The relative importance of crop pests in South Asia (NRI Bulletin No. 39)

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Summaries

SUMMARY

This is the second in a series of regional studies of crop pest importance carried out by the Natural Resources Institute (NRI). The aim of this study was to assess the relative economic importance of crop pests in the cropping systems of South Asia (defined as India, Nepal, Sri Lanka, Bangladesh and Pakistan). The area was divided into 30 different cropping system zones and the study provides guidance on which pests are important in each zone and on the zones which are important for particular pests.

In each zone, pests were arranged in five ranks of importance, with an indication of the crops they attacked. In principle, pests were defined as harmful organisms (arthropods, nematodes, pathogens, vertebrate pests, weeds) but the coverage varied between countries.

Pest importance estimates were given by experts. Whilst the majority of experts were research scientists, plant protection service staff were also interviewed. The relative importance of crops based on production value was calculated for each zone as an important factor to guide experts in ranking pests across crops. Rankings were given by panels of experts across all crops as well as by experts with narrower responsibilities for a particular crop or class of pest.

The ranking estimates of experts were synthesized into ranking lists for each zone across all pests. By converting ranks into scores and weighting these by zonal production value, aggregate weighted scores were generated to analyse the relative importance of pests of a single crop in India and South Asia as a whole. This was done for rice and wheat pests. Only arthropods, pathogens and nematodes were included in this analysis.

The analysis showed that the most serious pests were:

India	**South Asia**
Rice	
Rice blast (*Pyricularia oryzae*)	Rice blast
Yellow stemborer (*Scirpophaga incertulas*)	Yellow stemborer
Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Bacterial leaf blight
	Brown planthopper (*Nilaparvata lugens*)
Wheat	
Brown rust (*Puccinia recondita*)	Brown rust
Loose smut (*Ustilago nuda*)	Loose smut

The results of the study are presented as tables ranking the pests in each zone, together with some background information on zonal climate and cropping systems.

It is suggested that some individual countries might like to carry out further studies on pest importance in greater depth tailored more closely to their own national requirements.

RESUME

Voici la deuxième d'une série d'études régionales entreprises par le Natural Resources Institute (NRI) sur l'ordre d'importance des ennemis des cultures. Le but de cette étude était de déterminer l'ordre de gravité économique des ennemis des cultures dans les systèmes d'exploitation en Asie du Sud (définie comme étant l'Inde, le Népal, Sri Lanka, le Bangladesh et le Pakistan). Ce territoire fut divisé en 30 zones d'exploitation différentes et l'étude fournit une orientation sur le degré d'importance des différents ravageurs dans chaque zone et sur les zones qui ont de l'importance pour certains ennemis.

Dans chaque zone, les ennemis étaient classés en cinq catégories, avec l'indication des cultures attaquées. En principe, les ennemis étaient définis comme étant des organismes nuisibles (arthropodes, nématodes, pathogènes, vertébrés, adventices) mais leur représentation variait selon les pays.

Des évaluations de l'importance relative ont été fournies par des experts. Bien que la majorité d'entre eux aient été des chercheurs scientifiques, les personnels des services de protection des cultures ont également été consultés. Le degré relatif d'importance des cultures a été calculé pour chaque zone sur la base de la valeur relative de la production, considérée comme un indice utile du classement des ennemis dans les diverses cultures. Un classement a été établi par les experts pour l'ensemble des cultures, tandis que d'autres se chargeaient spécialement d'une culture particulière ou d'un type d'ennemi.

Les classements ainsi élaborés étaient synthétisés pour en faire des listes de tous les ravageurs dans chaque zone. En convertissant les classements en points et en les pondérant selon la valeur de la production par zone, on produisait un bilan pondéré pour analyser l'importance relative des ennemis d'une culture donnée en Inde et dans le Sud-Asiatique dans son ensemble. Cela s'est fait pour les ennemis du riz et du blé. Seuls, les arthropodes, les pathogènes et les nématodes figuraient dans cette analyse.

L'analyse a montré que les ennemis les plus graves étaient:

Inde	**Asie du Sud**
Riz	
Pyriculariose (*Pyricularia oryzae*)	Pyriculariose du riz
Foreur jaune des tiges (*Scirpophaga incertulas*)	Foreur jaune des tiges
Bactériose des feuilles (*Xanthomonas campestris* pv. *oryzae*)	Flétrissement des feuilles
	Fulgoridé brun (*Nilaparvata lugens*)
Blé	
Rouille brune (*Puccinia recondita*)	Rouille brune
Charbon nu (*Ustilago nuda*)	Charbon nu

Les résultats de l'étude sont présentés sous forme de tableaux classant les ennemis de chaque zone, avec certaines informations de base sur le climat et les systèmes de culture de la zone.

Il est suggéré que certains pays pourraient aimer à titre individuel à entreprendre de nouvelles études plus approfondies sur l'importance des ennemis, selon leurs propres besoins nationaux.

RESUMEN

Este es el segundo trabajo dentro de una serie de estudios regionales realizados por el Instituto de Recursos Naturales (NRI) sobre la importancia de las plagas del campo. El objetivo de este estudio es evaluar la importancia económica relativa de las plagas dentro de los sistemas de cultivo de la región meridional de Asia (definida como India, Nepal, Sri Lanka, Bangladesh y Paquistán). Tras haber realizado la división de la región en 30 zonas distintas de sistemas de cultivo, el estudio proporciona directrices sobre plagas de importancia para cada zona y sobre zonas de particular importancia para plagas específicas.

Dentro de cada zona, y dependiendo de su importancia, se llevó a cabo una clasificación de las plagas en cinco categorías, indicándose los cultivos a los que atacan. Si bien, en principio, se definieron como plagas organismos nocivos (artrópodos, nematodos, patógenos, vertebrados y malas hierbas), su extensión varió de un país a otro.

Los expertos proporcionaron cálculos sobre la importancia de las plagas. Valga apuntar que, aunque la mayor parte de los expertos eran científicos de investigación, se realizaron asimismo entrevistas con personal del servicio de protección de las plantas. También se llevó a cabo para cada zona el cálculo de la importancia relativa de los cultivos, sobre la base de su valor de producción, como importante factor guía al realizar la clasificación de las plagas en los distintos cultivos. El proceso de clasificación estuvo en manos de grupos de expertos de todos los cultivos, así como de expertos con responsabilidades más concretas por un cultivo o clase de plaga específicos.

Las clasificaciones asignadas por los expertos fueron sintetizadas en listas de clasificación de las plagas para cada zona. Mediante conversión de las clasificaciones en puntuaciones ponderadas por valor de producción zonal, se generaron puntuaciones ponderadas agregadas para analizar la importancia relativa de las plagas de un solo cultivo en la India y en la entera región meridional de Asia. Esta labor se llevó a cabo con las plagas del arroz y del trigo, habiéndose incluido únicamente en este análisis artrópodos, patógenos y nematodos.

El análisis demostró que las plagas más serias eran:

India	**Sur de Asia**
Arroz	
Tizón del arroz (*Pyricularia oryzae*)	Tizón del arroz
Taladrador amarillo del arroz (*Scirpophaga incertulas*)	Taladrador amarillo del arroz
Mancha foliar bacteriana (*Xanthomonas campestris* pv. *oryzae*)	Mancha foliar bacteriana
	Saltamontes marrón (*Nilaparvata lugens*)

Trigo	
Roya parda (*Puccinia recondita*)	Roya parda
Carbón desnudo (*Ustilago nuda*)	Carbón desnudo

Los resultados del estudio se presentan a manera de tablas en las que se clasifican las plagas de cada zona, a la vez que se proporciona cierta información de fondo sobre el clima y sistemas de cultivo de dichas zonas.

Se sugiere asimismo la posibilidad de que algunos países deseen realizar estudios adicionales más profundos sobre la importancia de las plagas, adaptados de manera más específica a las exigencias de cada nación interesada.

Section 1

Introduction

THE STUDY

This study is the second in a series being carried out by the Natural Resources Institute (NRI).* The first study (Geddes, 1990), divided sub-Saharan Africa into ten agro-ecological zones and assessed the relative importance of crop pests in each of them. It covered all crops and all pre- and post-harvest pests, with a special focus on insect-vectored plant diseases. This second study covers South Asia, which comprises India, Pakistan, Bangladesh, Sri Lanka, and Nepal. It assesses the relative importance of pre-harvest pests which in the widest sense consist arthropods, nematodes, vertebrates (rodents, pigs, birds etc.), pathogens and weeds. Post-harvest pests are omitted as insufficient information was obtained about them. The relative importance of pests is assessed in the 30 cropping system zones into which the region is divided.

OBJECTIVES AND USES

The formal objectives of the study were:

(1 to establish a system of agro-ecological zones reflecting cropping systems in South Asia.

(2 to rank the main pests in order of importance in each zone.

(3 to indicate in which zone and for which pest research is most relevant.

This study should prove useful in research planning as research moves 'downstream' from the basic and strategic to the more applied and adaptable. Where there is an interest in an area, the study will provide guidance on the relative importance of pests in that area. When there is an interest in a pest, the study will indicate those areas in which the pest is likely to be important. The study will also provide limited guidance for resource allocation on a broader scale by ranking pests in order of importance for the whole region. The data were considered to be sufficiently comprehensive to produce such rankings for all pests in the case of rice and wheat only. Pests of other crops are covered in the lists of outstanding pests compiled for the region as a whole and each of the five countries separately.

The study could also be used to provide initial guidance before embarking on a much more comprehensive study of pest importance in a particular country or area.

The relative importance of pests changes over time in response to many factors (Geddes, 1990). The ranking tables in this report give a current assessment of pest importance. Their validity will decrease over time and they will need to be updated periodically. As a number of years usually elapse between the start of research and its large-scale application in the field, caution is necessary if the study is to be used as a guide to the allocation of research resources; consideration should also be given to likely future trends.

* At the time the first study was carried out NRI was known as the Overseas Development Natural Resources Institute (ODNRI). The name was changed on 1 April 1990.

PEST IMPORTANCE AND RANK

It is necessary to define what is meant by pest importance in this study. Pests are a problem as they cause crop losses, hence pest importance is defined as economic importance.This also provides a common factor for comparison of all crops and all pests. Economic importance is determined by:

— actual losses with existing control measures

— the cost of current control measures

— reduction in output as a result of farmers growing less valuable crops in response to a particular pest

— reduction in yield potential of cultivars through breeders having to incorporate pest resistance at the expense of yield and farmers having to grow more pest resistant but lower-yielding varieties.

Respondents were asked to rank pests for economic importance taking these factors into account. The first two factors are responsible for most of the economic loss and these were given more consideration by respondents when ranking pests.

Some pests cause fairly consistent losses from year to year, whilst others are more sporadic, causing little or no loss in one year and serious or even devastating losses in other years. For two pests causing the same percentage losses averaged over a number of years, the sporadic pest is considered to be the more important. A farmer may take a long time to recover from a bad year or never fully recover, whereas he is likely to find it easier to cope with steady, more predictable losses.

For each zone pests are placed in one of five ranks with the first rank indicating highest importance. The order within the rank has no significance, except for Nepal, where order within the rank does indicate importance.

When pests are ranked as a group they have been ranked collectively; individually they might not warrant such a high ranking.

Section 2

The framework of zones

Each country was separately divided into zones which were, in general, based on zoning systems in use in the country.

INDIA

The study divided the country into 15 zones, adopting the Planning Commission's Resource Development Regions.* A preliminary analysis was made using crop distribution maps and data on crop area and production and a provisional framework of cropping system zones was then established. In India it was found that the Resource Development Regions reflected the distribution of crops reasonably well. This was not surprising as cropping systems were an important factor in their determination. Their use was recommended by the Director of the Indian Council of Agricultural Research, and their adoption will facilitate the use of the study in any future planning made on the basis of these Resource Development Regions.

