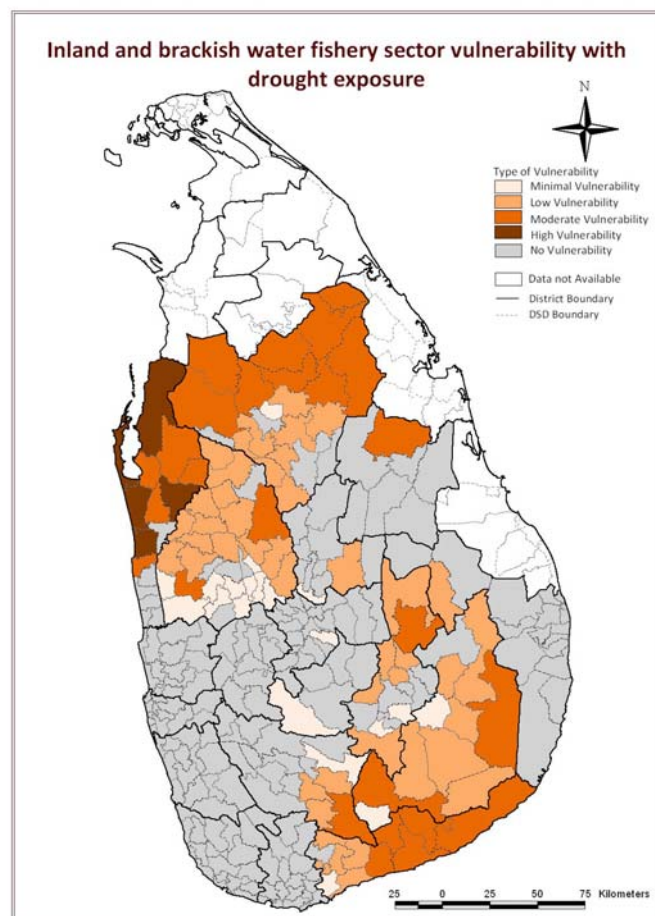


FIGURE 21 Vulnerability of the inland/brackish water fishery sector to drought exposure

Vulnerability of the inland/brackish water fishery sector to *drought* exposure:

- Vulnerability to drought exposure in the inland and brackish water fishery sector is widespread, particularly in the Dry and Intermediate zones.
- All 5 DSDs that fall within the highly vulnerable category in this regard are in the Puttalam District. These 5 DSDs have:
 - 457 ha of lagoons and mangroves, and 35 ha of tanks
 - 9,453 people employed in the inland fishery
- 23 additional DSDs fall within the moderately vulnerable category. These DSDs have:
 - 83 ha of lagoons and mangroves, and 516 ha of tanks
 - 6,597 people employed in inland fisheries
- With 5 DSDs as highly vulnerable, and another 5 DSDs within the moderately vulnerable category, Puttalam is clearly the district most vulnerable to drought exposure with regard to the inland/brackish water fishery.

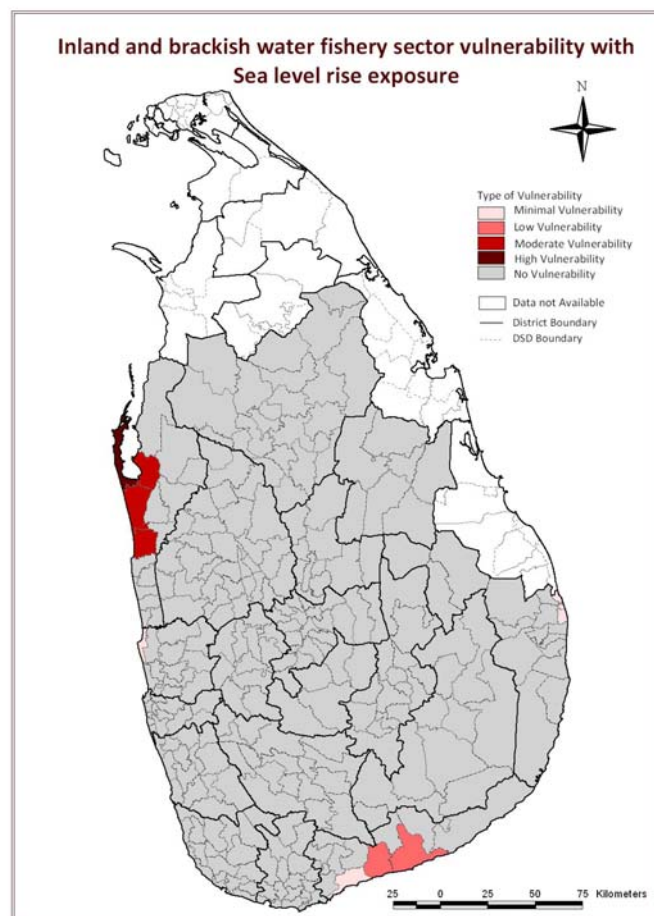


FIGURE 22 Vulnerability of the inland/brackish water fishery sector to sea level rise exposure

Vulnerability of the inland/brackish water fishery sector to sea level rise exposure:

- Vulnerability to sea level rise exposure of the inland and brackish water fishery sector is highest primarily in the Puttalam District, with a pocket of low vulnerability in the Hambantota District.
- All 4 DSDs that are either highly or moderately vulnerable in this regard are in the Puttalam District. These 4 DSDs have:
 - 343 ha of lagoons and mangroves
 - 9,899 people employed in the inland/brackish water fishery sector

3.0 Institutional and Policy Framework

3.1 Institutional set up^{hh}

The Ministry of Fisheries and Aquatic Resources (MFAR) is primarily responsible for formulating policies, plans and programmes for the development of fisheries and aquatic resources. In the implementation of its plans and programmes, MFAR is assisted by one department, four statutory bodies and a public company (Table 8). The mandate for fisheries and aquaculture development, management and research in Sri Lanka lies with agencies such as the Department of Fisheries and Aquatic Resources (DFAR), National Aquaculture Development Authority (NAQDA) and National Aquatic Resources Research and Development Agency (NARA). DFAR is the government agency mandated with the management, regulation, conservation and development of fisheries and aquatic resources in the country while NAQDA is the main state sector agency responsible for the development of aquaculture and inland fisheries. As the research arm of MFAR, NARA is responsible for carrying out research activities on all living and non-living aquatic resources.²¹ See more institutional details in APPENDIX C.

TABLE 8 Institutions involved in the fishery sector

Key Ministries with impact on fishery development	Key Agencies	Other agencies/groups with possible impact
<ul style="list-style-type: none"> Ministry of Fisheries & Aquatic Resources Development 	<ul style="list-style-type: none"> Department of Fisheries and Aquatic Resources National Aquaculture Development Authority National Aquatic Resources Research and Development Agency 	<ul style="list-style-type: none"> Ceylon Fishery Harbours Corporation Ceylon Fisheries Corporation CEYNOR Foundation Limited
<ul style="list-style-type: none"> Ministry of Irrigation & Water Resources Management 	<ul style="list-style-type: none"> Department of Irrigation Mahaweli Authority of Sri Lanka Water Resources Board 	<ul style="list-style-type: none"> Mahaweli Irrigation Development Programme
<ul style="list-style-type: none"> Ministry of Disaster Management 		<ul style="list-style-type: none"> Department of Meteorology Disaster Management Centre
<ul style="list-style-type: none"> Ministry of Environment 	<ul style="list-style-type: none"> Central Environmental Authority Marine Environment Protection Authority 	
<ul style="list-style-type: none"> Ministry of Ports & Aviation 	<ul style="list-style-type: none"> Department of Coast Conservation 	
<ul style="list-style-type: none"> Ministry of External Affairs 		<ul style="list-style-type: none"> Indian Ocean Marine Affairs Co-operation

^{hh} This section has been validated at the workshop to prepare the Water SVP and reflect the views of the many stakeholders consulted during the SVP development process.

3.2 Key policies and legislations that govern the sector

Table 9 gives the main legislation, policies and plans that influence the food fishery. The Fisheries and Aquatic Resources Act No. 2 of 1996 provides the overall legal basis for the management of fisheries in marine as well as inland waters. It also facilitates proper management of the inland fishery by making it mandatory to obtain a license to fish; the number of licenses given out depends on the fish resources available in the reservoir, thus limiting the numbers of licensed fishermen operating in a single reservoir. The Act which established the National Aquatic Research and Development Agency is also important for enhancing research and development in the fishery sector.

TABLE 9 Key legislation, policies and plans governing the fishery sector

Main legislation governing the fisheries sector	Other legislation having impact on the fisheries sector	Key policies/plans/strategies governing the fisheries sector
Fisheries Ordinance No. 24 of 1940 and its amendments, particularly the Fisheries and Aquatic Resources Act No. 2 of 1996 and its latest amendment Act No. 4 of 2001	Coast Conservation Act No. 57 of 1981, and the amendment Act No. 64 of 1988.	The National Fisheries and Aquatic Resources Policy of 2006
National Aquaculture Development Authority of Sri Lanka Act No. 53 of 1998	Urban Development Authority Law No. 37 of 1978, as amended by subsequent Acts, the recent ones being Act No. 44 of 1984 and Act No. 4 of 1992.	The Ten Year Development Policy Framework of the Fisheries and Aquatic Resources Sector of 2007
The Marine Pollution Prevention Act No. 59 of 1981 and its amendment Marine Pollution Prevention Act No. 35 of 2008 which became effective from 01.01.2009	Irrigation Ordinance No. 32 of 1946; Irrigation Act No.1 of 1951 and its subsequent amendments.	The Coastal Zone Management Plan of 2004, gazetted in 2006
National Aquatic Resources and Development Agency Act No. 54 of 1981.	The National Environmental Act No. 47 of 1980 and the amendment Act No. 56 of 1988.	
	The Fauna and Flora Protection Ordinance No. 2 of 1937, and subsequent amendments including Act No. 49 of 1993 and Act No. 22 of 2009.	

Key sector policies

This promotes increasing production of marine and inland fisheries and conserving the resource; development of aquaculture; improvement of infrastructure facilities for fisheries, including fishery harbours; product marketing; research; use of non-living aquatic resources; extension and training; up-lifting of the socio-economic status of the fisher community and rehabilitation of fisheries affected by the conflict and the tsunami; institutional and legal framework and international co-operation and conservation of the environment.

The National Fisheries and Aquatic Resources Policy of 2006²²

The National Fisheries and Aquatic Resources Policy Objectives

- To improve nutritional status and food security of the people by increasing the national fish production.
- To minimize post-harvest losses and improve quality and safety of fish products to acceptable standards.
- To increase employment opportunities in fisheries and aquatic resources related industries, and improve the socio-economic status of the fisher community.
- To increase foreign exchange earnings from fish and aquatic product exports.
- To conserve the aquatic environment.

A positive feature is that Sri Lanka's development policy framework envisages sustainable development of the fishery sector. The key elements in the main policy documents are given in BOX 7. These too would support formulation of adaptation measures for climate change.

BOX 7: SUPPORT FOR THE FISHERY SECTOR IN OVERARCHING NATIONAL POLICIES AND PLANS

- *The Mahinda Chintana 10 Year Horizon Development Framework*³

This envisages the fishery to veer away from the coastal region to the offshore region. It is targeted that the relative share of offshore/deep sea fishery will increase from 31.8% to 44.6%, and its contribution in terms of volume would increase by 114,000 MT or by 140% over the ten year period. Conversely, the production in the coastal sector (that is already over fished) will only increase by 60,000 MT or by 33%.

- *The Action Plan for the Haritha Lanka Programme*⁷

This programme directly addresses climate change through Mission 3 under which it addresses Establishing Food Security in the face of climate change threats. It also addresses 'wise use of the coastal belt and seas around' under Mission 4 and inland water resources under Mission 7. The programme has short-term, medium-term and long-term targets spanning 2009-2016, and could thus help with adaptation to climate change.

4.0 Current Policies/Plans/Strategies and Actions that Support Adaptation

Adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. To minimize the impacts of climate change, it is necessary to adopt adaptation measures that promote managing the agricultural system efficiently after a comprehensive assessment of potential vulnerability to climate change.

Adaptation to climate change would require better preparedness to the natural hazards that are expected to become more pronounced. With the anticipated negative impacts of climate change on production from the coastal fishery, and probably the inland fishery, minimizing other threats to the fishery industry that lowers productivity at present would be in the interests of the industry. This would require conserving fish stocks as well as their feeding and breeding grounds through effective management of the resource, gathering the required data for informed fishery sector management, and making the fishers more aware of the benefits of sustainable fishery. Planning within the sector would also have to take into account provisions required to safeguard those engaged in the fishery industry in the event of increased intensity and frequency of natural hazards resulting from climate change that could drastically affect their livelihoods and settlements. This would need establishing institutional support to cater to those involved in the fishery industry who are affected by disaster events, and to provide alternate employment as required.