An alternative way of zoning the county would have been to use the states as zones. This would have been relevant to planning, research and development at the state level and would have been convenient for follow-up work by state agricultural universities. It was also found that most respondents thought in terms of states in locating pest problems and tended to translate their knowledge from the state to the Resource Development Region framework when giving their answers. However, the state boundaries bore little relationship to cropping system zones.

Figure 1 shows the boundaries of the Resource Development Regions. There were a few places where they were a poor reflection of cropping systems. For instance, there is a clear difference in Zone 2 between the hill areas and the flood plain of the Brahmaputra which could perhaps have been amalgamated with Zone 3 (West Bengal). Zone 12's boundary would have been better a little further eastward to encompass more of the high elevation plantation crops, and the extension of Zone 9 so far north into Madhya Pradesh seemed poorly related to the cropping pattern.

NEPAL

Nepal has been divided into five physiographic regions by the Topographical Survey Branch (Figure 2). These were simplified into three cropping system zones for the purposes of the study.

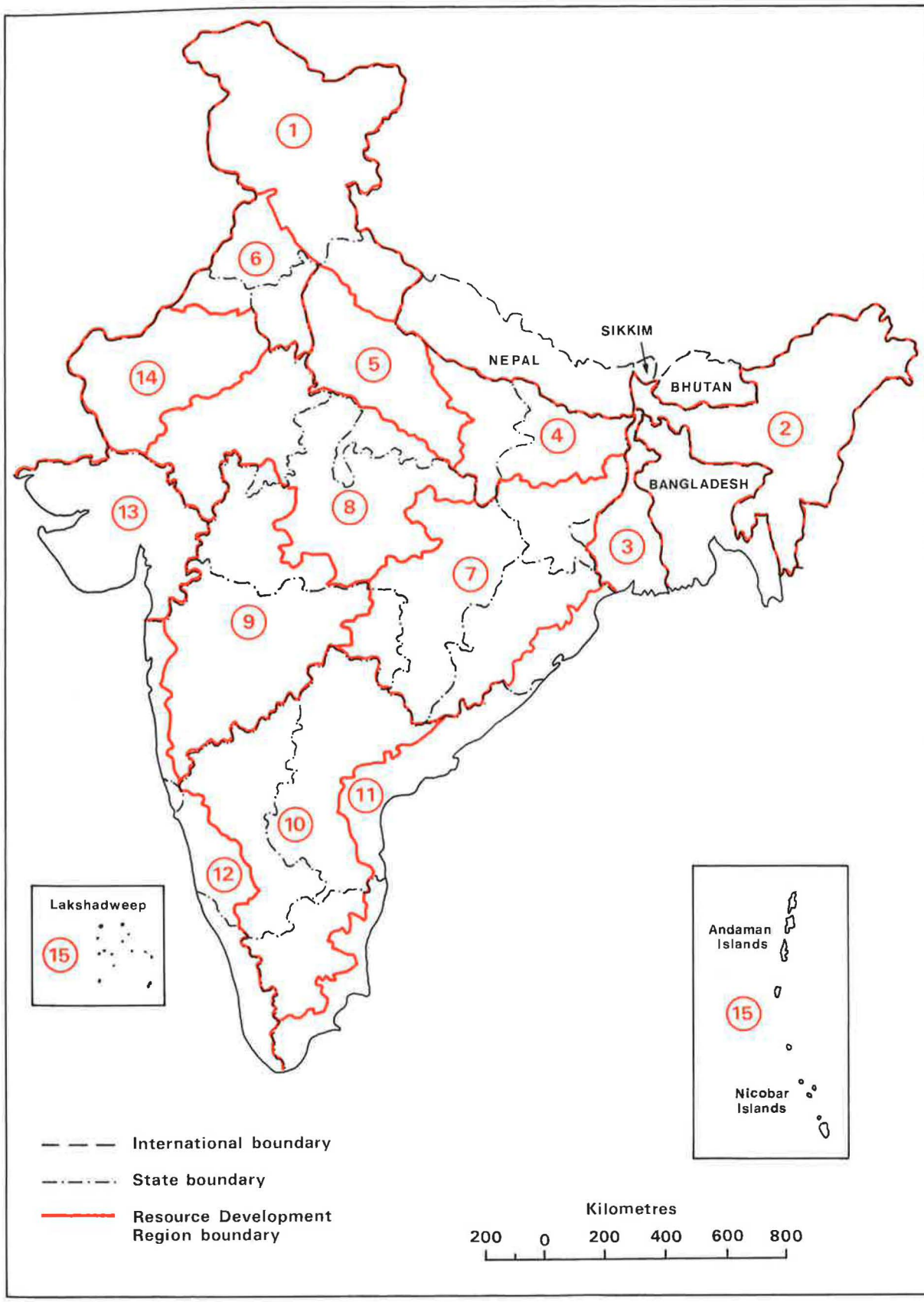
SRI LANKA

Sri Lanka was divided into four zones depending on altitude and rainfall probability, using an amalgamation of the 24 agro-ecological zones into which the country has been divided (Figure 3).

* Also referred to in different publications as agro-climatic regions and agro-climatic zones.

Figure 1

India Resource Development Regions
(used as cropping system zones in this study)



SOURCE: Planning Commission, Government of India.

Figure 2

Cropping system zones of Nepal

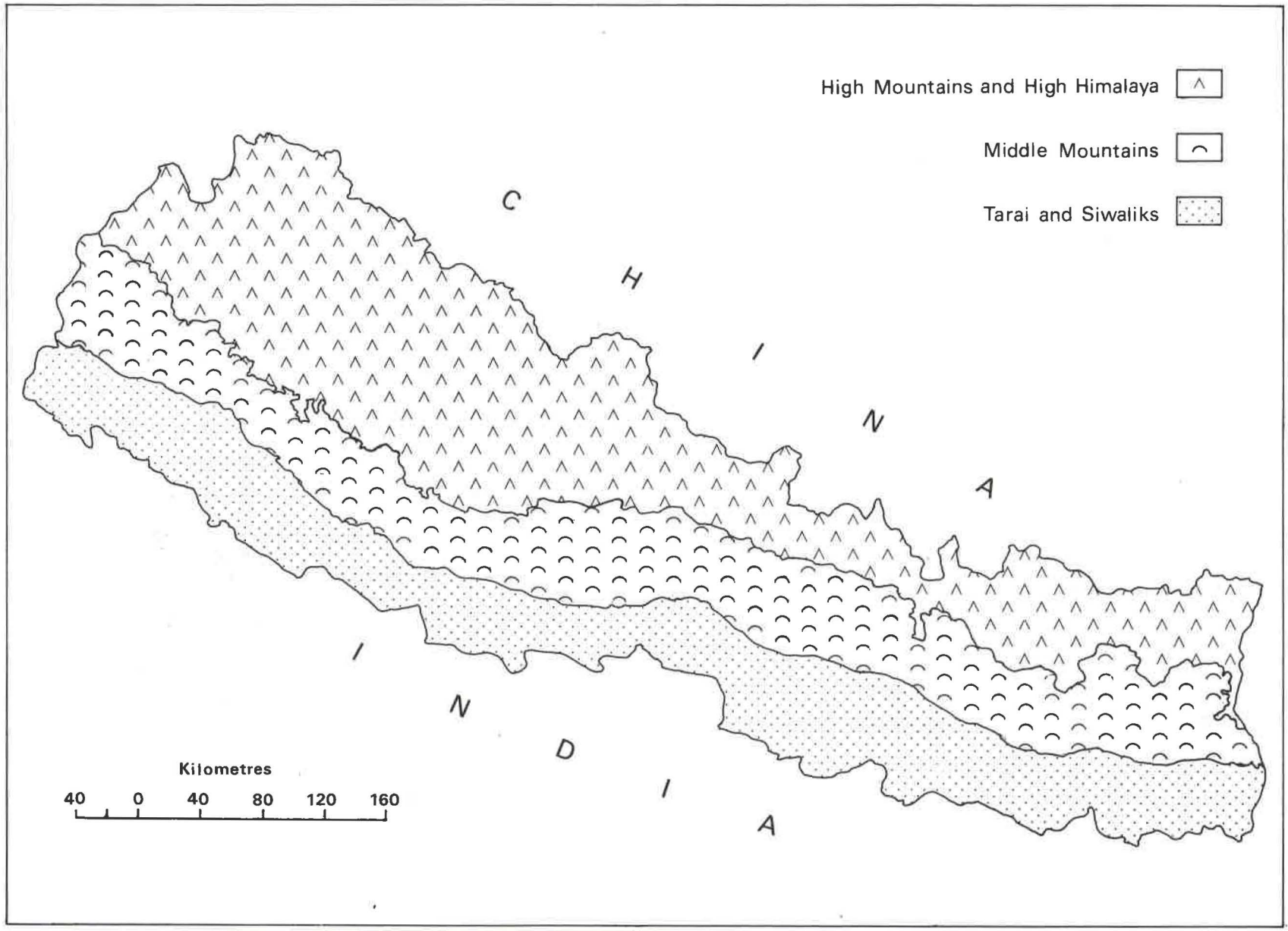


Figure 3

Sri Lanka cropping system zones

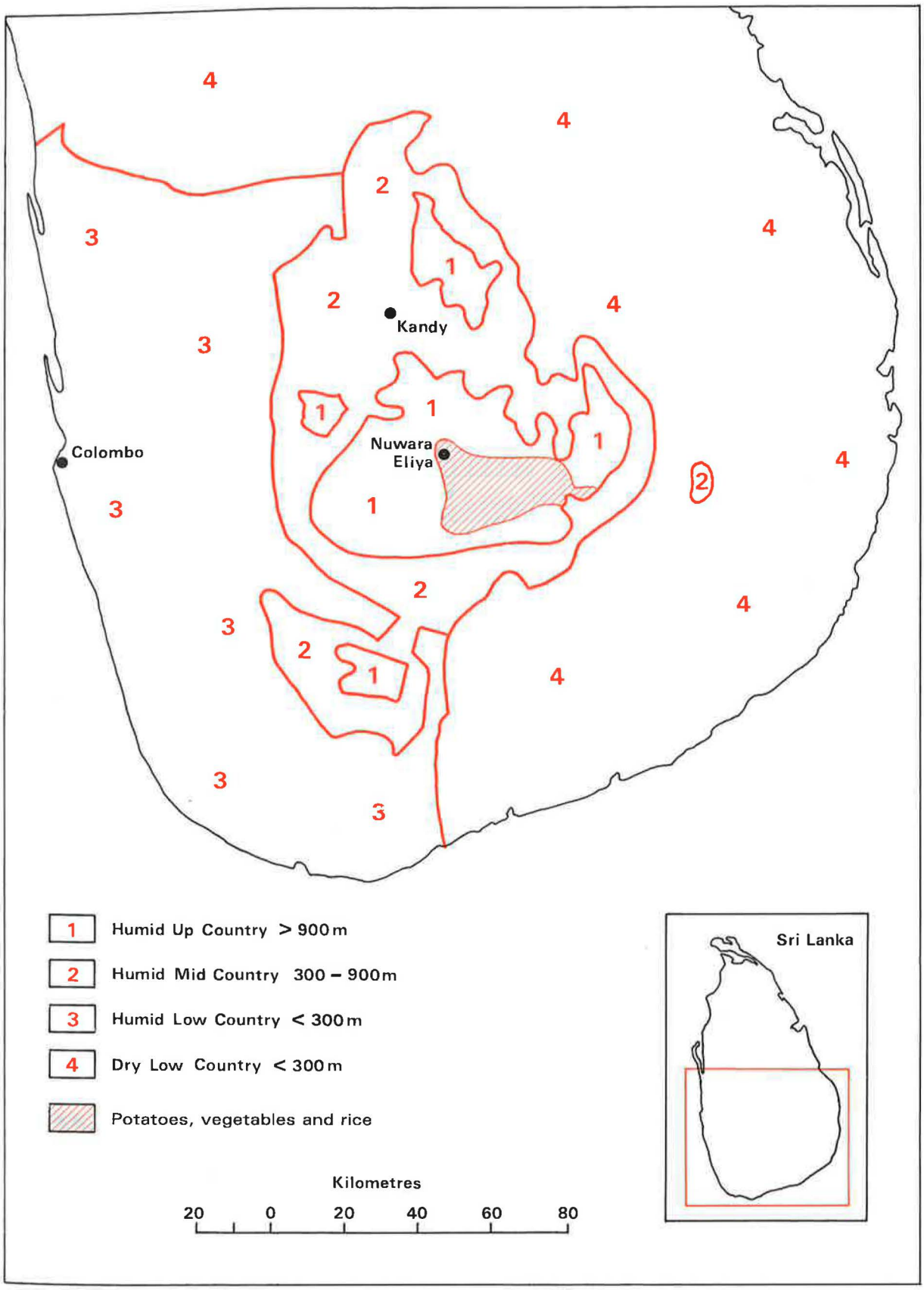
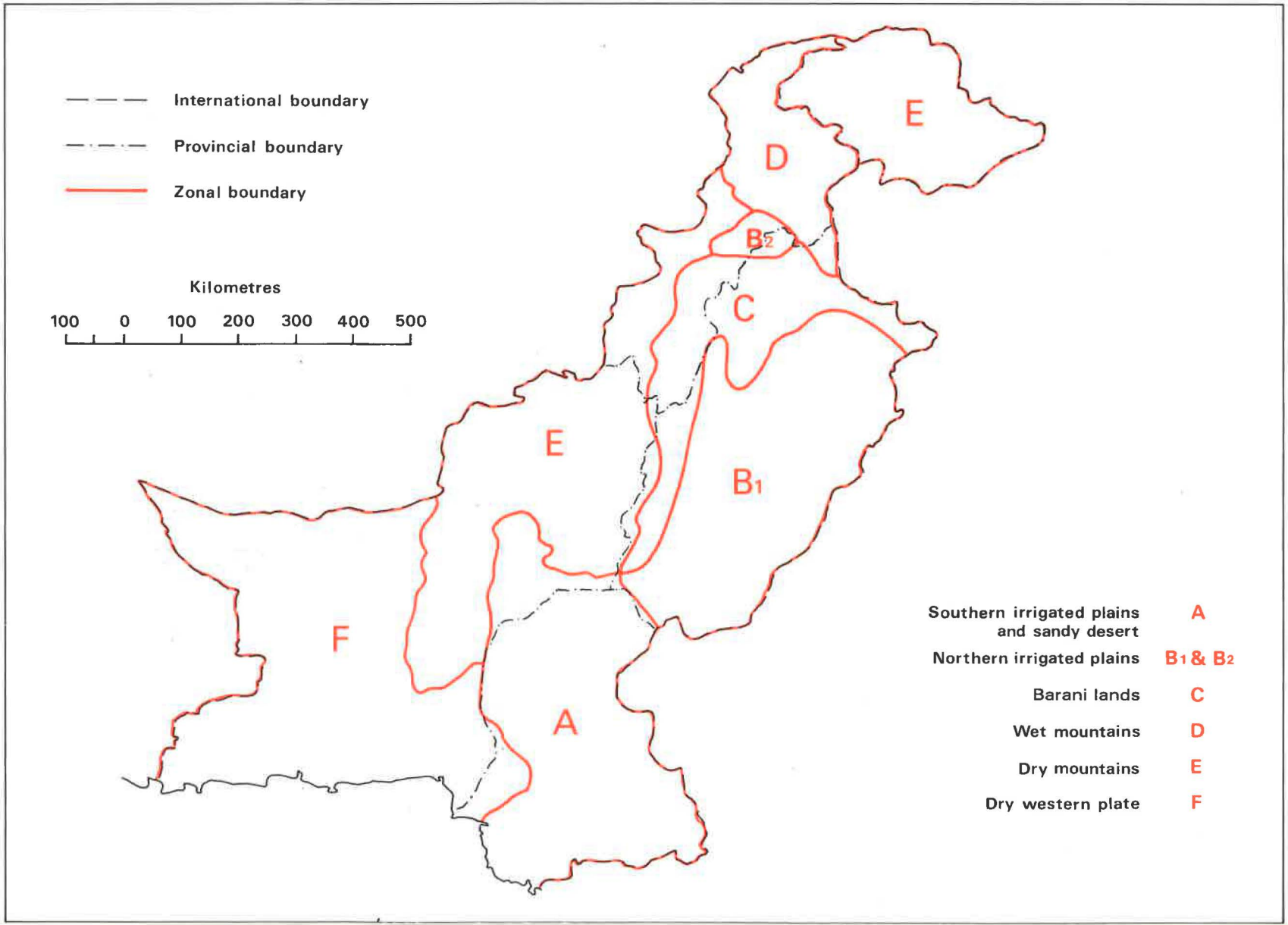


Figure 4

Pakistan cropping system zones



BANGLADESH

The exceptionally heavy dominance of rice cultivation in Bangladesh, coupled with a relatively uniform cropping system, little variation in rainfall and virtually none in elevation over most of the area, warranted treating Bangladesh as a single zone. Although it is similar to West Bengal in cropping pattern, there are some differences in the importance of pests, so the two zones were not amalgamated.

PAKISTAN

In Pakistan, zoning was based on the system of nine agro-ecological regions developed by the Pakistan Agricultural Research Council (1986). These were reduced to seven regions as shown in Figure 4. Altitude, rainfall and irrigation facilities are the main factors on which the system is based. The distinction between Zones A and B is mainly one of temperature, most of A being frost-free in winter. They also occupy different provinces and so their separation facilitated the ranking of their pests by provincial staff.

Section 3

The relative importance of crops

CRITERION FOR CROP IMPORTANCE

Once the zones were established, the next task was to estimate the relative importance of crops. Where sufficient data were available this estimate was made on the basis of the value of crop production. This is obviously highly relevant to crop importance, although it takes no account of income distribution and gives no extra weighting to the losses of poorer farmers.

The relative importance of crops is an important factor in determining pest importance, as it is directly related to yield losses from pest damage, cost of control measures and loss of yield potential from breeding for pest resistance. However, it may divert attention from the economic loss of farmers reducing their area of crop attacked and substituting a crop of lower value. For this reasons it may result in some under-estimation of the importance of the more serious pests.

CALCULATION OF CROP IMPORTANCE

India

The relative importance of crops is presented in Table 1. Crop production data from 1985–86 were used, this being the last year for which data were available for all districts. District data could be aggregated by zone as zonal boundaries do not cut across districts. The Directorate of Economics and Statistics was the source of this data. Price data from 1985–86 from the publication *Farm Harvest Prices of Principal Crops in India* (Directorate of Economics and Statistics, Ministry of Agriculture, 1988) were used to calculate production value. Prices were given by state rather than zone, so prices for zones were derived by averaging the prices of the main states within the zonal boundaries.

Absolute crop production values were converted into percentages of the total value of all the crops in the zone for which production values were calculated. These percentages show the relative importance of crops. Important crops for which no production data were available, most fruit and vegetables, are also listed. Presumably, production data was not recorded because the production of crops with multiple picking and cutting is difficult to measure.

Nepal

Recent production data were not available by physiographic region so the relative importance of crops could not be calculated. The main crops grown in each of the three cropping system zones are given in Section 8.

Table 1

India—relative importance of crops by zone: value of production as a percentage of zonal crop production* (1985–86 production and prices)

Crop	%	Crop	%	Crop	%
Zone 1		**Zone 2**		**Zone 3**	
Wheat	27	Rice	38	Rice	59
Maize	27	Tea	32	Jute	22
Rice	24	Jute	12	Potato	11
Soyabean	6	Potato	4	Wheat	4
Sugar cane	5	Ginger	3	Rape/mustard	2
Potato	4	Cardamom	3	Sesame	1
Rape/mustard	4	Rape/mustard	3	Chickpea	1
Finger millet	3	Banana	2	Sugar cane	1
Other crops		Sugar cane	1	*Other crops*	
Temperate fruits		Maize	1	Mango	
Vegetables		Wheat	1		
		Other crops			
		Citrus			
Total value of above crops in million rupees					
	9845		33,079		31,330
Zone 4		**Zone 5**		**Zone 6**	
Rice	38	Wheat	36	Wheat	44
Wheat	28	Sugar cane	25	Rice	27
Sugar cane	11	Rice	15	Cotton	10
Potato	5	Potato	5	Chickpea	7
Maize	5	Chickpea	5	Rape/mustard	4
Chickpea	4	Maize	4	Sugar cane	4
Jute	4	Pigeon pea	3	Maize	2
Pigeon pea	2	Rape/mustard	3	Pearl millet	1
Sweet potato	2	Pearl millet	2	Potato	1
Rape/mustard	1	Onion	1	Pigeon pea + sorghum	1
Onion	1	Sorghum	1		
Linseed + Pearl millet + Sorghum	1	*Other crops*		*Other crops*	
		Mango		Fodder	
Other crops				Vegetables	
Mango					
Vegetables					
Total value of above crops in million rupees					
	43,202		51,423		64,430
Zone 7		**Zone 8**		**Zone 9**	
Rice	71	Wheat	36	Sorghum	24
Sweet potato	3	Chickpea	23	Sugar cane	13
Groundnut	3	Sorghum	6	Cotton	13
Maize	3	Rape/mustard	6	Wheat	8
Chilli	3	Rice	5	Pigeon pea	6
Potato	3	Maize	5	Groundnut	6
Sesame	2	Soyabean	5	Chickpea	5
Pigeon pea	2	Pigeon pea	4	Rice	4
Wheat	2	Pearl millet	3	Banana	4
Chickpea	2	Groundnut	2	Ginger	3
Onion	1	Linseed	1	Safflower	3
Turmeric	1	Sugar cane	1	Pearl millet	2
Rape/mustard	1	Sesame	1	Maize	2
Sorghum	1	Cotton	1	Onion	2
Finger millet	1			Chilli	2
Linseed	1			Sunflower	2
				Linseed	1
				Sesame	1
				Other crops	
				Citrus	
				Grape	
				Mango	
				Vegetables	
Total value of above crops in million rupees					
	31,234		37,229		41,316

Table 1 (continued)

Crop	%	Crop	%	Crop	%
Zone 10		**Zone 11**		**Zone 12**	
Rice	19	Rice	58	Rice	29
Groundnut	19	Groundnut	11	Coffee	19
Sugar cane	12	Sugar cane	9	Coconut	14
Sorghum	10	Chilli	4	Cassava	10
Tobacco	4	Banana	4	Cardamom	10
Cotton	4	Cotton	4	Rubber	6
Finger millet	4	Coconut	2	Tea	3
Maize	4	Sorghum	1	Ginger	2
Coconut	3	Pearl millet	1	Black pepper	2
Tumeric	3	Turmeric	1	Banana	2
Tea	3	Kenaf	1	Finger millet	1
Chilli	3	Finger millet	1	Sugar cane	1
Banana	2	Sesame	1		
Pigeon pea	2	Pigeon pea	1	*Other crops*	
Pearl millet	2			Cashew	
Sunflower	1	*Other crops*		Arecanut	
Onion	1	Cashew		Cocoa	
Coffee	1			Fruits	
Safflower	1				
Wheat	1				
Sesame	1				
Chickpea	1				
Cassava	1				
Other crops					
Citrus					
Arecanut					
Grape					
Mango					
Sapota					
Total value of above crops in million rupees					
	56,491		44,699		34,706
Zone 13		**Zone 14**		**Zone 15**	
Cotton	22	Chickpea	30	Coconut	68
Groundnut	12	Pearl millet	29	Rice	32
Wheat	10	Wheat	27		
Pearl millet	10	Rape/mustard	13	*Other crops*	
Rice	8			Vegetables	
Sugar cane	8	*Other crops*			
Sorghum	5	Zizyphus or ber (fruit)			
Rape/mustard	5	Date palm			
Pigeon pea	4	Pomegranate			
Banana	4	Plantago (medicinal husk)			
Tobacco	4				
Castor	3	(pearl millet area 11 times that of chickpea)			
Onion	3				
Maize	2				
Total value of above crops in million rupees					
	18,834		2649		221

* Total value of the listed crops valued at 1% or more of the total for the zone listed.