The government has already identified and addressed some of these needs as prerequisites for sustainability of the fishery. These initiatives support adaptation measures within the fishery sector. Some of the key policies, plans, strategies and actions that could support the formulation of adaptation measures are given below.

4.1 Measures to ensure sustainable development of the fishery

- *Legislative coverage*

The Fisheries and Aquatic Resources Act No. 2 of 1996 deals comprehensively with conservation of the fishery resource—both marine and inland—and helps ensure sustainable development of the industry. The Fisheries Act empowers enacting regulations when required to strengthen monitoring, controlling and surveillance (MCS) capabilities to facilitate effective fisheries management and to prevent over-use of resources and destructive fishing. This Act represents a shift of focus to the active management of the fishery resource, by taking into account environmental concerns and the need to actively involve the fishing community in fisheries management, rather than being solely control centered.

- *The National Fisheries and Aquatic Resources Policy of 2006*

The policy is noteworthy in that:

- ☐ Responsibility of implementation of the National Fisheries and Aquatic Resources Policy lies with the ministry in charge of the subject of fisheries and aquatic resources.
- ☐ A precautionary approach is followed in the management of resources.

This policy promotes: responsible fishery practices, surveys on fisheries and aquatic resources and stock assessments; use of appropriate harvest technology and resource friendly fishing gear; and management of coastal fisheries to conserve the resource. It also seeks to protect the rights of the traditional coastal fishers and to regulate the use of fishing gear that will harm the fishery or other marine species in accordance with international obligations. It enables participation of all stakeholders in developing inland fisheries and seeks to protect the right of inland fishers to fish in irrigation reservoirs.

- *Caring for the Environment: Path to sustainable development (NEAP of 2008-2012)*

This document provides a sectoral analysis for the marine resources, including issues and problems in the marine resource sector and related policies; and 12 strategies and relevant actions under each for management of the marine sector. Of these, strategies 4, 5, 6 and 7 cover management of the fishery resource. These include actions to conduct surveys for sustainable resource development and management, improving management of the fisheries and aquatic resources, improving quality and safety control measures in fish and aquatic products, promoting sustainable resource use and improving skills of fishermen to this end.

- *The Coastal Zone Management Plan (CZMP) of 2006*

Chapter 5 of the CZMP deals with 'Integrating Coastal Fisheries and Aquaculture with Coastal Zone Management' and the relevant policies, strategies and actions as an integral part of coastal zone management rather than merely for increasing fishery productivity. It acknowledges that optimizing the outcome of fishing and aquaculture practices is the responsibility of MFAR, DFAR and NAQDA. It, however, recognized that issues related to the sustainable development of the coastal fishery are not only sector related, but encompass other sectors and economic activities as well as coastal ecosystem health, and that fisheries and aquaculture affect other economic activities within the coastal zone.

- *Major initiatives to promote sustainable management of the fishery*

The Coastal Resources Management Project (CRMP) 2002-2005

This project included institutional strengthening for fisheries resource management to achieve sustainable marine and coastal fishery supported by the construction of fisheries harbours, anchorages and ancillary facilities necessary for improvement of fish quality and the reduction of handling losses. It also dealt with addressing the problem of fishery resource depletion, and promoted activities and actions that will reduce pollution in lagoons and estuaries and relieve pressure on coastal resources. This project also set up a basic management information system/framework for better connectivity of agencies under the ministry dealing with fisheries and their outlying offices, including developing a data gathering network which was piloted to gather catch and effort data as a first step towards interpreting and managing the biological state of the fishery.

The Coastal Resources Management Project (CRMP) 2002-2005

This was a major initiative of the then Ministry of Fisheries and Oceanic Resources (MFOR) implemented with funds amounting to US\$ 80 million from the ADB, the Netherlands Government and the Government of Sri Lanka. This project had four major components, namely (a) Coastal stabilization which addresses the problem of coastal erosion, (b) Fisheries Resource Management and Quality Improvement, (c) Coastal Environmental Resources Management, and (d) Institutional strengthening to enhance the institutional capabilities of MFOR and its line agencies.

Source: CCD, 2006

Enhancing inland fisheries and aquaculture

The ADB funded Aquatic Resources Development and Quality Project (ARDQIP) supported NAQDA in developing freshwater capture fisheries and aquaculture.

- *Capacity enhancement of NARA (CENARA)*

This is being carried out through the *Uthuru Wasanthaya* programme where the cultivation of sea cucumber, sea weed and other non-traditional fishery products will be encouraged and promoted among the people for livelihood development.

4.2 Addressing disaster events

The main national initiatives for addressing natural disasters are given in Part 1 under section 4.2.

Very relevant to the fisheries sector is the preparedness for coastal hazards that need to be carefully identified to formulate and implement adaptation mechanisms that will counter the negative impacts of climate change to the extent possible. The LIDAR study is an example of a project that will provide the initial base for simulating sea level rise.

Case study of addressing natural hazards that may affect coastal areas

Vulnerability can be assessed by advanced methods incorporating LIDAR (light detection and ranging) surveys or less expensive methods such as Aerial Video Assisted Vulnerability Analysis. In the aftermath of the Indian Ocean Tsunami, LIDAR Surveys supported with satellite images were carried out on the west, south and eastern coasts of Sri Lanka. The project, which was funded by the Italian Government, provided a valuable database covering a distance from the mean sea water level up to 2 to 2.5 km inland. This database provides valuable information for the preparation of a vulnerability database. However, to do so there is a need for adequate ground based measurements. The availability of LIDAR surveys is a considerable advantage for both vulnerability analysis and modeling of hazards.

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Appendices

Appendix A

Overarching Policies for Sustainable Development in Sri Lanka

Mahinda Chintana: A Vision for a New Sri Lanka

The *Mahinda Chintana* recognizes the agriculture sector as a significant determinant of national and provincial GDP. The 10 year development plan aims for the agriculture sector to grow at a faster rate of 4 to 5% with a higher contribution coming from the non plantation sector through promoting other food crops (not paddy), fruits and vegetables, fisheries and livestock. Small and medium scale operations will be supported to improve their commercial orientation with continued support and improved facilities including improved access to bank credits. Increased income generation in the rural sector through agriculture will be promoted contributing to rural poverty reduction.

The vision for the agriculture sector will be pursued through the 10 year development plan which seeks to achieve “An agriculture sector contributing to regionally equitable economic growth, rural livelihood improvement, and food security through efficient production of commodities for consumption, for agro-based industries and for exporting competitively to the world market.”.

The main policy goal of the livestock sector is for the farmers to achieve sustainable and equitable economic and social benefits and to increase the availability domestic livestock products at competitive prices. These will be achieved through specific policies for dairy poultry and meat sub-sectors.

The vision for fisheries is “Sri Lanka to become a leader in the South Asian Region in sustainable utilization of fisheries and aquatic resources directing the utilization of fisheries and aquatic resources for the benefit for the current and future generations.”. The policy objectives are (i) to improve the nutritional status and food security of the people by increasing the national fish production (ii) to minimize post-harvest losses and improve quality and safety of fish products to acceptable standards (iii) to increase employment opportunities in fisheries and related industries and improve the socio-economic status of the fisher community (iv) to increase foreign exchange earnings from fish products and (v) to conserve the aquatic environment.

The Action Plan for *Haritha Lanka* Programme

This programme was developed through an interactive process involving all key ministries. Its mission is to focus on addressing critical environmental issues which, if left unattended, would frustrate the nation’s economic development programme. Actions to address key issues that would enable sustainable development are embodied in the strategies and proposed actions set out under the ten missions of the *Haritha Lanka* Programme. The implementation of the programme will be overseen by the Ministry of Plan Implementation, while the secretariat for the NCSD is located within the Ministry of Environment.

The 10 missions of the Action Plan for *Haritha Lanka* Programme:

1. Clean air - everywhere
2. Saving the fauna, flora and ecosystems
3. Meeting the challenges of climate change
4. Wise use of the coastal belt and the sea around
5. Responsible use of the land resources
6. Doing away with dumps
7. Water for all and always
8. Green cities for health and prosperity
9. Greening the industries
10. Knowledge for right choices

The *Randora* National Infrastructure Development Programme

The *Randora* National Infrastructure Development Programme complements the *Mahinda Chintana* and articulates in detail the plan and financing requirements for all major infrastructure investment across the country between 2006 and 2016. A summary of planned investments under the key infrastructure sub-sectors of economic infrastructure (i.e. roads, electricity, water supply and sanitation, ports and aviation, transport and rural infrastructure development); irrigation, education and health, industries (i.e. industrial development, tourism, science and technology, environment and biodiversity) and urban development and townships are outlined in the *Randora* National Infrastructure Development Programme.

The National Physical Planning Policy and Plan (NPPPP&P)

This gives vision and direction for structural physical development in Sri Lanka up to 2030. It targets maximizing national economic development while taking into consideration the global economy. It is an integrated plan that takes into account all sectors of the country.

The underlying theme of the NPPPP&P is to preserve equilibrium between conservation and production. It encourages urban centre development while protecting environmentally sensitive areas such as forests, wildlife habitats, archaeological sites and areas prone to natural disasters. It acknowledges the need for Sri Lanka to carefully manage its urban growth, and avert (and in some cases reverse) the over-burdening of the island's natural systems with rapid and unplanned development.

The NPPPP&P was approved by the National Physical Planning Council chaired by H.E. the President, and formally adopted on 3rd July, 2007. This is required by section 3(1) of the Town and Country Planning Amendment Act No. 49 of 2000.

Guided by the NPPPP&P, Provincial Regional Physical Plans are being prepared, some of which are now complete.

The targeted development envisioned in the NPPPP&P is expected to reduce pressure on critical environmental systems, and to ensure development of human settlements that are more efficient and sustainable.

Key elements of the NPPPP&P

- Incorporating potential internal development opportunities
- Implementing environmentally friendly sustainable development across the country
- Strengthening ethnic integration between communities
- Introduction of planned re-settlement
- Introduction of a planned settlement network
- Conservation of valuable environmentally sensitive areas
- Mitigation measures by limiting development in areas prone to natural disasters
- Evolving compact cities with modern urban facilities and utilities.

(Source: *Sri Lanka in 2030: Guide to urban physical infrastructure development and environmental conservation*)

Appendix B

Vulnerability Maps and Ranking Tables

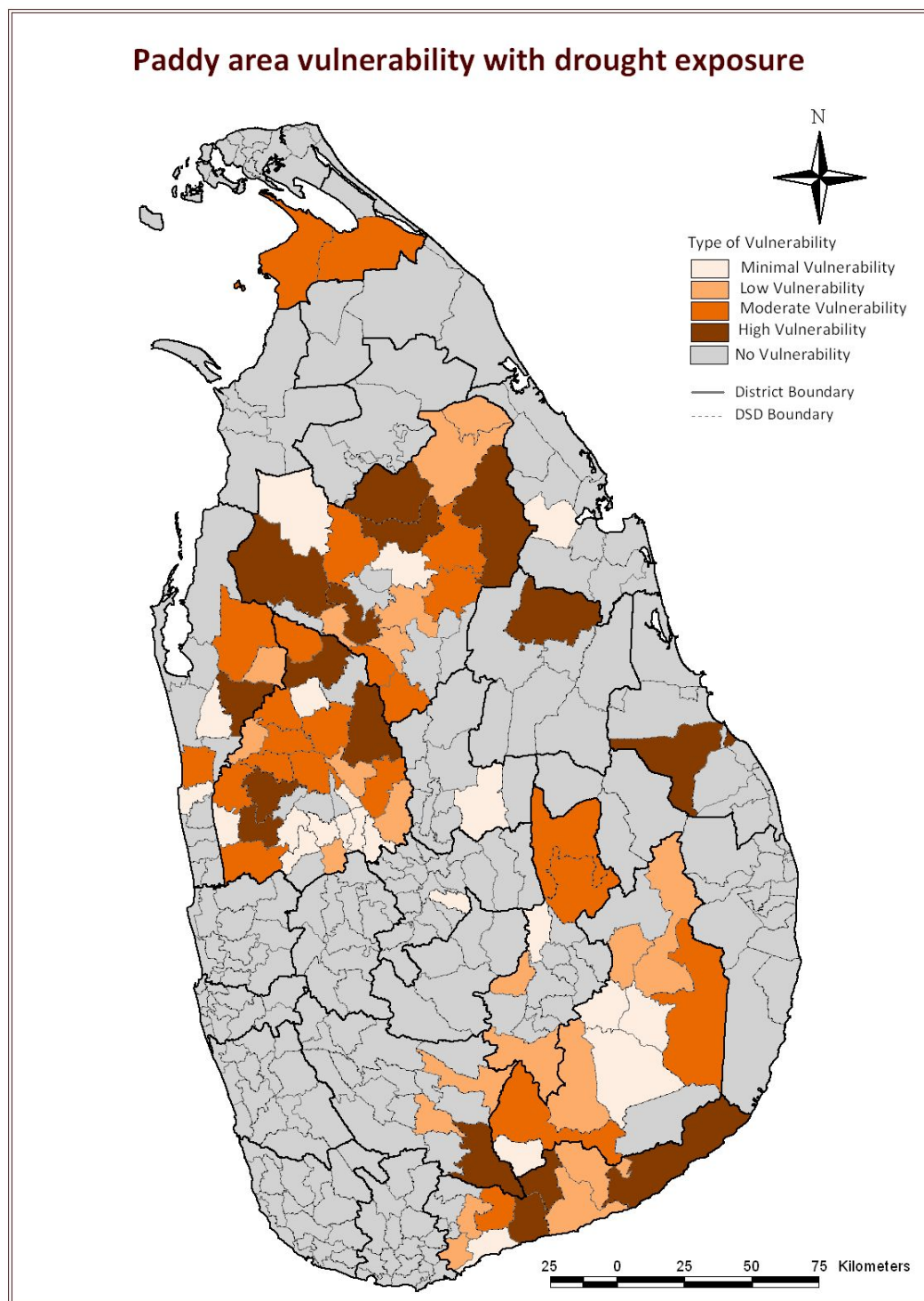
- **Paddy**

Highly Vulnerable to Impacts of Droughts - Paddy Sector

Rank	District	DS Division	Highly Vulnerable
1	Puttalam	Anamaduwa	
2	Hambantota	Ambalantota	
3	Kurunegala	Polpithigama	
4	Ratnapura	Embilipitiya	
5	Polonnaruwa	Medirigiriya	
6	Kurunegala	Kuliyapitiya West	
7	Anuradhapura	Thalawa	
8	Batticaloa	Eravur Pattu	
9	Hambantota	Suriyawewa	
10	Kurunegala	Panduwasnuwara	
11	Anuradhapura	Nochchiyagama	
12	Anuradhapura	Horowpothana	
13	Hambantota	Tissamaharama	
14	Anuradhapura	Medawachchiya	
15	Kurunegala	Galgamuwa	
16	Anuradhapura	Rambewa	

Moderately Vulnerable to Impacts of Droughts - Paddy Sector

Rank	District	DS Division	Moderately Vulnerable	Rank	District	DS Division
17	Badulla	Mahiyanganaya		29	Kurunegala	Giribawa
18	Hambantota	Angunukolapelessa		30	Badulla	Rideemaliyadda
19	Moneragala	Siyambalanduwa		31	Kurunegala	Bingiriya
20	Anuradhapura	Galenbindunuwewe		32	Kurunegala	Kotawehera
21	Anuradhapura	Kahatagasdigiliya		33	Kilinochchi	Poonakary
22	Kurunegala	Wariyapola		34	Puttalam	Arachchikattuwa
23	Anuradhapura	Galnewa		35	Puttalam	Karuwalagaswewa
24	Kurunegala	Ibbagamuwa		36	Kilinochchi	Karachchi
25	Kurunegala	Mahawa		37	Anuradhapura	Nuwaragam Palatha Central
26	Kurunegala	Nikaweratiya		38	Kurunegala	Pannala
27	Kurunegala	Kobeigane		39	Moneragala	Thanamalwila
28	Anuradhapura	Palagala				

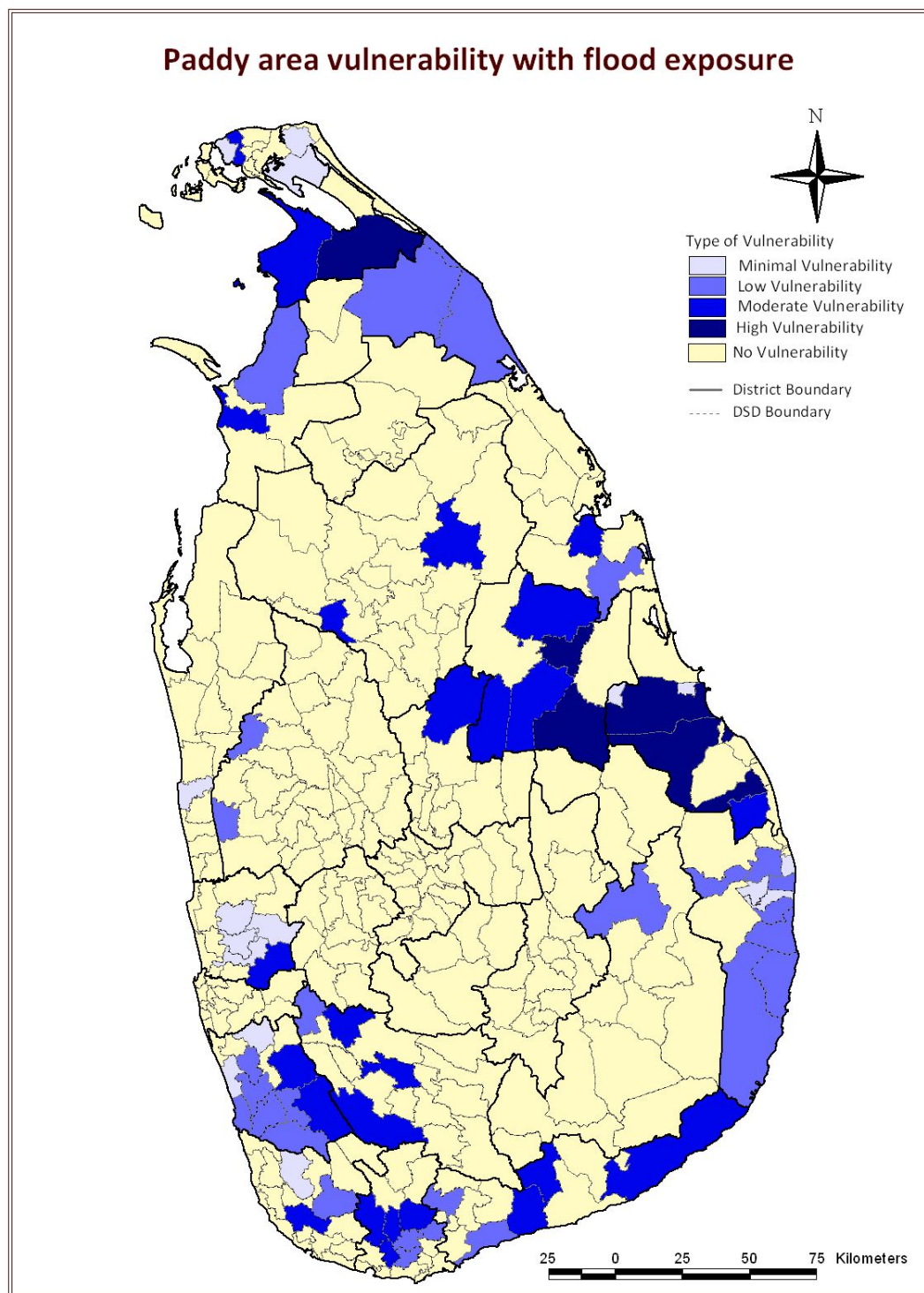


Highly Vulnerable to Impacts of Floods - Paddy Sector

Rank	District	DS Division	Highly Vulnerable
1	Polonnaruwa	Dimbulagala	
2	Batticaloa	Eravur Pattu	
3	Kilinochchi	Karachchi	
4	Batticaloa	Manmunai South - West	
5	Batticaloa	Koralai Pattu (Valach.)	
6	Polonnaruwa	Lankapura	

Moderately Vulnerable to Impacts of Floods - Paddy Sector

Rank	District	DS Division	Moderately Vulnerable	Rank	District	DS Division
7	Matara	Mulatiyana		20	Jaffna	Sandilipay
8	Matara	Akuressa		21	Kalutara	Bulathsinhala
9	Polonnaruwa	Thamankaduwa		22	Hambantota	Tissamaharama
10	Ratnapura	Pelmadulla		23	Anuradhapura	Kahatagasdigiliya
11	Polonnaruwa	Medirigiriya		24	Galle	Baddegama
12	Hambantota	Ambalantota		25	Kilinochchi	Poonakary
13	Gampaha	Dompe		26	Batticaloa	Porativu Pattu
14	Polonnaruwa	Elaheera		27	Kalutara	Palindanuwara
15	Matale	Dambulla		28	Matara	Athuraliya
16	Trincomalee	Kinniya		29	Hambantota	Suriyawewa
17	Rathnapura	Kalawana		30	Anuradhapura	Thambuttegama
18	Matara	Malimbada		31	Mannar	Nanaddan
19	Rathnapura	Kuruwita				

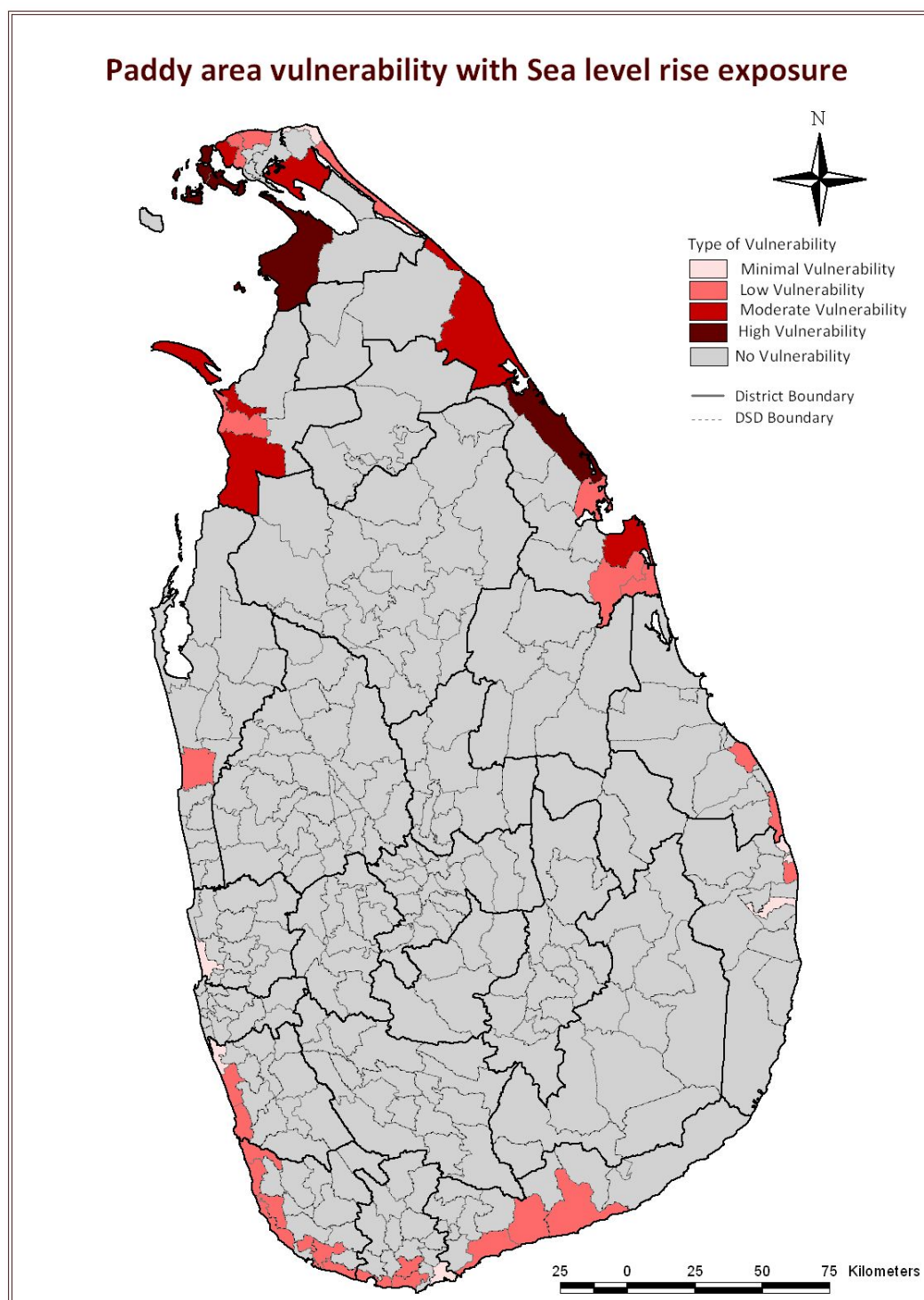


Highly Vulnerable to Impacts of Sea-level rise - Paddy Sector

Rank	District	DS Division	Highly Vulnerable
1	Trincomalee	Kuchaveli	
2	Jaffna	Velanai	
3	Jaffna	Kayts	
4	Kilinochchi	Poonakary	