Sri Lanka

In Sri Lanka, no production data were available by agro-ecological zone, so the relative importance of crops could not be calculated. Instead a ranking order for crop importance was estimated with the aid of Sri Lankan agriculture experts (Table 2).

Bangladesh

For Bangladesh, the study used 1984 crop production values taken from Navin and Khalil (1988). Table 3 shows the relative value of crops.

Pakistan

In Pakistan, 1985–86 district production data were aggregated by zone, using official statistics (Government of Pakistan, 1987). Price data from 1987 (Government of Pakistan, 1988) were used to calculate production values.

Table 2

Sri Lanka—order of importance of crops in Zones 1–4

Zone 1	Humid up-country	Zone 2	Humid mid-country
1.	Tea (high grown)	1.	Rice
2.	Potato	2.	Kandy mixed home gardens (banana, mango, mangosteen, durian, avocado, coconut, arecanut, breadfruit, jackfruit, root crops, ginger, turmeric)
3.	Temperate vegetables		
4.	Cardamom		
5.	Rice (often in rotation with potato)		
6.	Kandy mixed home gardens (mostly tree crops)	3.	Mid grown tea
	Fruits (pear, strawberry, banana, avocado, guava)	4.	Spices (clove, nutmeg, black pepper)
	Floriculture under glass	5.	Rubber
			Cocoa
		6.	Coffee
			Vegetables (temperate and tropical: beans, cucurbits, brinjal, cauliflower, cabbage, beetroot, radish)
		7.	Tobacco

Zone 3	Humid low country (ultra wet to semi-wet)	Zone 4	Dry low country (semi-dry to very dry)
Major crops			
	Rice	1.	Rice (mostly irrigated)
	Coconut	2.	Pulses (soyabean, cowpea, green gram, black gram)
	Rubber		
	Tea (low grown)	3.	Groundnut
			Chilli
Secondary crops			Onion
			Coconut (Kalpitiya and Jaffna)
	Yam, sweet potato, other tubers		Cotton
	Turmeric, ginger		Floriculture (for export)
	Banana		Palmyra palm (for making arrak—particularly Jaffna and islands)
	Pineapple		Vegetables (okra, brinjal, cucurbis, bean, tomato)
	Papaya		Tobacco
	Mangosteen		Maize (some as green cobs)
	Passion fruit		Finger millet
	Arecanut		Sesame
	Rambutan		Cashew
	Black pepper (little but increasing)		Sugar cane
	Tropical vegetables (cucumber, pumpkin, brinjal, capsicum, chilli, fresh cowpea, okra, leafy vegetables)		Fruit (mango, citrus, banana)
			Gerkin (pickled for export)
			Potato

Table 3

Bangladesh – relative importance of crops: value of production as a percentage of total crop production value (1984)

Rice	
—Aman	44
—Aus	15
—Boro	18
—Total	77
Jute	5.3
Wheat	4.4
Sugar cane	3.6
Potato	2.7
Tobacco	2.0
Oilseeds	2.0
Tea	1.7
Pulses	1.2
Onion	0.2
Cauliflower	0.2
Cabbage	0.1

Total value of crops listed 113,147 million Tk.

Source: Navin, R. E. and Khalil, I. (1988)

Where price data were not available for some crops, prices were estimated from those given for similar crops. The relative values of crops are given in Table 4. Further details of the method of calculation are given in Appendix 3.

Table 4

Pakistan – relative importance of crops as a percentage of valve of zonal crop production

Crop	%	Crop	%	Crop	%
Zone A		**Zone B1**		**Zone B2**	
Wheat	24	Wheat	35	Sugar cane	26
Rice	21	Cotton	23	Wheat	16
Cotton	18	Rice	11	Maize	16
Sugar cane	15	Sugar cane	8	Tobacco	16
Chilli	5	Other vegetables†	6	Other fruit	12
Other vegetables†	3	Citrus	4	(mostly pear and plum)	
Mango	3	Chickpea	3	Other vegetables†	6
Onion	3	Potato	2	Garlic	3
Date	2	Other fruits	2	Potato	2
Banana	2	Maize	2	Citrus	1
Rape/mustard	1	Rape/mustard	1	Barley	1
Sorghum	1	Onion	1	Sugarbeet	1
Lathyrus	1	Black gram, green gram,			
Sorghum	1	lentil	1		
		Mango	1		
Total value*		Total value*		Total value*	
19,107 million rupees		61,930 million rupees		3365 million rupees	

Crop	%	Crop	%
Zone C		**Zone D**	
Wheat	43	Maize	24
Chickpea	13	Wheat	19
Sorghum	8	Apple	12
Other vegetables†	8	Other fruit (mostly apricot, plum and	
Pearl millet	6	persimmon)	12
Groundnut	6	Rice	10
Maize	5	Other vegetables†	6
Fruit (citrus etc)	3	Potato	5
Rape/mustard	2	Onion	2
Black gram	2	Tobacco	2
Sugar cane	2	Sugar cane	2
Rice	2	Barley	1
Green gram	1	Rape/mustard	1
Cotton	1	Green gram	1
		Black gram	1
		Citrus	1
Total value*		Total value*	
6093 million rupees		3347 million rupees	
Zone E		**Zone F**	
Apple	19	Date	66
Tomato and vegetables†	19	Wheat	17
Almond	12	Onion	6
Sorghum	8	Castor	5
Wheat	8	Sorghum	2
Apricot	6	Mango	1
Grape	4	Rice	1
Onion	4	Potato	1
Maize	4	Citrus	1
Potato	4		
Cumin	2		
Pomegranate	2		
Plum	2		
Chilli	2		
Peach	1		
Barley	1		
Total value*		Total value*	
5044 million rupees		633 million rupees	

*Calculated as a percentage of the total value of the crops listed. Crops with production values of less than 1% of the zone total were omitted. See text for basis of calculations.

†Based on the production statistics for 'vegetables excluding potato and sugarbeet'. These statistics are assumed to exclude onion, garlic and chillies as well on the grounds that they are treated as spices. If this assumption is incorrect the value for 'other vegetables' in this table will be too high.

Section 4

Methodology for assessing relative importance

CONSULTATION WITH EXPERTS IN SOUTH ASIA

A total of seven weeks was spent visiting the countries studied. The study in Nepal was conducted by Mr Iles, whilst Mr Geddes covered the remaining countries.

Before embarking on the study tour, appropriate institutions were contacted to inform them of the study and to arrange the programme of visits. During the tour discussions were held with as many well-informed and experienced people as possible to elicit their estimates of the relative importance of pests in each zone. They were reminded of the climatic conditions of the zone and informed of the relative importance of crops on the basis of production values in each zone. Discussions were particularly useful with panels of three or more specialists in different disciplines who could make estimates across all crops and for all pests considered together.

These estimates were cross-checked with the rankings given by experts in different disciplines who could rank, for example, insects across all crops in a zone (or zones), and those given by crop experts who could rank all pests attacking a single crop. Some respondents had an even narrower focus, giving, for instance, a ranking of pathogens on one crop. In India, Sri Lanka and Bangladesh, respondents included small panels from the national plant protection services which have pest monitoring, advisory and control roles. All other respondents were from the agricultural research services.* Respondents only gave estimates for their own countries.

In India, the tour was confined to New Delhi and Hyderabad, visiting institutions with responsibilities across the whole country. The full statistics on the relative importance of crops by zone (Table 1) were not available at that stage, but tables showing crop percentage of the zonal production value for nine major crops† were shown, with the other important crops in the zone listed.

In Sri Lanka, central institutes were visited in Peradeniya, and two important single crop institutes, those for tea and coconuts, were also visited.

In Bangladesh, which was treated as one zone, visits were made to the Bangladesh Agricultural Research Institute, the Bangladesh Rice Research Institute and organizations in Dhaka. Most attention was given to rice which accounts for about 75% of the value of crop production.

A particularly full coverage was achieved in Pakistan with visits to North West Frontier Province and the Punjab and discussions were held with representatives from Sind and Baluchistan provinces and the Cotton Research Station, Multan. It was possible to make a synthesis of all the information collected and discuss the final rankings with a panel of 16 specialists from the Pakistan Agricultural Research Council and the National Agricultural Research Centre.

The institutions visited and the persons consulted are given in Appendix 1.

*Except for one member of the Punjab Department of Plant Protection at the final session reviewing pest rankings in Pakistan on 17 February 1990.
†Rice, wheat, maize, pearl millet, sorghum, cotton, sugar cane, oilseeds and pulses.

SEMINAR AND POSTAL INQUIRIES

After an initial analysis of data and production of pest ranking tables from a synthesis of respondents' estimates, a seminar was held in the Natural Resources Institute (NRI) attended by about 20 staff from relevant disciplines. The results were presented and discussed.

Pest ranking tables were then despatched to the respondents visited in South Asia for their opinions. Some respondents whose focus of work was judged too specialized to take a broad enough view of the synthesis were omitted.

These tables were also sent for revision and comment to six more institutes in India which had not been visited (Appendix 1). These institutes covered cotton, sugar cane, horticultural crops and rice. The Research Association at Jorhat, Assam, was asked to rank tea pests in Zone 2.

The analysis of the relative importance of rice pests in India across all zones had demonstrated that there was a considerable difference of opinion between different respondents. A comprehensive table was prepared comparing the rankings made by all six sets of respondents on rice pests and they were asked to comment and revise their rankings if they thought fit in the light of this comparison.

A few other minor queries mostly arising from the seminar, were also made by post.

When making the final pest ranking consideration was given to the comments made at the seminar, the discussions it generated and the replies to the postal inquiries.

LITERATURE STUDY

Some literature relevant to the study is listed in Appendix 3. Most of this was collected during the study tour. Reference was made to a few publications to provide additional evidence of pest importance, particularly when respondents differed widely in their ranking estimates. Publications such as the *Handbook of Agriculture* (ICAR, 1987) were useful in identifying pests recorded by their English or Indian name. However, the rankings depended heavily on the estimates made by respondents rather than the literature.

During the preparatory stage before the tour a number of publications and sets of maps were studied to get broad information on the cropping systems and geography of the area as a guide to zoning. For India, Saxena (1989) was particularly useful.

LIMITATIONS OF STUDY

Too little information was gathered on post-harvest pests for them to be included. The treatment of vertebrate pests and weeds varies from one country to another. Birds, rodents and wild boars are omitted from India (apart from a mention in Zone 14) and birds are omitted from Sri Lanka. Weed species were included in the rankings for Sri Lanka. The main weeds in the other countries are listed by crop and zone but not ranked.

The following summarizes the coverage of pre-harvest pests:

Pests included in the rankings

	India	Sri Lanka	Bangladesh	Pakistan	Nepal
Arthropods	★	★	★	★	★
Pathogens	★	★	★	★	★
Nematodes	★	★	★	★	★
Rodents and pigs		★	★	★	★
Birds			★	★	★
Weeds		★			

Pests listed but not ranked

	India	Sri Lanka	Bangladesh	Pakistan	Nepal
Weeds	★		★	★	★

Crops for which there were more specialist respondents received more comprehensive coverage and so tended to have more pests listed. In India, this applied to rice and the crops studied at ICRISAT – sorghum, pearl millet, groundnut, chickpea and pigeon pea. On the other hand, sugar cane was not covered by sugar cane specialists and some sugar cane pests may have been omitted. However, it is unlikely that the most important pests will have been overlooked, and all pests mentioned should still be ranked correctly in relation to each other.

Section 5

The cropping systems in India

RAINFALL

Figure 5 shows the annual rainfall for South Asia. Rain falls in two monsoon seasons. The summer, or southwest monsoon, is the main rainy season in most areas; it starts in June and lasts for about four months. It brings moderate to high rainfall to the southwest coast, eastern and central India and the northern plains and hills. The winter, or northeast monsoon, starts during September through to December, starting later moving from northwest to southeast. It brings moderate rain to southern and eastern India and parts of the north-western hills. It is particularly important for south-eastern and south-central India (Zones 10 and 11); for parts of these zones it brings more rainfall than the summer monsoon.

IRRIGATION

About 30% of the cropped area in India is irrigated. Table 5 shows the different irrigation situations in 1980-81 in terms of percentage of holdings.

Table 5

India: number of holdings by irrigation category as a percentage of all holdings (1980-81)

Wholly irrigated	23
Partially irrigated	23
Wholly unirrigated	54

Source: Directorate of Economics and Statistics, Ministry of Agriculture (1989)

Irrigation is most important in Zones 2, 3, 4, 5, 6, 11 and the southern part of Zone 10 (in Tamil Nadu). Irrigation water is supplied from canal systems, open wells and tubewells, and dams (known as tanks).

TOPOGRAPHY

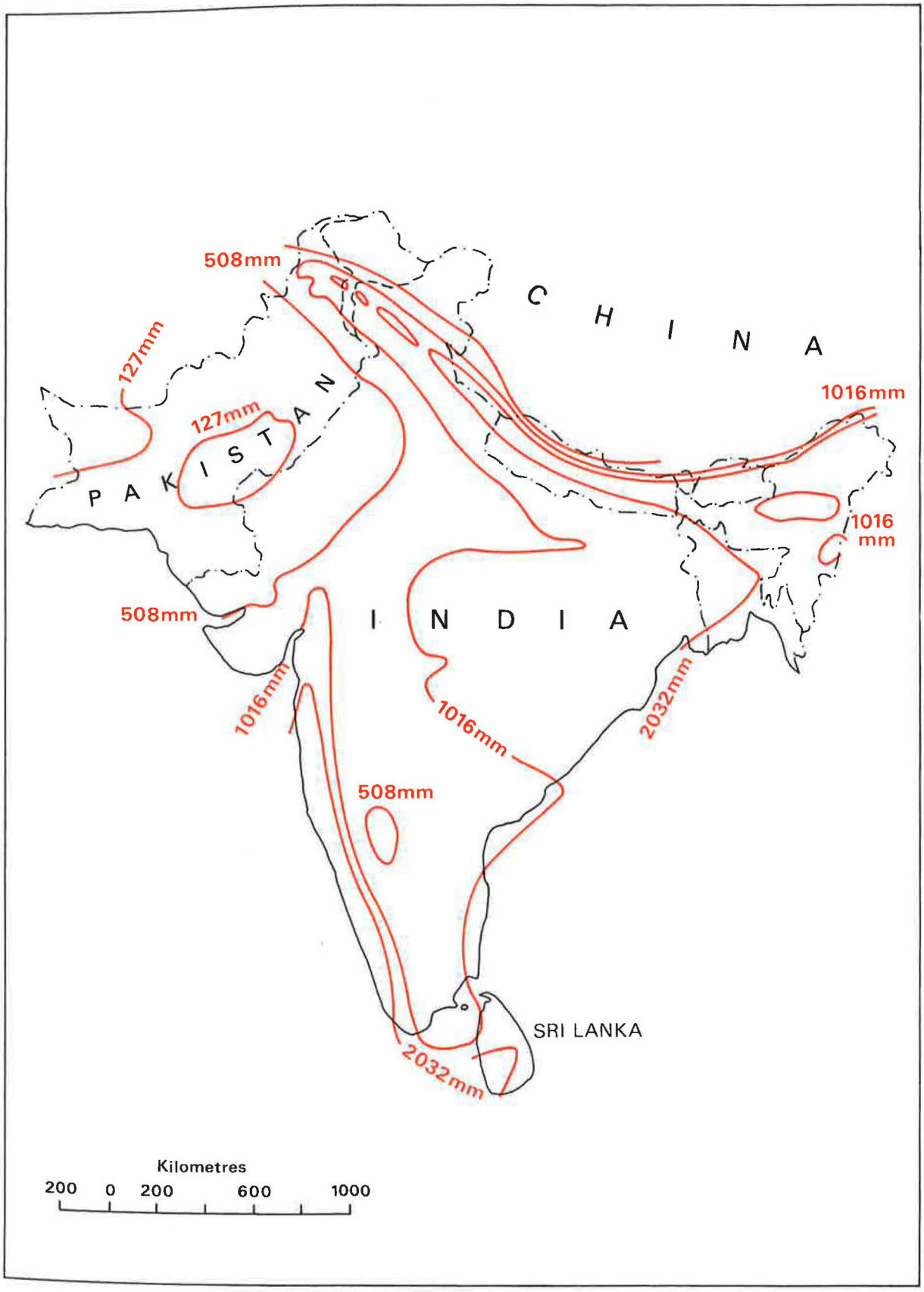
Zones 3-6, 11, 13 and 14 are plains, with an elevation of less than 300 m. Zones 3-6 comprise the northern plains. The Ganges and other rivers rising in the Himalayas flow through them and provide a reliable source of irrigation water. Bangladesh and the Brahmaptura valley in Zone 2 form part of the same system of plains and rivers.

There are coastal plains in Zones 11 and 12, but those in Zone 11 along the east coast are much wider. All these plains areas, except Zones 13 and 14, have rainfall above 1000 mm or are relatively well supplied with irrigation facilities.

Zones 7-10 and all but the narrow coastal plains of Zone 12 comprise an area of plateaux, hills and valleys, with an elevation for the most part of

Figure 5

South Asia annual rainfall



SOURCE: Butt A. K. and Geib M. M. (1987) Atlas of South Asia. Westview Press.

300-1000 m. The Western Ghats along the border area of Zones 10 and 12, and the southern part of Zone 10, are higher, with hills of 1000-2000 m.

Zone 14, a dry area with less than 500 mm of rain and few irrigation facilities, has an elevation of 200–300 m.

Zone 1 is an area of steep-sloped hills, rising to mountains too high for cultivation which occupy most of the northern part of the zone. Narrow irrigated valleys wind up into the hills, with a broader inner valley formed by the Vale of Kashmir. Most of the mountainous area of Zone 2 is below 3000 m.

CROPPING SYSTEMS BY ZONES

The relative importance of crops in each zone is given in Table 1.

Zone 1

In Zone 1, maize, apple and other temperate fruits, potato and other vegetables are the main crops cultivated in the higher areas. Rice and wheat are grown in the valleys, mainly under irrigation.

Zone 2

The mountains of Zone 2 have a much higher rainfall than Zone 1 and temperature at the same altitude is somewhat higher in winter. Shifting cultivation is a common practice, with rice the main crop in most areas. Maize is the principal crop in Sikkim. This zone is the major tea growing area in India; it is grown mostly in Assam and in the Darjeeling hills. Rice, jute and tea are principal crops of the plains.

Zones 3-6

Zones 3-6 have alluvial soils. Zone 3 has climatic and topographic characteristics similar to those of the plains of Zone 2 and to Bangladesh. Rice and jute are the main crops.

In Zones 4, 5 and 6 rice and wheat are the dominant crops. Wheat is grown in winter and its production increases as rainfall and winter temperature decrease moving northwest from Zone 4 to Zone 6. Most wheat cultivation is irrigated, particularly in Zone 6. Rice is most important in Zone 4, but its production has been increasing rapidly in Zone 6. Only about 33% of the rice crop is irrigated in Zones 4 and 5, whereas virtually all the rice in Zone 6 is irrigated. Zone 5 is a major sugar cane production area.

Potato and mango are important secondary crops in Zones 3, 4 and 5 and chickpea is an important secondary crop in Zones 4, 5 and 6.

The mean size of holding is much larger in Zone 6 (3.5 ha in 1980-81) than in Zones 3, 4 and 5 (1 ha in 1980-81). Zone 6 is the most agriculturally advanced in India, with high levels of inputs, tractor use and yield. Farmers are poorest in Zone 4; their input levels are low, irrigation facilities are underdeveloped and there are problems of flooding.

Zone 7

Zone 7 has a good annual rainfall of 1000-2000 mm and some irrigation facilities, notably the Mahanandi valley dam and canal system. The soils are mostly red and yellow (in the northwest) or red. About 70% of the zone's production value is accounted for by rice, the greatest concentration of rice of any zone in India. Pulses, oilseeds and millets are secondary crops, the former being grown mostly in the winter season.

Zone 8

Zone 8 has an annual rainfall of 500-1000 mm, increasing from northwest to southeast. Most of the soil in the southeast is black but soils vary in other parts of the zone. Wheat and chickpea are the main crops cultivated. Various oilseeds and other crops are also grown (Table 1). Farm size is large (a mean of about 4 ha in 1980-81) but about 75-80% of the area is rainfed and input use and yields are low.

Zones 9 and 10

Rainfall over most of Zones 9 and 10 is between 500 and 1000 mm annually. About 80% of the cropped area is rainfed. The soil in Zone 9 and the northwest of Zone 10 is black; in the rest of Zone 10 it is mostly red. Sorghum, sugar cane, cotton and groundnut are amongst the six most important crops in both zones (Table 1). Pigeon pea and chickpea are important secondary crops in Zone 9, with wheat grown in the northern part in the winter. Rice and groundnut are the most important crops in Zone 10, although this zone has a wide range of crops. In the south these include spices and plantation crops, such as turmeric and tea. Fruit crops are important in both zones, particularly citrus, grape and mango.

Zone 11

Zone 11, the east coast plains, has an annual rainfall of 780-1300 mm. The southern part of the zone depends more on the northeast monsoon, with October and November being the wettest months. There are several river deltas and other areas where over 50% of the crop area is irrigated. Soils are fertile but there are problems of flooding and drainage. Coastal soils are alluvial, further inland they are mainly red. Rice is the major crop (Table 1); Zone 11 is the largest rice producer in India. Groundnut and sugar cane are the leading secondary crops.

Zone 12

Zone 12 has a high annual rainfall of over 2000 mm over most of the zone. Inland of the coastal plain the land rises to the Western Ghats with elevations of over 2000 m. Rice is the main food crop (Table 1). Most of the other crops are plantation crops and spices. The mean farm size (0.4 ha in 1980-81) is the smallest of any zone.

Zone 13

Zone 13 is almost identical to Gujarat State. Rainfall increases from below 400 mm in the northwest to about 1000 mm in the southeast. About 23% of the area is irrigated, largely through open wells and tubewells. Cotton is the main crop (Table 1), but groundnut and a range of other crops are also important. The average holding is quite large (3.5 ha in 1980-81) and most of the cultivation is done by tractor.

Zone 14

Zone 14 is the driest in India with an annual rainfall below 500 mm and with desert conditions along the Pakistan border. The rainfall is also unreliable. There is very little irrigation and soil is of the desert type. Pearl millet is the main summer crop and chickpea and wheat the main winter crops. Guar and moth bean are also grown in the summer and rape/mustard in the winter. Ber or zizyphus (a fruit), date palm, pomegranate and plantago (medicinal husk) are also grown. The average holding is large (4.4 ha in 1980-81) and there is considerable use of tractors.

Zone 15

Zone 15 comprises the Andaman, Nicobar and Lakshadweep islands. They have an annual rainfall of about 3000 mm distributed over eight or nine months. Their principal crops are rice and coconuts.

Section 6

Pest ranking in India

Non-weed pests are ranked by zone in Tables 6 to 20. Comparison with Table 1 shows the heavy influence of relative importance of crops on the relative importance of pests. A further analysis of the relative importance in India as a whole of the pests of the two most important crops, rice and wheat, is given in Sections 15 and 16.