Moderately Vulnerable to Impacts of Sea-level rise - Paddy Sector

Rank	District	DS Division	Moderately Vulnerable
5	Jaffna	Chavakachcheri	
6	Mannar	MannarTown	
7	Mulattivu	Maritimepattu	
8	Trincomalee	Muttur	
9	Jaffna	Chankanai	
10	Mannar	Musalai	



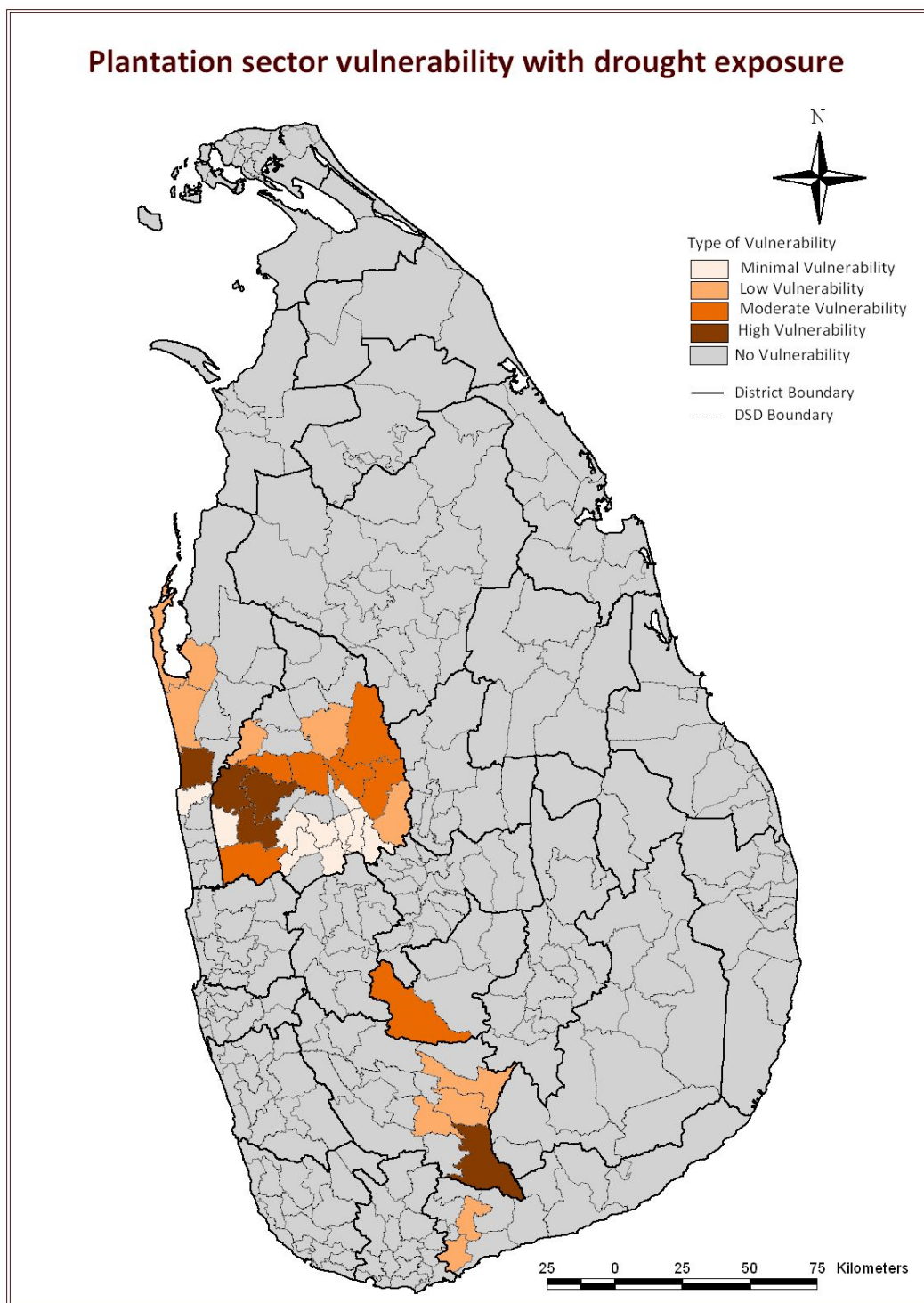
Plantations

Highly Vulnerable to Impacts of Droughts - Plantations Sector

Rank	District	DS Division	Highly Vulnerable
1	Kurunegala	Kuliyapitiya West	
2	Kurunegala	Panduwasnuwara	
3	Ratnapura	Embilipitiya	
4	Puttalam	Arachchikattuwa	
5	Kurunegala	Bingiriya	

Moderately Vulnerable to Impacts of Droughts - Plantations Sector

Rank	District	DS Division	Moderately Vulnerable
6	Kurunegala	Polpithigama	
7	Nuwara Eliya	Ambagamuwa	
8	Kurunegala	Pannala	
9	Kurunegala	Wariyapola	
10	Kurunegala	Ibbagamuwa	
11	Kurunegala	Kobeigane	
12	Kurunegala	Ganewatta	

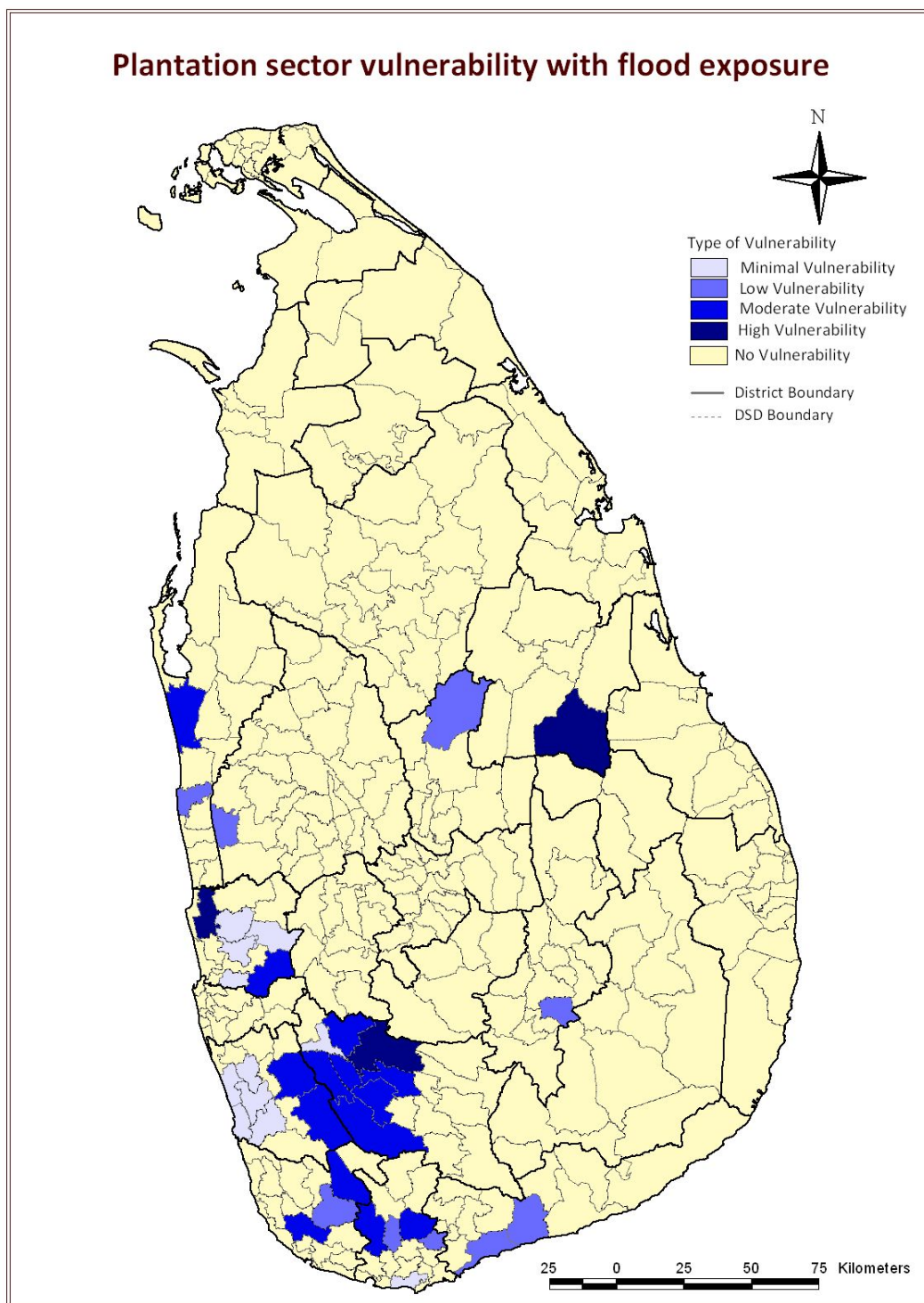


Highly Vulnerable to Impacts of Floods - Plantations Sector

Rank	District	DS Division	Highly Vulnerable
1	Ratnapura	Rathnapura	
2	Gampaha	Katana	
3	Polonnaruwa	Dimbulagala	

Moderately Vulnerable to Impacts of Floods - Plantations Sector

Rank	District	DS Division	Moderately Vulnerable
4	Ratnapura	Kalawana	
5	Kalutara	Bulathsinhala	
6	Matara	Mulatiyana	
7	Galle	Thawalama	
8	Galle	Baddegama	
9	Kalutara	Palindanuwara	
10	Ratnapura	Ayagama	
11	Gampaha	Dompe	
12	Matara	Akuressa	
13	Ratnapura	Pelmadulla	
14	Puttalam	Mundalama	
15	Ratnapura	Nivithigala	
16	Ratnapura	Kuruwita	
17	Ratnapura	Elapatha	