Table 21 gives the major weeds in each zone and the crops they affect. In general there is no attempt to rank the weeds, although this is done for weeds of wheat in Zones 1, 13 and 14 and for weeds of pearl millet in Zone 14. Respondents ranking other pests drew attention to *Phalaris minor* as a weed of wheat in Zones 5 and 6, where it is a particularly serious pest. It is clear from the tables that in India as a whole, *Phalaris minor* is the most severe weed problem of wheat and the worst pest of wheat overall, with *Echinochloa* spp., causing the most severe weed problems of rice.

Table 6

Pest ranking in India – Zone 1

Rank	Pest	Crops attacked
1.	Scab (*Venturia inaequalis*)	Apple
2.	Cutworm (*Agrotis* spp.)	Maize, potato
3.	Rice blast (*Pyricularia oryzae*)	Rice
	Turcicum leaf blight (*Setosphaeria turcica*)	Maize
	Late blight (*Phytophthora infestans*)	Potato
4.	Loose smut (*Ustilago nuda*)	Wheat
	Brown rust (*Puccinia recondita*) and yellow rust (*Puccinia striiformis*)	Wheat
	Powdery mildew (*Erysiphe graminis*)	Wheat
	Hill (Complete) bunt (*Tilletia laevis*)	Wheat
	Stalk rot (*Diplodia maydis*)	Maize
	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
	Grain discoloration	Rice
	White-backed planthopper (*Sogatella furcifera*)	Rice
	Rice hispa (*Dicladispa armigera*)	Rice
	Yellow stemborer (*Scirpophaga incertulas*)	Rice
	Powdery mildew (*Erysiphe pisi*)	Pea
	Cabbage butterfly (*Pieris brassicae* or *rapae*)	Cabbage, cauliflower
	San José scale (*Quadraspidiotus perniciosus*)	Apple
5.	Molya disease (*Heterodera avenae* nematode)	Wheat
	Other nematodes as a group:	
	Meloidogyne spp., *Pratylenchus* spp. *Hoplolaimus* spp.	Fruits (Kashmir)
	Meloidogyne hapla, Meloidogyne incognita	Potato (Himachal Pradesh)
	Citrus die-back complex	Citrus
	Mustard aphid (*Lipaphis erysimi*)	Maize
	Curd rot	Seed cauliflower
	Codling moth (*Cydia pomonella*)	Apple (Ladakh)
	Head smut (*Sphacelotheca reiliana*)	Maize

Table 7

Pest ranking in India – Zone 2

Rank	Pest	Crops attacked
1.	Rice blast (*Pyricularia oryzae*)	Rice
	Yellow stemborer (*Scirpophaga incertulas*)	Rice
	Ufra disease (*Ditylenchus angustus* nematode)	Rice
	Root-knot nematode (*Meloidogyne incognita*)	Tea, jute, vegetables, ginger
	Rice hispa (*Dicladispa armigera*)	Rice
2.	Foot rot (*Fusarium* spp.)	Rice
	Cutworm and armyworm (*Agrotis* spp., *Mythimna* spp., *Spodoptera* spp.)	Rice
	Sucking insects of tea as a group:	
	tea mosquito (*Helopeltis theivora*)	Low grown tea
	tea jassid (*Amrasca flavescens*)	Low and high grown tea
	tea thrips (*Scirtothrips dorsalis*)	Low and high grown tea
	Leaf disease of tea as a group:	
	black rot (*Corticium invisum, Corticium theae*)	Low grown tea
	blister blight (*Exobasidium vexans*)	Low and high grown tea
	brown blight (*Colletotrichum camelliae*)	Low grown tea
	grey blight (*Pestalotiopsis theae*)	Low grown tea
3.	Jute apion (*Apion corchori*)	Jute
	Citrus nematode (*Tylenchulus semipenetrans*) and citrus decline complex	Citrus
	Root diseases of tea as a group:	
	charcoal stump rot (*Vistilina zonata*)	Tea
	brown root rot (*Fomes lamaoensis*)	Low grown tea
	black root rot (*Rosellina arcuata*)	Low and high grown tea
	red rot (*Poria hyoplateritia*)	Low grown tea
	purple root rot (*Helicobasidium compatrum*)	Low grown tea
	honey fungus (*Armillaria mellea*)	High grown tea
	violet root rot (*Sphaerostilbe repens*)	Low grown tea
	Leaf defoliators of tea as a group:	
	looper caterpillar (*Buzura suppressaria*)	Low grown tea
	red slug caterpillar (*Eterusia magnifica*)	Low grown tea
	bunch caterpillar (*Andraca bipunctata*)	Tea
	flush worm (*Laspeyresia leucostoma*)	High grown tea
	Tea mites as a group:	
	red spider mite (*Lygonychus coffeae*)	Low grown tea
	scarlet mite (*Brevipalpus phoenicis*)	Low and high grown tea
	purple mite (*Calacarus carinatus*)	Tea
	pink mite (*Acaphylla theae*)	Tea
	Tea termites as a group:	Tea
	Microcerotermes sp.	
	Odontotermes sp.	
	Red rust (*Cephaleuros parasiticus*)	Low grown tea
4.	Mustard aphid (*Lipaphis erysimi*)	Rape/mustard
	Root nematode (*Hirschmanniella oryzae*)	Rice
	Branch cankers as a group:	
	Poria bypobrunnea	Low grown tea
	Tunstallia aculeata	High grown tea
	Agloaspor aculeata	High grown tea
	Root lesion nematode (*Pratylenchus brachyurus*)	Tea
	Scale (*Eriochiton theae*)	High grown tea
5.	*Pratylenchus indicus* nematode	Rice (upland)
	Ginger soft rot (*Pythium aphanidermatum*)	Ginger
	Root-knot nematode (*Meloidogyne graminicola*)	Rice (nursery; irrigated at higher elevation)
	Wart (*Synchytrium endobioticum*)	Potato
	Chirke mosaic streak virus	Cardamom
	Foorkey virus	Cardamom
	Cockchafer grub (*Holotrichia impressa*)	Low grown tea
	Tea red borer (*Zeuzera coffeae*)	Low grown tea
	Large faggot worm (*Clania crameru*)	Low grown tea
	Nettle grub (*Parasa pastoralis*)	Low grown tea
	Thread blight	Low grown tea

Table 8

Pest ranking in India – Zone 3

Rank	Pest	Crops attacked
1.	Rice hispa (*Dicladispa armigera*)	Rice
	Rice blast (*Pyricularia oryzae*)	Rice
	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
	Yellow stemborer (*Scirpophaga incertulas*)	Rice
2.	Brown planthopper (*Nilaparvata lugens*)	Rice
	Green leafhopper (*Nephotettix spp.*), tungro virus, and sheath rot (*Sarocladium oryzae*) as a group	Rice
	Jute apion (*Apion corchori*)	Jute
	Semi-looper (*Anomis sabulifera*)	Jute
3.	Ufra disease (*Ditylenchus angustus* nematode)	Rice
	Root nematode (*Hirschmanniella oryzae*)	Rice
	Root-knot nematode (*Meloidogyne incognita*)	Jute, vegetables
4.	Root lesion nematode (*Pratylenchus indicus*)	Rice (upland)
	Root-knot nematode (*Meloidogyne graminicola*)	Rice
	Foliar blight (*Drechslera* spp., *Septoria* spp.)	Wheat
	Wart (*Synchytrium endobioticum*)	Potato (West Bengal hills)
	Late blight (*Phytophthora infestans*)	Potato
	Mango malformation (*Fusarium moniliforme*)	Mango
	Mango leafhopper (*Idioscopus* spp., *Amritodus* spp.)	Mango
5.	Mango mealybug (*Drosicha mangiferae*)	Mango
	Mango borer (*Batocera rubus, Batocera rufomaculata*)	Mango
	Brown rust (*Puccinia recondita*)	Wheat
	Mustard aphid (*Lipaphis erysimi*)	Rape/mustard
	White rust (*Albugo candida*)	Rape/mustard

Table 9

Pest ranking in India – Zone 4

Rank	Pest	Crops attacked
1.	Gundhi bug (Rice bug) (*Leptocorisa* sp.)	Rice
	Yellow stemborer (*Scirpophaga incertulas*)	Rice
	Rice blast (*Pyricularia oryzae*)	Rice
	Green leafhopper (*Nephotettix* spp.) and tungro virus (together)	Rice
	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
2.	Brown leaf spot (*Cochliobolus miyabeanus*)	Rice
	False smut (*Ustilaginoidea virens*)	Rice
	Brown rust (*Puccinia recondita*)	Wheat
3.	Root-knot nematode (*Meloidogyne incognita*)	Jute, potato, vegetables, pulses, oilseeds
	Leaf blight (*Alternaria triticina*)	Wheat
	Mango malformation (*Fusarium moniliforme?*)	Mango
4.	Root nematode (*Hirschmanniella oryzae*)	Rice
	Bollworm (*Helicoverpa armigera*)	Chickpea, pigeon pea
	Loose smut (*Ustilago nuda*)	Wheat
	Jute apion (*Apion corchori*)	Jute
	Early blight (*Alternaria solani*) and Late blight (*Phytophthora infestans*)	Potato
	Stemborer (various species)	Sugar cane
	Ear cockle (*Anguina triticae* nematode)	Wheat
	Fusarium oxysporum f.sp. *ciceris* wilt and root rot	Chickpea
	Reniform nematode (*Rotylenchulus reniformis*)	Vegetables, pulses, oilseeds
5.	Mustard aphid (*Lipaphis erysimi*)	Rape/mustard
	Grey mould (*Botrytis cinerea*)	Chickpea
	Stunt (Bean leaf roll virus, aphid vector)	Chickpea
	Podborer (*Maruca testulalis*)	Pigeon pea
	Fusarium wilt (*Fusarium udum*)	Pigeon pea
	Sterility mosaic virus	Pigeon pea
	Powdery mildew (*Oidium mangiferae*)	Mango
	Ectoparasitic nematodes	Sugar cane
	Sweet potato weevil (*Cylas formicarius*)	Sweet potato

Table 10

Pest ranking in India – Zone 5

Rank	Pest	Crops attacked
1.	Stemborer (*Chilo* spp., etc)	Sugar cane
2.	Red rot (*Glomerella tucumanensis*)	Sugar cane
	Whitefly (*Neomaskellia bergii, Aleurolobus barodensis*)	Sugar cane
	Sugar cane planthopper (*Pyrilla perpusilla*)	Sugar cane, wheat
	Loose smut (*Ustilago nuda*)	Wheat
	Karnal bunt (*Tilletia indica*)	Wheat
	Brown rust (*Puccinia recondita*)	Wheat
	Mango leafhopper (*Idioscopus* spp., *Amritodus* spp.)	Mango
3.	Brown leafspot (*Cochliobolus miyabeanus*)	Rice
	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
	Mango mealybug (*Drosicha mangiferae*)	Mango
	Mango malformation (*Fusarium moniliforme*)	Mango
4.	Bollworm (*Helicoverpa armigera*)	Chickpea, pigeon pea
	Fusarium wilt (*Fusarium oxysporum* f.sp *cuceris* and root rots)	Chickpea
	Scale (*Melanaspis glomerata, Ceroplastes actiniformis*)	Sugar cane
	Early blight (*Alternaria solani*) and Late blight (*Phytophthora infestans*)	Sugar cane
	False smut (*Ustilaginoidea virens*)	Rice
	White-backed planthopper (*Sogatella furcifera*)	Rice
	Yellow stemborer (*Scirpophaga incertulas*)	Rice
	Reniform nematode (*Rotylenchulus reniformis*)	Vegetables, oilseeds, pulses
	Mustard aphid (*Lipaphis erysimi*)	Rape/mustard
	Termites (various species)	Wheat
	Root-knot nematode (*Meloidogyne incognita*)	Potato, vegetables, oilseeds, pulses
5.	Rice root weevil (*Echinocnemus oryzae*)	Rice
	Root nematode (*Hirschmanniella oryzae*)	Rice
	Tuber moth (*Phthorimaea operculella*)	Potato
	Grey mould (*Botrytis cinerea*)	Chickpea
	Stunt (Bean leaf roll virus)	Chickpea
	Ascochyta blight (*Ascochyta rabiei*)	Chickpea
	Podborer (*Maruca testulalis*)	Pigeon pea
	Fusarium wilt (*Fusarium udum*)	Pigeon pea
	Sterility mosaic virus	Pigeon pea
	Ectoparasitic nematodes	Sugar cane
	Stemborer (*Sesamia inferens*)	Wheat
	Climbing cutworm (*Mythimna* spp.)	Wheat
	Ear cockle (*Anguina triticae* nematode)	Wheat

Table 11

Pest ranking in India – Zone 6

Rank	Pest	Crops attacked
1.	Loose smut (*Ustilago nuda*)	Wheat
2.	Yellow rust (*Puccinia striiformis*)	Wheat
	Brown rust (*Puccinia recondita*)	Wheat
	Rice blast (*Pyricularia oryzae*)	Rice
3.	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
	Sheath blight (*Corticium sasakii*)	Rice
	White-backed planthopper (*Sogatella furcifera*)	Rice
	Karnal bunt (*Tilletia indica*)	Wheat
	Cotton bollworm (mostly pink) (*Pectinophora gossypiella*)	Cotton
	Jassid (*Amrasca biguttula*)	Cotton
	Stemborer (*Earias insulana*)	Cotton
4.	Yellow stemborer (*Scirpophaga incertulas*)	Rice
	Leaf folder (*Cnaphalocrocis medinalis*)	Rice
	Brown leaf spot (*Cochliobolus miyabeanus*)	Rice
	Sheath rot (*Sarocladium oryzae*)	Rice
	Molya disease (*Heterodera avenae* nematode)	Wheat
	Flag smut (*Urocystis agropyri*)	Wheat
	Termites (various species)	Wheat
	Whitefly (*Bemisia tabaci*)	Cotton
	Black arm (*Xanthomonas campestris* pv. *malvacearum*)	Cotton
	Sugar cane planthopper (*Pyrilla perpusilla*)	Sugar cane
	Stemborer (various species)	Sugar cane
	Bollworm (*Helicoverpa armigera*)	Chickpea
	Fusarium wilt (*Fusarium oxysporum* f. sp. *ciceris*) and root rot	Chickpea
	Grey mould (*Botrytis cinerea*)	Chickpea
	Mustard aphid (*Lipaphis erysimi*)	Rape/mustard
	White rust (*Albugo candida*)	Rape/mustard
	Leaf spot (*Alternaria brassicae*)	Rape/mustard
	Citrus die-back	Sweet orange
	Root-knot nematode (*Meloidogyne incognita*)	Pulses, oilseeds, vegetables
5.	Ascochyta blight (*Ascochyta rabiei*)	Chickpea
	Stunt (Bean leaf roll virus, aphid vector)	Chickpea
	Early blight (*Alternaria solani*) and Late blight (*Phytophthora infestans*)	Potato
	White grub (*Scarabaeidae*)	Groundnut
	Citrus greening disease vectored by psyllid (*Diaphorina citri*)	Sweet orange
	Climbing cutworm (*Mythimna* spp.)	Wheat
	Stemborer (*Sesamia inferens*)	Wheat
	Ear cockle (*Anguina triticae* nematode)	Wheat
	Root nematode (*Hirschmanniella oryzae*)	Rice
	Reniform nematode (*Rotylenchulus reniformis*)	Cotton, pulses, oilseeds
	False smut (*Ustilaginoidea virens*)	Rice

Table 12

Pest ranking in India – Zone 7

Rank	Pest	Crops attacked
1.	Rice blast (*Pyricularia oryzae*)	Rice
	Brown planthopper (*Nilaparvata lugens*)	Rice
	Gall midge (*Orseolia oryzae*)	Rice
2.	Yellow stemborer (*Scirpophaga incertulas*)	Rice
	White-backed planthopper (*Sogatella furcifera*)	Rice
3.	Leaf folder (*Cnaphalocrocis medinalis*)	Rice
4.	Green leafhopper (*Nephotettix* spp.)	Rice
	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
	Seed rot/blight (*Corticium rolfsii*)	Rice
	Gundhi bug (Rice bug) (*Leptocorisa* spp.)	Rice
	Root-knot nematode (*Meloidogyne graminicola*)	Rice
	Root nematode (*Hirschmanniella oryzae*)	Rice
5.	Sheath rot (*Sarocladium oryzae*)	Rice
	White tip nematode (*Aphelenchoides besseyi*)	Rice
	Rice caseworm (*Nymphula depunctalis*)	Rice
	Rice mealybug (*Ripersia oryzae*)	Rice
	Ants (taking away seeds)	Rice (upland)
	Bollworm (*Helicoverpa armigera*)	Chickpea
	Leafminer (*Aproaerema modicella*)	Groundnut
	Rust (*Puccinia arachidis*) and Leaf spot (*Mycosphaerella arachidis, Mycosphaerella berkeleyi*)	Groundnut
	Safflower aphid (*Dactynotus carthami, Microsiphum solidaginis*)	Safflower, linseed
	Sweet potato weevil (*Cylas formicarius*)	Sweet potato
	Root-knot nematode (*Meloidogyne incognita*)	Oilseeds, vegetables, pulses
	Reniform nematode (*Rotylenchulus reniformis*)	Oilseeds, vegetables, pulses

Table 13

Pest ranking in India – Zone 8

Rank	Pest	Crops attacked
1.	Termites (various species)	Wheat
	Brown rust (*Puccinia recondita*)	Wheat
	Bollworm (*Helicoverpa armigera*)	Chickpea
2.	White grub (Scarabaeidae)	Sorghum, pearl millet, groundnut
	Fusarium wilt (*Fusarium oxysporum* f.sp. *ciceris, Fusarium oxysporum* f.sp. *lini*)	Chickpea, linseed
	Foot rot (*Cochliobolus sativus* or *Fusarium* spp.)	Wheat
	Black rust (*Puccinia graminis*)	Wheat
3.	Stemborer (*Sesamia inferens*)	Wheat
	Dry root rot (*Macrophomina phaseolina*)	Chickpea, soyabean
	Root rot (*Macrophomina* spp.)	Soyabean
	Bud rot	Soyabean
	Podborer (*Maruca testulalis*)	Pigeon pea
	Stemborer (*Chilo partellus*)	Sorghum, maize
	Shootfly (*Atherigona soccata*)	Sorghum
	Gall midge (*Orseolia oryzae*)	Rice
	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
	Mustard aphid (*Lipaphis erysimi*)	Rape/mustard
4.	Climbing cutworm (*Mythimna* spp.)	Wheat
	Loose smut (*Ustilago nuda*)	Wheat
	Ear cockle (*Anguina triticae* nematode)	Wheat
	Sheath rot (*Sarocladium oryzae*)	Rice
	Brown leaf spot (*Cochliobolus miyabeanus*)	Rice
	Stunt (Bean leaf roll virus, aphid vector)	Chickpea
	White rust (*Albugo candida*)	Rape/mustard
	Leaf spot (*Alternaria* sp.)	Rape/mustard
	Girdle beetle (Cerambycidae? Buprestidae?)	Soyabean
	Yellow mosaic virus	Soyabean, *Vigna* spp., horsegram
	Smut	Pearl millet
	Sorghum midge (*Contarinia sorghicola*)	Sorghum
	Earhead bug (*Calocoris angustatus*)	Sorghum
	Smut (*Sphacelotheca* spp.?)	Sorghum
	Anthracnose (*Colletotrichum graminicola*)	Sorghum
	Hairy caterpillar (*Amsacta moori, Spilosoma obliqua*)	Maize
	Stemborer (*Sesamia inferens*)	Maize
	Turcicum leaf blight (*Setosphaeria turcica*)	Maize
	Root-knot nematode (*Meloidogyne incognita*)	Pulses, oilseeds
	Reniform nematode (*Rotylenchulus reniformis*)	Pulses, oilseeds
5.	Safflower aphid (*Dactynotus carthami, Microsiphum solidaginis*)	Safflower
	Rust (*Puccinia arachidis*) and Leaf spot (*Mycosphaerella arachidis*)	Groundnut
	Downy mildew (*Sclerospora graminicola*)	Pearl millet
	Ergot (*Claviceps fusiformis*)	Pearl millet
	Rust (*Puccinia lini*)	Linseed

Table 14

Pest ranking in India – Zone 9

Rank	Pest	Crops attacked
1.	Grain mould (several fungi involved)	Sorghum
	Sorghum midge (*Contarinia sorghicola*)	Sorghum
	Stemborer (various species)	Sugar cane
	Whitefly (*Bemisia tabaci*)	Cotton
	Jassid (*Amrasca biguttula*)	Cotton
	Bollworm (*Pectinophora gossypiella, Earias* spp.)	Cotton
	Citrus blackfly (*Aleurocanthus woglumi*) and Citrus whitefly (*Dialeurodes citri*) as a group	Citrus
	Citrus decline	Citrus
2.	Shootfly (*Atherigona soccata*)	Sorghum
	Sugar cane planthopper (*Pyrilla perpusilla*)	Sugar cane
	Downy and powdery mildews	Grape
	Root-knot nematode (*Meloidogyne* spp.)	Grape, vegetables
	Fusarium wilt (*Fusarium oxysporum* f.sp. *ciceris, Fusarium oxysporum* f.sp. *vasinfectum*)	Chickpea, cotton
	Bollworm (*Helicoverpa armigera*)	Chickpea, pigeon pea
3.	Stemborer (*Chilo partellus*)	Sorghum
	Shootbug (*Peregrinus maidis*)	Sorghum
	Ergot (*Sphacelia sorghi*)	Sorghum
	Downy mildew (*Sclerospora sorghi*)	Sorghum
	Earhead bug (*Calocoris angustatus*)	Sorghum
	Leaf blight (*Alternaria triticina*)	Wheat
	Brown rust (*Puccinia recondita*)	Wheat
	Black rust (*Puccinia graminis*)	Wheat
	White grub (Scarabaeidae)	Sorghum, pearl millet, groundnut
	Late leaf spot (*Phaeoisariopsis personata*) and rust (*Puccinia arachidis*)	Groundnut
	Termites (various species)	Wheat, pearl millet
4.	Root rot (*Macrophomina phaseolina*) and stalk rot (*Colletotrichum graminicola*)	Sorghum (rabi crop)
	Sorghum aphid	Sorghum
	Whitefly (*Aleurolobus barodensis*)	Sugar cane
	Scale (*Melanaspis glomerata, Ceroplastes actiniformis*)	Sugar cane
	Root rot (*Fusarium* spp., *Cochliobolus sativus*)	Wheat
	Mango malformation	Mango
	Mango leafhopper (*Idioscopus* spp., *Amritodus* spp.)	Mango
	Mango mealybug (*Drosicha mangiferae*)	Mango
	Tobacco caterpillar (*Spodoptera litura*)	Groundnut
	Bugs (various species)	Pigeon pea
	Podborer (*Maruca testulalis*)	Pigeon pea
	Fusarium wilt (*Fusarium udum*)	Pigeon pea
	Dry root rot (*Macrophomina phaseolina*)	Chickpea
5.	Rust (*Puccinia sorghi*)	Sorghum
	Smut (*Sphacelotheca* or *Tolyposporium* spp.)	Sorghum
	Safflower aphid (*Dactynotus carthami, Microsiphum solidaginis*)	Safflower
	Rust (*Puccinia helianthi*)	Safflower, sunflower
	Leaf spot (*Alternaria helianthi*)	Safflower, sunflower
	Stemborer (*Scirpophaga incertulas*)	Rice
	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
	Leaf miner (*Aproaerema modicella*)	Groundnut
	Tomato spotted wilt virus (vector *Thrips*)	Groundnut, tomato, legumes
	Downy mildew (*Sclerospora graminicola*)	Pearl millet
	Fusarium wilt (*Fusarium oxysporum* f.sp. *ciceris*)	Chickpea
	Collar rot (*Corticium rolfsi*)	Chickpea
	Podfly (*Ophiomyia phaseoli*)	Pigeon pea
	Bunchy top virus Banana aphid (*Pentalonia nigronervosa* vector)	Banana
	Red rot (*Glomerella tucumanensis*)	Sugar cane
	Rust (*Puccinia melancophala*)	Sugar cane
	Mealybug (*Planococcus citri*)	Citrus, grape
	Citrus nematode (*Tylenchulus semipenetrans*)	Citrus
	Ectoparasitic nematodes	Sugar cane
	Reniform nematode (*Rotylenchulus reniformis*)	Pulses, vegetables, cotton
	Cyst nematode (*Heterodera cajani*)	Pigeon pea