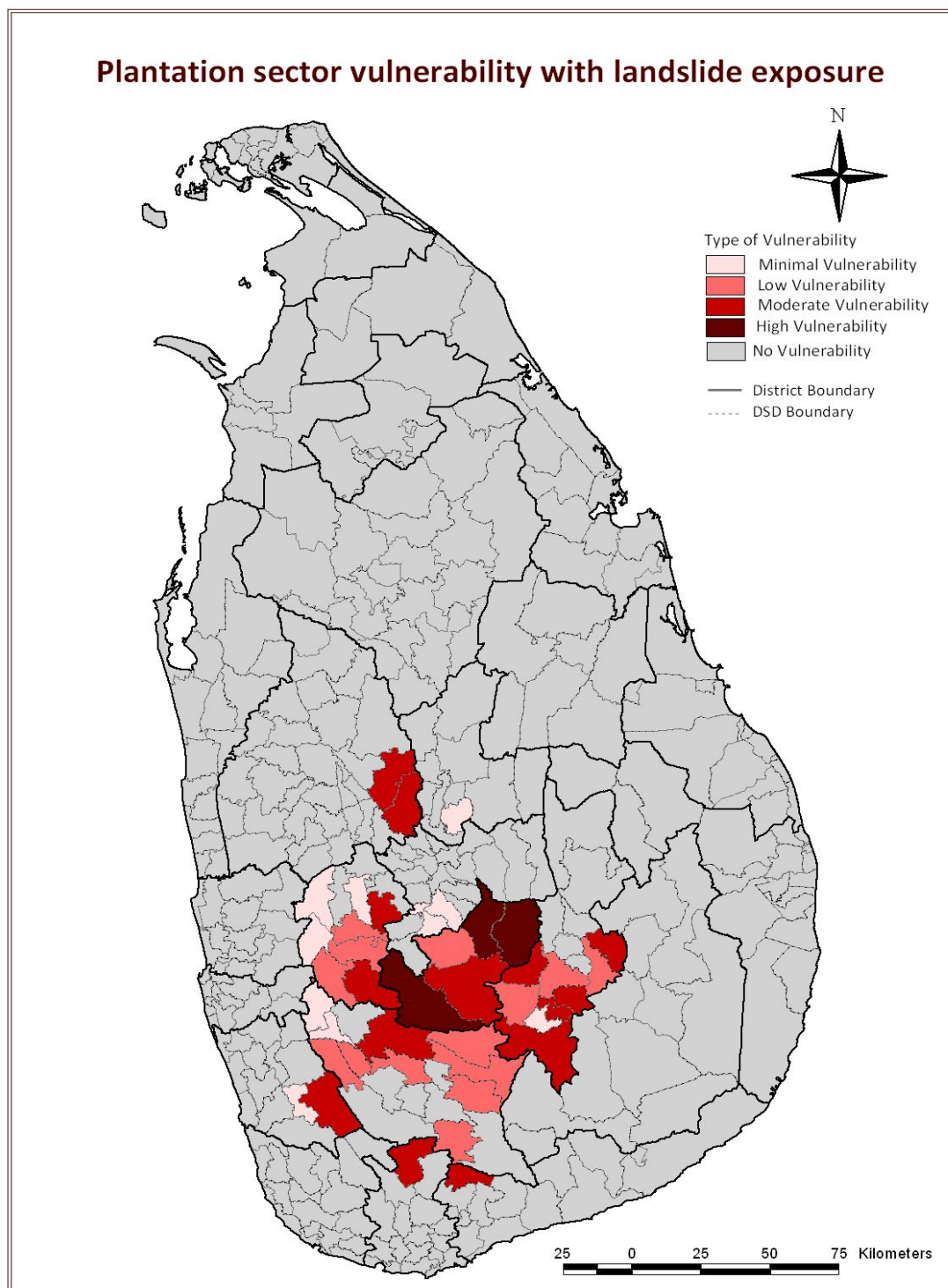


Highly Vulnerable to Impacts of Landslides - Plantations Sector

Rank	District	DS Division	Highly Vulnerable
1	Nuwara Eliya	Walapane	
2	Nuwara Eliya	Ambagamuwa	
3	Nuwara Eliya	Hanguranketha	

Moderately Vulnerable to Impacts of Landslides - Plantations Sector

Rank	District	DS Division	Moderately Vulnerable
4	Ratnapura	Ratnapura	
5	Badulla	Bandarawela	
6	Nuwara Eliya	Nuwara Eliya	
7	Kegalle	Deraniyagala	
8	Matara	Kotapola	
9	Badulla	Haldummulla	
10	Badulla	Lunugala	
11	Kurunegala	Rideegama	
12	Kegalle	Aranayaka	
13	Hambantota	Katuwana	
14	Kalutara	Palindanuwara	
15	Badulla	Ella	
16	Badulla	Uva Paranagama	
17	Kurunegala	Ibbagamuwa	



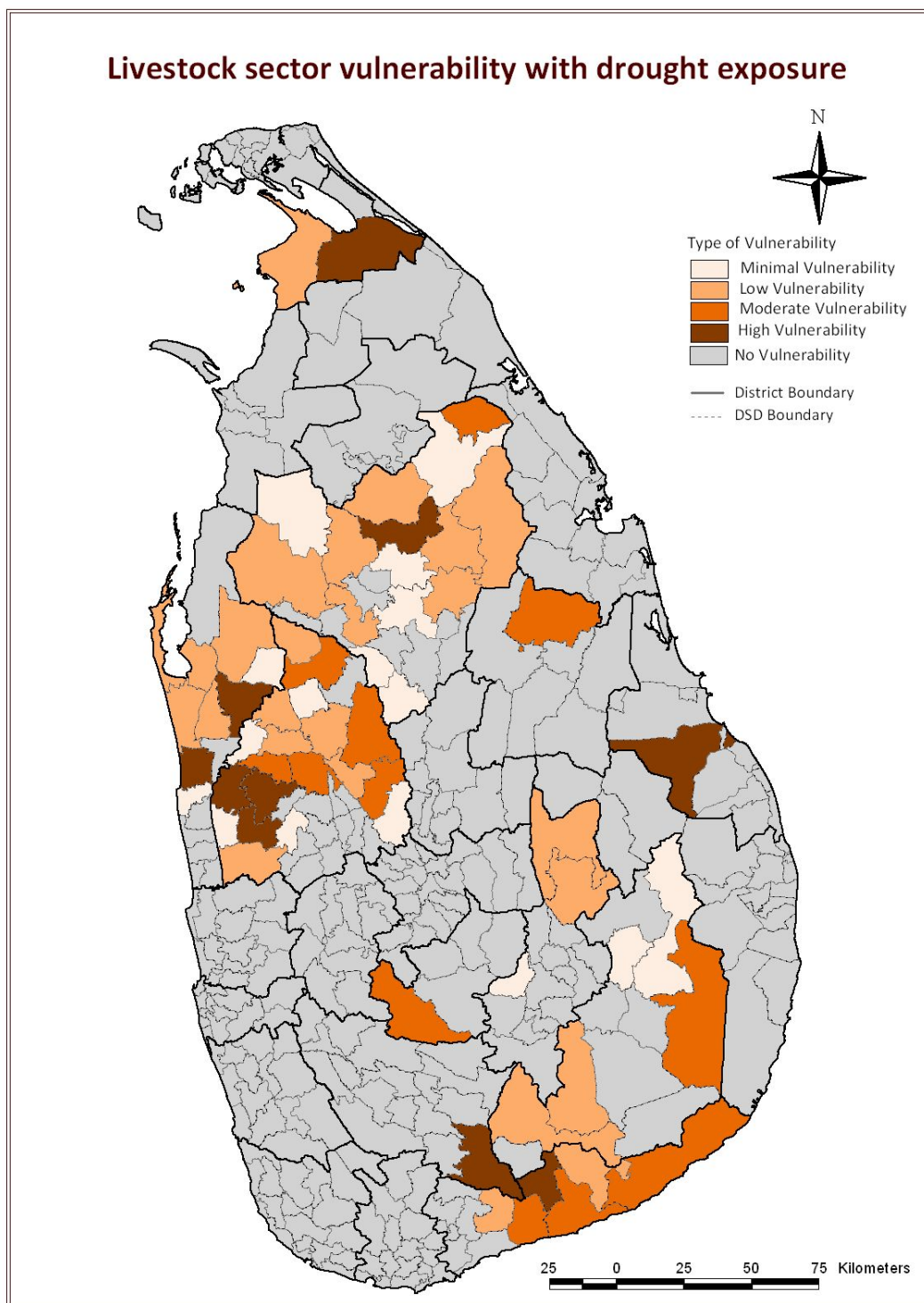
- Livestock**

Highly Vulnerable to Impacts of Droughts - Livestock Sector

Rank	District	DS Division	Highly Vulnerable
1	Kurunegala	Panduwasnuwara	
2	Puttalam	Anamaduwa	
3	Batticaloa	Eravur Pattu	
4	Kurunegala	Kuliyapitiya West	
5	Puttalam	Arachchikattuwa	
6	Kurunegala	Bingiriya	
7	Ratnapura	Embilipitiya	
8	Kilinochchi	Karachchi	
9	Anuradhapura	Rambewa	
10	Hambantota	Suriyawewa	

Moderately Vulnerable to Impacts of Droughts - Livestock Sector

Rank	District	DS Division	Moderately Vulnerable
11	Kurunegala	Polpithigama	
12	Kurunegala	Kobeigane	
13	Hambantota	Ambalantota	
14	Hambantota	Tissamaharama	
15	Kurunegala	Wariyapola	
16	Anuradhapura	Padaviya	
17	Kurunegala	Ibbagamuwa	
18	Nuwara Eliya	Ambagamuwa	
19	Kurunegala	Galgamuwa	
20	Polonnaruwa	Medirigiriya	
21	Hambantota	Hambantota	
22	Moneragala	Siyambalanduwa	

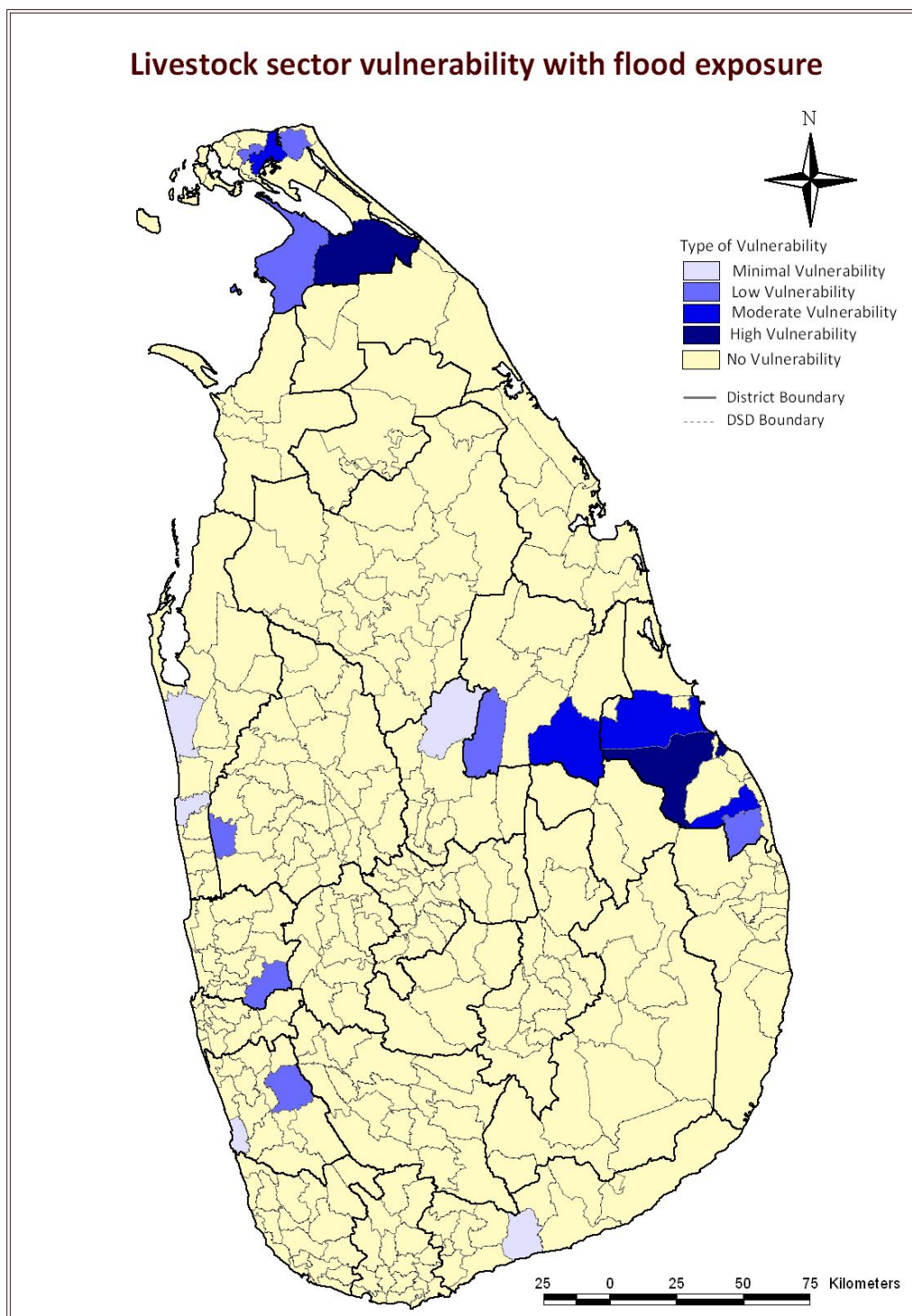


Highly Vulnerable to Impacts of Floods - Livestock Sector

Rank	District	DS Division	Highly Vulnerable
1	Kilinochchi	Karachchi	
2	Batticaloa	Eravur Pattu	

Moderately Vulnerable to Impacts of Floods - Livestock Sector

Rank	District	DS Division	Moderately Vulnerable
3	Polonnaruwa	Dimbulagala	
4	Batticaloa	Koralai Pattu (Valach.)	
5	Batticaloa	Manmunai South - West	
6	Jaffna	Kopay	

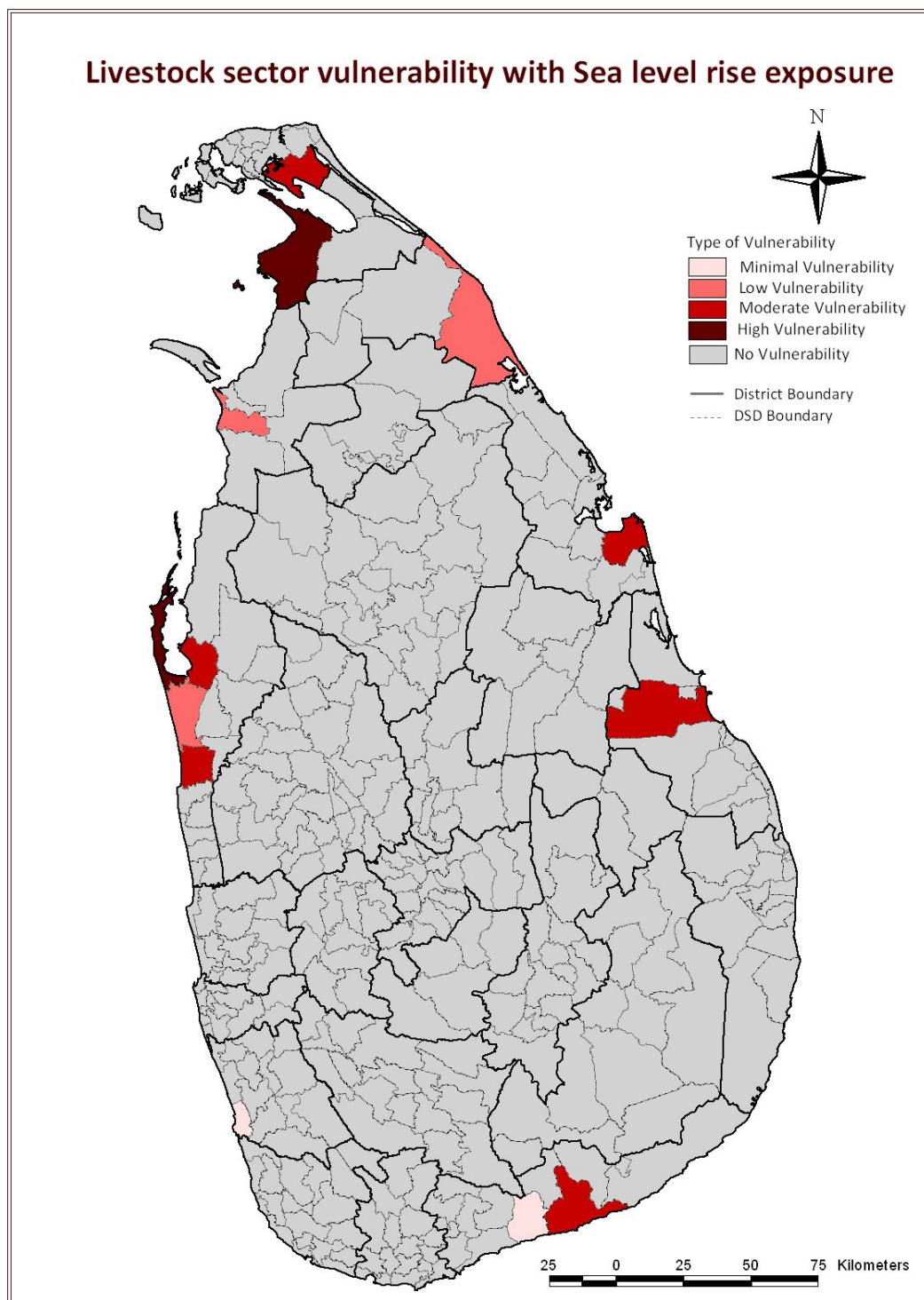


Highly Vulnerable to Impacts of Sea-level rise - Livestock Sector

Rank	District	DS Division	Highly Vulnerable
1	Puttalam	Kalpitiya	
2	Kilinochchi	Poonakary	

Moderately Vulnerable to Impacts of Sea-level rise - Livestock Sector

Rank	District	DS Division	Moderately Vulnerable
3	Batticaloa	Koralai Pattu (Valach.)	
4	Jaffna	Chavakachcheri	
5	Trincomalee	Muttur	
6	Puttalam	Puttalam	
7	Puttalam	Arachchikattuwa	
8	Hambantota	Hambantota	



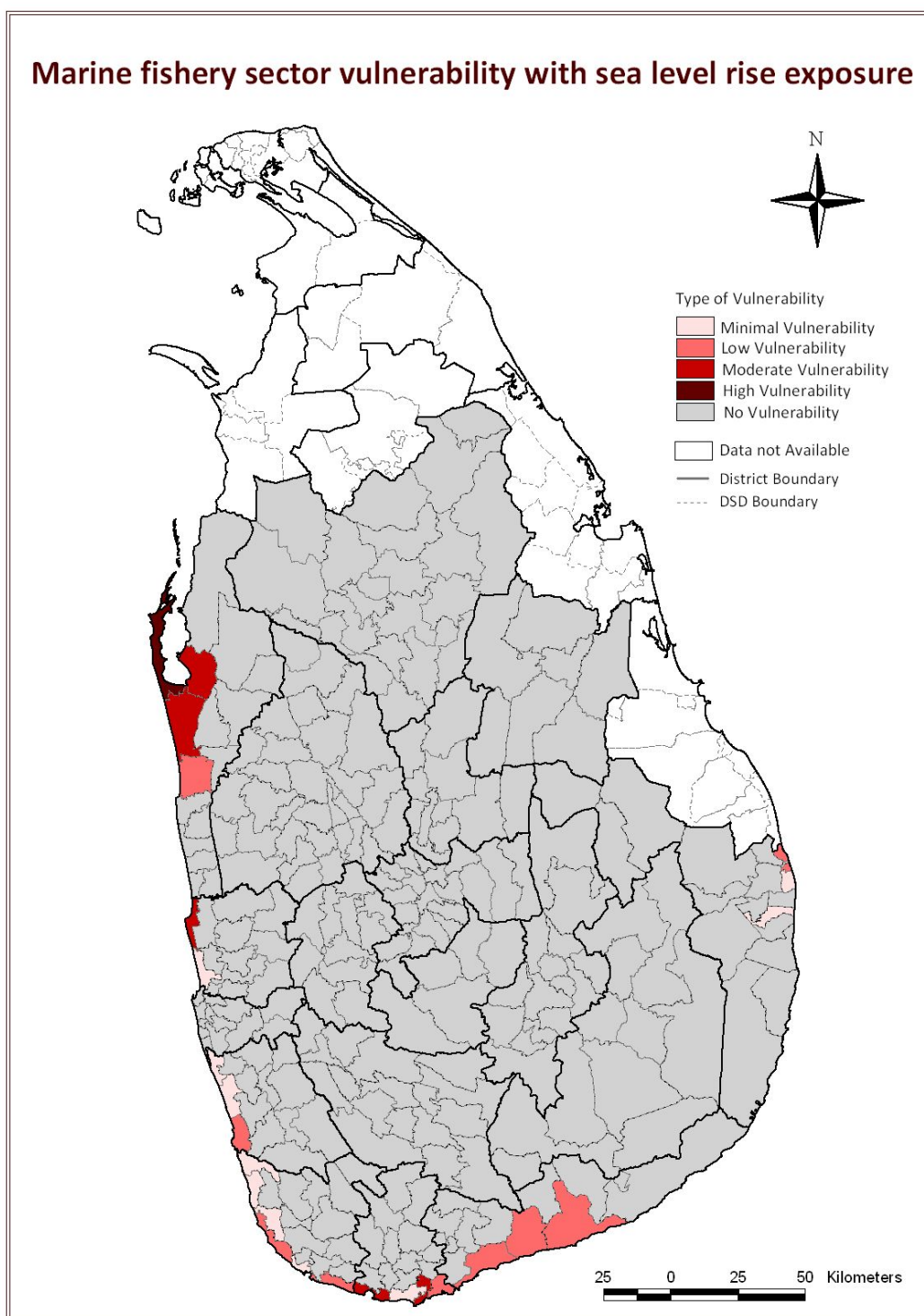
- **Marine Fishery**

Highly Vulnerable to Impacts of Sea-level rise – Marine Fishery

Rank	District	DS Division	Highly Vulnerable
1	Puttalam	Kalpitiya	

Moderately Vulnerable to Impacts of Sea-level rise – Marine Fishery

Rank	District	DS Division	Moderately Vulnerable
2	Puttalam	Mundalama	
3	Gampaha	Negombo	
4	Matara	Devinuwara	
5	Puttalam	Puttalam	
6	Matara	Weligama	



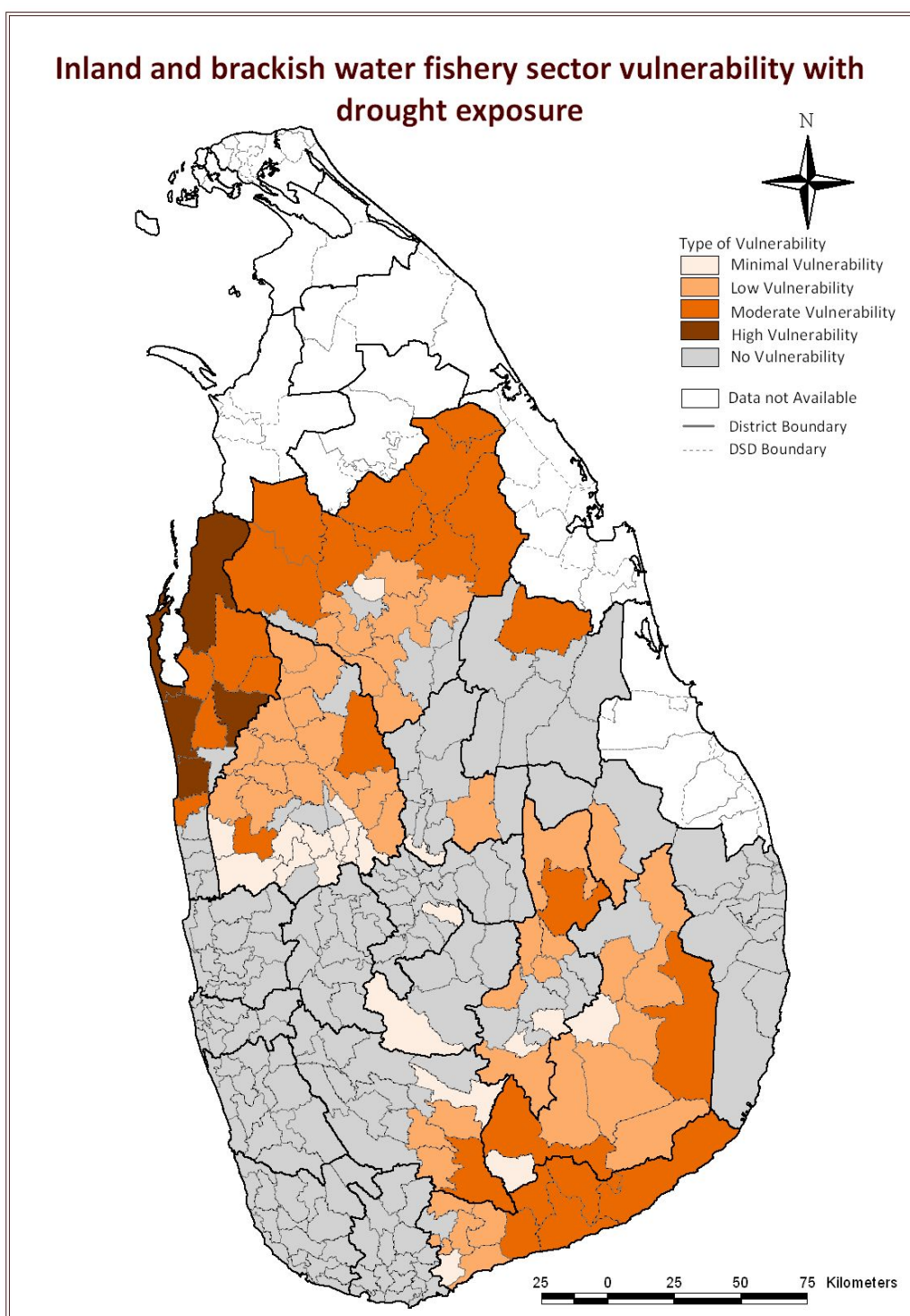
- Inland and Brackish water Fishery**

Highly Vulnerable to Impacts of Droughts - Inland & Brackish water Fishery

Rank	District	DS Division	Highly Vulnerable
1	Puttalam	Kalpitiya	
2	Puttalam	Vanathavilluwa	
3	Puttalam	Arachchikattuwa	
4	Puttalam	Mundalama	
5	Puttalam	Anamaduwa	

Moderately Vulnerable to Impacts of Droughts - Inland & Brackish water Fishery

Rank	District	DS Division	Moderately Vulnerable
6	Anuradhapura	Padaviya	
7	Puttalam	Karuwalagaswewa	
8	Puttalam	Puttalam	
9	Hambantota	Ambalantota	
10	Puttalam	Mahakumbukkadawala	
11	Moneragala	Siyambalanduwa	
12	Anuradhapura	Rambewa	
13	Anuradhapura	Horowpothana	
14	Polonnaruwa	Medirigiriya	
15	Puttalam	Chilaw	
16	Anuradhapura	Nuwaragam Palatha Central	
17	Anuradhapura	Medawachchiya	
18	Puttalam	Nawagattegama	
19	Kurunegala	Kuliyapitiya West	
20	Anuradhapura	Maha Vilachchiya	
21	Kurunegala	Polpithigama	
22	Moneragala	Thanamalwila	
23	Hambantota	Tissamaharama	
24	Anuradhapura	Kebithigollewa	
25	Anuradhapura	Kahatagasdigiliya	
26	Hambantota	Hambantota	
27	Anuradhapura	Nochchiyagama	
28	Hambantota	Lunugamvehera	

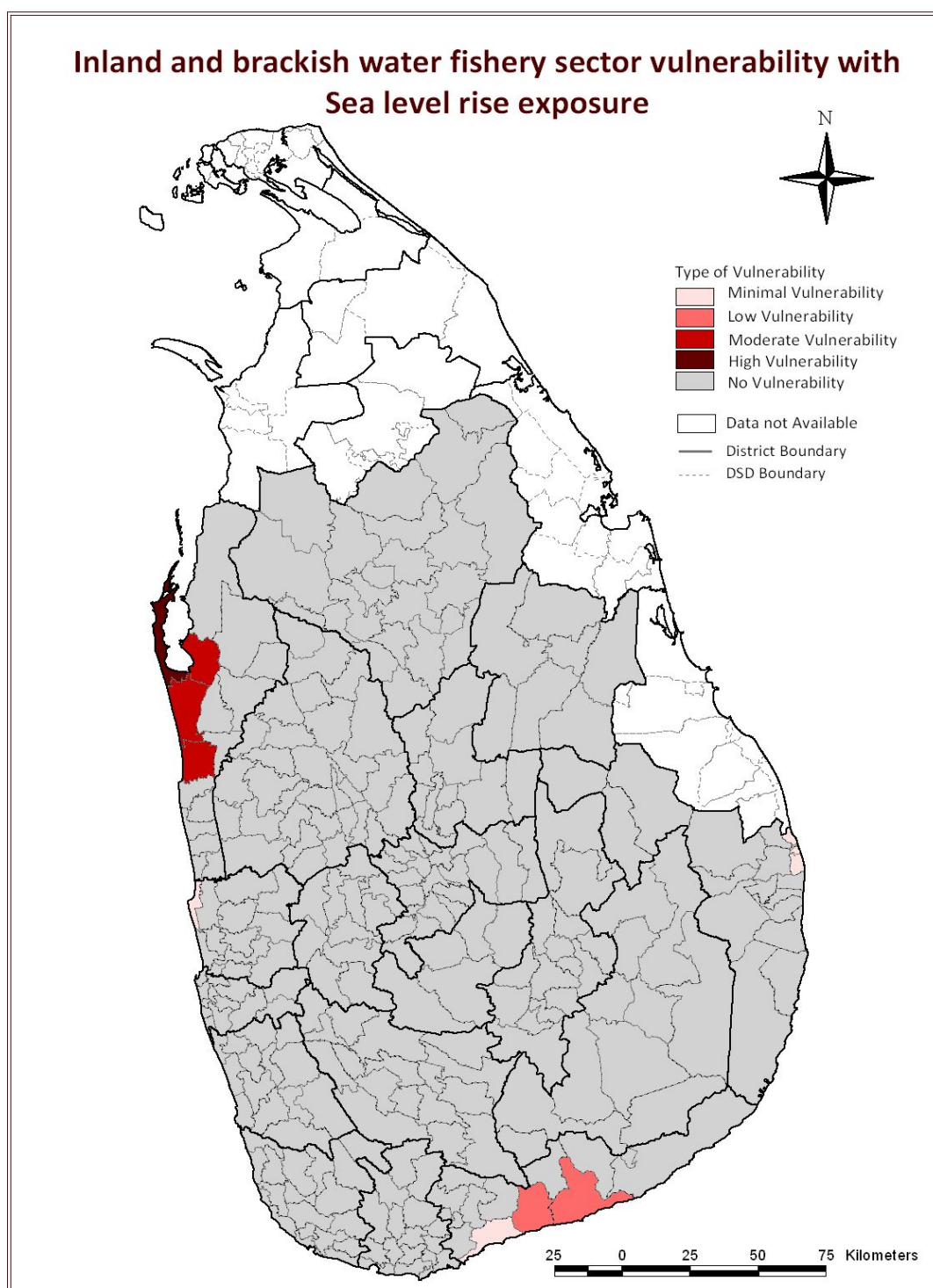


Highly Vulnerable to Impacts of Sea-level rise – Inland & Brackish water Fishery

Rank	District	DS Division	Highly Vulnerable
1	Puttalam	Kalpitiya	

Moderately Vulnerable to Impacts of Sea-level rise – Inland & Brackish water Fishery

Rank	District	DS Division	Moderately Vulnerable
2	Puttalam	Mundalama	
3	Puttalam	Puttalam	
4	Puttalam	Arachchikattuwa	



Appendix C

Key State Agencies Mandated with Agricultural Productivity and Livestock Development

Part I - Agriculture & Livestock

- **The Department of Agriculture (DOA)**

This was established in 1912 as the premier institution concerned with research and development for the food crop sector in the country. It is mandated to deal with rice and other field crops, horticultural crops, root and tuber crops, ornamental plants and plants of medicinal values. It also deals with formulation/reform of policy/law/and regulations pertaining to the agricultural sector; setting up institutional coordination; research at ecosystem, species and genetic levels; survey and documentation of anthropological and cultural values of agro-biodiversity; sustainable use of agro-biodiversity; taxonomic studies for food crops; survey, inventory and monitoring and setting up *ex-situ* conservation centres (including seed banks); *ex-situ* management of species and artificial propagation of endangered species - including tissue culture; and information management and database development for food crops.

There are several divisions, centres and research institutes under the DOA that play a vital role in enhancing agricultural productivity. These include the: Horticultural Research and Development Institute (HORDI), Rice Research and Development Institute (RRDI), Field Crops Research and Development Institute (FCRDI), Seed Certification and Plant Protection Centre (SCPPC), Extension and Education Division, and the Seed and Planting Materials Division.

The DOA has several Regional Agricultural Research and Development Centres (RARDCs) and a further network of research sub-stations island-wide. The Rice Research and Development Institute (RRDI) has one regional station; the Field Crops Research and Development Institute (FCRDI) located at Maha Iluppallama has a regional centre at Bandarawela headed by a Deputy Director; the Horticultural Crops Research and Development Institute (HORDI) has six regional centres and two officers dealing with horticultural crops at the FCRDI at Maha Iluppallama. More information is available at <http://www.agridept.gov.lk/>

- **The Natural Resource Management Centre (NRMC)**

This functions under the DOA and obtains its mandate for soil conservation from the Soil Conservation (amendment) Act No. 24 of 1996. This agency deals with formulation and reform of agricultural policy/laws and regulations for the DOA. It is also responsible for promoting and implementing the Soil Conservation Act and for supporting and implementing laws and policies with respect to the agricultural sector.

- **Horticultural Research and Development Institute (HORDI)**

This is the main national institute mandated to undertake *ex-situ* conservation of horticultural crops and for information management and dissemination for horticultural crops. It is also mandated for demand driven research on vegetables, fruit, root and tuber crops in a manner that is productive, eco-friendly and sustainable. HORDI carries out extension services at the central and regional levels through its six regional centres to promote horticultural crop development in the country among farmers and the general public. HORDI has also placed officers dealing with horticultural crops at the FCRDI at Maha Iluppallama.

- **Seed Certification and Plant Protection Centre (SCPPC)**

This institution addresses plant quarantine and seed health. The National Plant Quarantine Service at Katunayake, the Office of the Registrar of Pesticides, the Plant Protection Service at Gannoruwa, the Seed Certification Service and the Plant Genetic Resources Centre (PGRC) at Gannoruwa function under the SCPPC. There are also Plant Quarantine Offices at Gannoruwa, the sea port (in Colombo) and the airport (at Katunayake). The SCPPC is responsible for the implementation of the Plant Protection Act No. 35 of 1999, the Seed Act of 2002 and the Control of Pesticides Act No. 33 of 1980 as amended by Act No. 6 of 1994. All exports of plant materials have to be given a

phytosanitary certificate through the SCPPC, and all imports of plant material (including food items and horticultural plants or plant parts) need permits from the SCPPC for importation and release into the country. There are customised agreements drawn up by the SCPPC, with specific instructions issued for each importation permit on a case by case basis.

- **The Plant Genetic Resources Centre (PGRC)**

The Plant Genetic Resource Centre (PGRC) was established in 1988 with the support of JICA. It functions under the DOA and is well equipped to conserve and manage indigenous plant germplasm of crops and their wild relatives as well as to promote their sustainable use. Its seed gene banks provide storage conditions to maintain seed viability under low moisture (5% seed moisture) and low temperature (1°C and 5°C) conditions. One of its main aims is increasing food security. This agency functions under the Seed Certification and Plant Protection Centre (SCPPC) of the DOA, and is the main repository of crop germplasm in the country, including wild relatives and traditional varieties of crops. Accordingly, its functions include exploration, acquisition, characterization, evaluation, conservation and documentation, distribution, seed conservation, biotechnology and data management. The activities of the PGRC are important for conservation of plant genetic diversity for future use in the face of climate change. Presently 12,647 accessions are held at the PGRC.

- **The Department of Export Agriculture (DEA)**

The main responsibility of the Department of Export Agriculture (DEA) is to make necessary actions to develop the Export Agriculture Crops (EAC) namely, cinnamon, pepper, cardamom, cloves, nutmeg, coffee, cocoa, citronella, betel and arecanut as well as new crops with export potential such as lemon grass and vanilla. The main activities of the DEA include promoting production and productivity of export agriculture crops, enhancing quality of produce and facilitating product diversification and value addition to these industries. The DEA is basically a technical department and functions are focused on research and development activities of the EAC sector. Act No. 46 of 1992 empowers the DEA for its functions and services pertaining to EAC.

- **The Department of Animal Production and Health**

The DAPH is responsible for implementing the Animals Act No. 46 of 1988 and the Animal Disease Act No. 33 of 1992. It has several divisions which deal with Animal Breeding, Animal Health, Planning and Economics, Finance, and Human Resource Development. There is also an institute of continuing education (ICE) in Animal Production and Health with good residential training facilities. Training is offered to the private sector on request. The activities of the DAPH are decentralized through Provincial Departments of Animals Production and Health, which are funded by the Provincial Councils. Most of these provincial agencies are under the provincial ministries dealing with livestock, but the Provincial Directors are under the all-island service of the DAPH, and are monitored by the Central Service. There are also several regional Animal Quarantine Centres, including a branch office at the airport, and farmer training centres at the Provincial level.

- **The Veterinary Research Institute (VRI)**

This agency functions under the DAPH with the mission “to be the centre of excellence in research and development in the livestock industry”. Although research in the livestock sector is addressed by several institutions, this responsibility lies mainly with the Veterinary Research Institute (VRI). It is mandated to carry out veterinary research as well as other research in all aspects of animal breeding and genetic improvement, and carries out research on disease control and regulatory functions, animal feeds, farming systems and production of vaccines (e.g. eight have been produced at present, mostly for cattle and poultry), and human resource development (research training) to meet the objectives of the DAPH. Conservation of economically important indigenous animal species and the use of traditional varieties of domestic cattle and poultry for livestock breeding is the responsibility of both the DAPH and the VRI. There are veterinary surgeons of the VRI under the Provincial administration as well as under the central service. Efforts by the Department of Animal Production and Health and the Veterinary Research Institute (VRI) to conserve the indigenous animal species of economic value have been constrained by insufficient funds and infrastructure.

Part II - Fisheries

- **The Ministry of Fisheries and Aquatic Resources (MFAR)**

The Ministry of Fisheries and Aquatic Resources (MFAR) and its line agencies have the premier role in management of the fishery industry. According to the Fisheries Act of 1996, the Minister responsible for fisheries can declare fisheries reserves when and where necessary. There are currently nine Fisheries Management Areas, but no fisheries reserves have been declared as yet, although the Minister could do so under this Act.

- **The Department of Fisheries and Aquatic Resources (DFAR)**

The Department of Fisheries and Aquatic Resources (DFAR) is mandated with conservation and sustainable use of fish species through the Fisheries Act No. 2 of 1996. The DFAR is currently under the Ministry of Fisheries Aquatic Resources. It is mandated to formulate/reform conservation policy/laws/regulations in the fisheries sector and to promote or implement relevant laws and policies. The divisions of this department include Administration, Fisheries Management, Fisheries Industry, Quality Control, Monitoring Control and Surveillance. The DFAR has Regional District Fisheries Offices in Batticaloa, Chilaw, Colombo, Galle, Jaffna, Kalmunai, Kalutara, and Kilinochchi, Mannar, Matara, Mulatiu, Negombo, Puttalam and Tangalle.

- **National Aquaculture Development Authority (NAQDA)**

NAQDA was established in 1999 under the provisions made available by the National Aquaculture Development Authority Act No. 53 of 1998. It is the main state sponsored organization mandated for the task of development of the aquaculture and inland fisheries sector in Sri Lanka. Presently, it comes under the purview of the Ministry of Fisheries and Aquatic Resources with a mandate to:

- develop aquaculture and aquaculture operations, with a view of increasing fish production and consumption in the country;
- promote the creation of employment opportunities through the development of fresh water, brackish water and coastal aquaculture and mariculture;
- promote the farming of high value species including ornamental fish for export;
- promote the optimum utilization of aquatic resources through environmentally friendly aquaculture programmes;
- promote and develop small, medium and large scale private sector investment in aquaculture;
- manage, conserve and develop aquatic resources used for aquaculture and aquaculture operations;
- Prepare, implement and assist in preparing and implementing plans and programmes for the management, conservation and development of aquaculture and aquaculture operations.

- **National Aquatic Research and Development Agency (NARA)**

The National Aquatic Resources Research and Development Agency (NARA) is the apex national institute vested with the responsibility of carrying out and coordinating research, development and management activities on the subject of aquatic resources in Sri Lanka. NARA is a statutory body duly established by the NARA Act No. 54 of 1981. During its past 27 years it has conducted numerous scientific researches in the field of fisheries and aquatic resources. NARA also provides services for development and sustainable utilization of living and non-living aquatic resources. NARA as the premier research institution dealing with aquatic systems is engaged in gathering data relevant for conservation and development of the fishery industry (e.g. fisheries data), from which assumptions on coastal resource and habitat conservation and sustainable use should be made.

More information at <http://www.nara.ac.lk/>

- **The Marine Environment Protection Authority (MEPA)**

The Marine Pollution Prevention Act of 1981 enabled the establishment of the Marine Pollution Prevention Authority (MPPA) and provided for the prevention, reduction and control of pollution in Sri Lankan waters, and for giving effect to international conventions that Sri Lanka is a signatory to for the prevention of pollution of the sea. The 2009 revision of this Act has strengthened the MPPA and renamed it as the Marine Environment Protection Agency. MEPA is responsible for warning and promoting prompt remedial action in the event of a major oil spill in Sri Lankan waters, or in

adjacent waters that may affect the country's marine environment. MEPA is the focal point for UNCLOS (United Nations Convention on the Law of the Sea), the MARPOL Convention (for the prevention of pollution from ships) and several other international conventions, and is responsible for some functions under the Basel Convention (i.e. for control of transboundary movements of hazardous wastes and their disposal).

The MEPA has a regional office in Galle. MEPA will delegate various functions at the time of an oil spill contingency to various agencies (*i.e.* Sri Lanka Ports Authority, Ceylon Petroleum Corporation, Sri Lanka Navy, Sri Lanka Air Force, Sri Lanka Army, Sri Lanka Police, Department of Meteorology, Coast Conservation Department, Local Authorities) to work at both on-shore and off-shore levels.

- **Coast Conservation Department (CCD)**

This department is presently located under the Ministry dealing with Ports and Aviation, and is the prime agency responsible for coastal issues in Sri Lanka. Its mandate provides it with a key role to play in conserving and managing coastal and marine biodiversity according to the periodically revised Coastal Zone Management Plan. The Director of the Coast Conservation Department is responsible for administration and implementation of the provisions of the Coast Conservation Act, including the survey and inventorization of coastal resources.

The CCD is also responsible for the conservation and management of natural coastal habitats and areas of cultural and recreational value in the coastal zone. Programmes carried out so far by the CCD cover mitigating coastal erosion, policy development and coastal resources management, including issuing of permits for coastal development and revision of the Coastal Zone Management Plans periodically to regulate and control development activities in the coastal zone.

Primary source of institutional profiles in Appendix C: MENR (2007). The thematic Assessment Report on Biodiversity of the national Capacity Needs Self-assessment for Global Environmental Management prepared by J D S Dela. Ministry of Environment and Natural Resources, Battaramulla, Sri Lanka.

Appendix D

Country Profile in Brief

Population status

Sri Lanka is a multi-ethnic, multi-religious secular state, with a total population of over 20.4 million and a population density of 326 persons per km². The Wet Zone, with a very high biological diversity, and more favourable climate and better socio-economic considerations than the water scarce Dry Zone, contains about two thirds of the country's population despite its coverage of less than a third of the island. The population in Sri Lanka is still predominantly rural as only about 20% of the population live in urban areas.

Healthcare and life expectancy

Sri Lanka has achieved remarkable progress in health and social welfare relative to other low income countries and its neighbouring South Asian counterparts as shown by a Human Development Index (HDI) of 0.759 in 2007. This is due to a large share of public expenditure being redistributed to households perceived to be in need in the form of free education and health services, as well as food subsidies and subsidized credit to improve living standards.

Sri Lanka has relatively high standards of health care, and the national health indicators are comparable with those of developed countries. The Government of Sri Lanka provides free health care services through a network of western and traditional health care institutions including hospitals, dispensaries and health units located in all parts of the country. There is also significant enhancement of health services for women and children through pre- and post-natal care nutritional programmes. Sri Lanka's consistent decline in maternal mortality for over 5 decades is attributed to a wide network of maternal services which is integrated with childcare. The life expectancy at birth for males and females is respectively 70.3 and 77.9 years. Infant mortality rates are low at 10 (per '000), while under five mortality at 14 (per 1,000) live births is the lowest for the WHO South East Asian region.

Education

The net enrolment ratio in primary education exceeds 98%, and the country has an island-wide network of schools which include public, private and religious education centers. Education was made compulsory for all children between the ages of 5-14 in 1997 and is free of charge to all students in state schools since 1945. Hence, Sri Lanka has a high adult literacy rate of 92.5%. Sri Lanka has 15 universities, six postgraduate institutions and about seven institutions affiliated to the universities which offer Bachelor's Degree courses in specialised fields. University education is a public sector monopoly as yet and free of charge, except for the Open University which is open to students of any age and with varying basic educational backgrounds.

Status of women

Men and women are granted equal status and rights under the Constitution of Sri Lanka and Sri Lankan women - including women in the rural areas - have a comparatively better status than their counterparts in many developing countries. Gender wise the literacy rate is 94.5% for males and 90.6% for females. Sri Lanka has achieved gender equality in primary and secondary education in the generations that had access to free education. Overall there has been a perceptible upward social mobility in the status of women since gaining independence in 1948, mainly due to increased access to free education, economic opportunities for employment in the industrial sector and migrant domestic employment overseas. Sri Lanka's Gender Development Index (GDI) in 2007 was 0.756 but the Gender Empowerment Measure (GEM) was only 0.389.

Housing and lifestyles

Lifestyles are changing in Sri Lanka with increased household income, and household consumption is shifting from food (as in the past) to communication, education, recreation, housing and utilities. The average household size is at present 4.1 persons. About 79% of households now own a radio or TV and 36% own a refrigerator. Household access to motorized transport and telephone facilities stand at 22% and 25% of households respectively. The demand for houses and urban infrastructure is increasing. About 75% of the population outside the north and east live in houses with more than three rooms, and over 72% of houses throughout the island comprise modern building and roofing

materials such as bricks and cement for walls and tiles or asbestos for roofing; about 77% of households have sanitary and toilet facilities, 86% have electricity and 84.8% of households have access to safe water – although only about 35.5% have access to pipe-borne water. Consequently much of the rural population still depend mainly on well water, water from forest streams, reservoirs, canals and streams which become contaminated with faecal matter and other pollutants.

Economic trends and poverty

Per capita income in Sri Lanka exceeded US\$2000 in 2009, but very high regional disparities remain. According to government figures, 15 percent of Sri Lankans live below the official poverty line of Rs 3,087 a month. The country's commitment to alleviating poverty is reflected in Sri Lanka's macroeconomic policies which are pro-growth and pro-poor while continuing to uphold market based economic policies. The economic policies of the country also encourage foreign investments by providing foreign exchange and employment opportunities to catalyze the development process. Overall, the country's monetary and fiscal policies are geared towards improving macroeconomic stability by enhancing development, increasing investment and poverty reduction. The country's economic growth and poverty alleviation programmes focus on regionally balanced growth with rural and small and medium private sector development with the medium-term objective of macroeconomic stability and a regionally balanced economic growth rate of about 6-8 percent. Being an open economy, open market operations prevail with considerable individual freedom. This has to some degree had a positive impact on the environment.

Importance of bio-resources for economic development

Sri Lanka's diverse bio resources serve to maintain a range of economic activities within the island. Foremost among these are agriculture, the marine and brackish water fishery and tourism. Agriculture, forestry and fisheries had contributed only about 12% of the GDP. The fisheries sector provides direct employment to about 208,731 people, and sustenance to at least 2.5 million. Fish also constitutes the top source of animal protein for Sri Lankans. Sri Lanka's rich biodiversity offers ample potential to support the government's current tourism related policy aimed at maximizing potential for nature-based tourism and cultural tourism.

Industrial growth

Sri Lanka has been gradually changing from an agricultural based economy to an industrial based one over the last few decades and presently follows a liberalized industrial policy. At present industry comprises 28.6% of the GDP. Sri Lanka has been promoting the development of private sector-led, export-oriented industries with sufficient diversification in relation to both products and geographical location. However, relatively little attention has been paid in the past to ensure environmentally sustainable economic growth.

Adapted from the Country Profile in Brief from the 4th National Report to the Convention on Biological Diversity as updated with data from Central Bank (2010), Human Development Report 2009, UNDP; Household Income and Expenditure Survey, 2005, Department of Census and Statistics.

Appendix E

List of Persons/Institutions Consulted

The consulting team has attempted to consult a broad range of stakeholders throughout the SVP preparation process through working group discussions and individual consultations. All consulted across sectors are given below.

Government Organizations (GOs)

SNC Project Team	Mr. H.M. Bandarathillake	National Project Manager
	Dr. M.C.M. Iqbal	Team Leader - Vulnerability and Adaptation(SNC)
	Mr. Jayathilaka Banda	Team Leader- Education, Training & Awareness(SNC)
	Prof. Hemanthi Ranasinghe	Team Leader- Mitigation(SNC)
	Mr. Nimal Perera	Team Leader- GHG Inventory(SNC)
Asian Disaster Preparedness Centre (ADPC), DMC	Mr. Rohan Cooray	Program Co-ordinator (PIP-SL)
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National Climate Change Adaptation Strategy for Sri Lanka 2011-2016

Information, Education and Communications Strategy for Climate Change Adaptation in Sri Lanka

NCCAS Brochures

Compilation of Climate Change Adaptation Project Concept Notes

Sector Vulnerability Profiles:

- Urban Development, Human Settlements and Economic Infrastructure
- Agriculture and Fisheries
- Water
- Health
- Biodiversity and Ecosystem Services

Public Perceptions Survey on Climate Change in Sri Lanka

Prepared with assistance from
ADB TA 7326 (SRI)
Strengthening Capacity for Climate Change Adaptation

Implemented by:
Climate Change Secretariat
Ministry of Environment
Sri Lanka

www.climatechange.lk