Table 15

Pest ranking in India – Zone 10

Rank	Pest	Crops attacked
1.	Yellow stemborer (*Scirpophaga incertulas*)	Rice
	Leaf miner (*Aproaerema modicella*)	Groundnut
2.	Rice blast (*Pyricularia oryzae*)	Rice
	Gall midge (*Orseolia oryzae*)	Rice
	Late leaf spot (*Mycosphaerella berkeleyi*) and rust (*Puccinia arachidis*)	Groundnut
	Hairy caterpillar (*Amsacta* spp.?, *Spilosoma obliqua*?)	Groundnut
	Sorghum midge (*Contarinia sorghicola*)	Sorghum
3.	Leaf folder (*Cnaphalocrocis medinalis*)	Rice
	Brown planthopper (*Nilaparvata lugens*)	Rice
	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
	Smut (*Ustilago scitaminea*)	Sugar cane
	Grain mould (several fungi involved)	Sorghum
	Shootfly (*Atherigona soccata*)	Sorghum
	Earhead bug (*Calocoris angustatus*)	Sorghum
	White grub (Scarabaeidae)	Groundnut
	Root-knot nematode (*Meloidogyne incognita*)	Vegetables, potato, chilli, cotton, tobacco
4.	Rice caseworm (*Nymphula depunctalis*)	Rice
	Sheath rot (*Sarocladium oryzae*)	Rice
	Rice root nematode (*Hirschmanniella oryzae*)	Rice
	White tip nematode (*Aphelenchoides besseyi*)	Rice
	Potato cyst nematode (*Heterodera rostochiensis*)	Potato (Nilgri hills)
	Bollworm (*Helicoverpa armigera*)	Pulses, cotton
	Bollworm (*Earias, Pectinophora*)	Cotton
	Whitefly (*Bemisia tabaci*)	Cotton
	Stemborer (various species)	Sugar cane
	Citrus decline	Mandarin
	Mango stone weevil (*Sternochetus mangiferae*), fruit fly (*Bactrocera* spp.)	Mango
	Mildew (*Uncinula necator, Plasmopara viticola*)	Grape
	Rhinoceros beetle (*Oryctes rhinoceros*)	Coconut
	Ganoderma wilt (root rot) (*Ganoderma* spp.)	Coconut
	Black-headed caterpillar (*Opisina arenosella*)	Coconut
	Scale (*Coccus* spp.)	Citrus, coffee, guava
	Stemborer (*Chilo partellus*)	Sorghum
	Ergot (*Sphacelia sorghi*)	Sorghum
	Downy mildew (*Sclerospora sorghi*)	Sorghum
	Tomato spotted wilt virus (*Thrips* (*Scirtothrips dorsalis* vector))	Groundnut, tomato, legumes
	Reniform nematode (*Rotylenchulus reniformis*)	Cotton, tobacco, turmeric, vegetables
	Rot (*Pythium* spp.)	Turmeric, ginger
5.	Late blight (*Phytophthora infestans*)	Potato
	Tobacco caterpillar (*Spodoptera litura*)	Tobacco
	Root-knot nematode (*Meloidogyne javanica*)	Tobacco
	Jassid (*Amrasca biguttula*) and cotton aphid (*Aphis gossypii*)	Cotton
	Mealybug (*Planococcus citri*)	Coffee
	Coffee rust (*Hemileia vastatrix*)	Coffee
	Stemborer (various species)	Coffee
	Tea mosquito (*Helopeltis theivora*)	Tea
	Blister blight (*Exobasidium vexans*)	Tea
	Bunchy top (Banana aphid (*Pentalonia nigronervosa* vector)	Banana
	Scale (*Melanaspis glomerata, Ceroplastes actiniformis*)	Sugar cane
	Red rot (*Glomerella tucumanensis*)	Sugar cane
	Smut (*Ustilago scitaminea*)	Sugar cane
	Wilt/little leaf	Brinjal
	Yellow vein	Okra
	Root rot (*Colletotrichum* spp.)	Chilli
	Blast (*Pyricularia setariae*)	Finger millet
	Bacterial canker (*Xanthomonas campestris* pv. *citri*)	Mandarin
	Citrus nematode (*Tylenchulus semipenetrans*)	Mandarin
	Aphid (*Aphis craccivora*)	Groundnut
	Shootbug (*Peregrinus maidis*)	Sorghum
	Root and stalk rots (various species)	Sorghum
	Rust (*Puccinia sorghi*)	Sorghum
	Smut (*Sphacelotheca* spp.)	Sorghum
	Sterility mosaic virus	Pigeon pea
	Yellow mosaic virus	Legumes (*Vigna* spp.) horsegram

Table 15 (continued)

Rank	Pest	Crops attacked
	Burrowing nematode (*Radopholus similis*)	Plantation crops, spices
	Rice hispa (*Dicladispa armigera*)	Rice
	Sheath blight (*Corticium sasakii*)	Rice
	Root-knot nematode (*Meloidogyne graminicola*)	Rice
	Cyst nematode (*Heterodera oryzae*)	Rice

Table 16

Pest ranking in India – Zone 11

Rank	Pest	Crops attacked
1.	Rice blast (*Pyricularia oryzae*)	Rice
	Yellow stemborer (*Scirpophaga incertulas*)	Rice
2.	Brown planthopper (*Nilaparvata lugens*)	Rice
	Gall midge (*Orseolia oryzae*)	Rice
	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
3.	Leaf folder (*Cnaphalocrocis medinalis*)	Rice
	Late leaf spot (*Mycosphaerella berkeleyi*) and rust (*Puccinia arachidis*)	Groundnut
	Tobacco caterpillar (*Spodoptera litura*)	Groundnut, cotton, vegetables
	Stemborer (various species)	Sugar cane
4.	Root nematode (*Hirschmanniella oryzae*)	Rice
	Bollworm (*Helicoverpa armigera*)	Groundnut, cotton
	Whitefly (*Bemisia tabaci*)	Cotton, chilli, vegetables
	Jassid (*Amrasca biguttula*) and cotton aphid (*Aphis gossypii*)	Cotton
	Root-knot nematode (*Meloidogyne* spp.)	Cotton, chilli, vegetables
	Whitefly (*Aleurolobus barodensis*)	Sugar cane
5.	Black-headed caterpillar (*Opisina arenosella*)	Coconut
	Bud rot (*Phytophthora palmivora*)	Coconut
	Rhinoceros beetle (*Oryctes rhinoceros*)	Coconut
	Bunchy top (Banana aphid (*Pentalonia nigronervosa* vector))	Banana
	Panama wilt (*Fusarium oxysporum* f.sp. *cubense*)	Banana
	Tea mosquito (*Helopeltis theivora*)	Cashew
	Root and stem borer (*Plocaederus ferrugineus*)	Cashew
	Leaf miner (*Aproaerema modicella*)	Groundnut
	Aphid (*Aphis craccivora*)	Groundnut
	White grub (Scarabaeidae)	Groundnut
	Hairy caterpillar (*Amsacta* spp.?, *Spilosoma obliqua*?)	Groundnut
	Bollworm (*Earias, Pectinophora*)	Cotton
	Reniform nematode (*Rotylenchulus reniformis*)	Cotton, vegetables, turmeric
	Thrips (*Scirtothrips dorsalis*)	Chilli
	Green leafhopper (*Nephotettix* spp.)	Rice
	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
	Ufra disease (*Ditylenchus angustus nematode*)	Rice
	White tip nematode (*Aphelenchoides besseyi*)	Rice
	Sheath blight (*Corticium sasakii*)	Rice
	Root-knot nemtode (*Metoloidogyne graminicola*)	Rice
	Red rot (*Glomerella tucumanensis*)	Sugar cane
	Smut (*Ustilago scitaminea*)	Sugar cane
	Scale (*Melanaspis glomerata, Ceroplastes actiniformis*)	Sugar cane

Table 17

Pest ranking in India – Zone 12

Rank	Pest	Crops attacked
1.	Blast (*Pyricularia oryzae*)	Rice
2.	Yellow stemborer (*Scirpophaga incertulas*)	Rice
	Brown planthopper (*Nilaparvata lugens*)	Rice
	Coffee scale (*Coccus* spp.)	Coffee
	Coffee mealybug (*Planococcus citri*)	Coffee
	Coconut root wilt (kerala wilt?)	Coconut
	Black-headed caterpillar (*Opisina arenosella*)	Coconut
	Burrowing nematode (*Radopholus similis*)	Coconut, arecanut, black pepper, banana, ginger, turmeric
3.	Gall midge (*Orseolia oryzae*)	Rice
	Grassy stunt virus (Brown planthopper *Nilaparvata lugens* vector)	Rice
	Tungro virus (Greenleafhopper *Netphotettix* spp. vector)	Rice
	Cyst nematode (*Heterodera oryzae*)	Rice
	Mosaic virus	Cassava
	Stemborer (various species)	Coffee
	Tea mosquito (*Helopeltis theivora*)	Cashew, tea
	Fruit/bud rot (*Phytophthora palmivora*)	Arecanut, coconut
	Root-knot nematode (*Meloidogyne incognita*)	Spices, vegetables
4.	Sheath blight (*Corticium sasakii*)	Rice
	Sheath rot (*Sarocladium oryzae*)	Rice
	Coffee rust (*Hemileia vastatrix*)	Coffee
	Scale (*Aonidiella orientalis* etc.)	Arecanut
	Root and stemborer (*Plocaederus ferrugineus*)	Cashew
	Thrips (*Scirtothrips cardomoni*)	Cardamom
5.	False smut (*Ustilaginoidea virens*)	Rice
	Root nematode (*Hirschmanniella oryzae*)	Rice
	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
	Pollu beetle (*Longitarsus nigripennis*)	Black pepper
	Quick wilt (*Phytophthora piperis*)	Black pepper
	Stemborer (various species)	Sugar cane
	Tea mite (various species)	Tea
	Cocoa mealybug (*Planococcus citri*)	Cocoa
	Ginger soft rot (*Pythium aphanidermatum*)	Ginger
	Spider mite (*Tetranychus cinnabarinus, Tetranychus neocaledonicus, Eutetranychus orientalis, Oligonychus biharensis*)	Cassava
	Bunchy top (Banana aphid *Pentalonia nigronervosa* vector)	Banana
	Marble mosaic (Katte) disease (Banana aphid *Pentalonia nigronervosa* vector)	Cardamom

Table 18

Pest ranking in India – Zone 13

Rank	Pest	Crops attacked
1.	Bollworm (*Earias, Pectinophora, Helicoverpa*)	Cotton (*H. armigera* also groundnut and pigeon pea)
	Whitefly (*Bemisia tabaci*)	Cotton, tobacco, vegetables
	Jassid (*Amrasca biguttula*)	Cotton, groundnut
2.	Late leaf spot (*Mycosphaerella berkeleyi*) and rust (*Puccinia arachidis*)	Groundnut
	White grub (Scarabaeidae)	Groundnut, pearl millet
3.	Root-knot nematode (*Meloidogyne arenaria*)	Groundnut
	Root-knot nematode *Meloidogyne incognita*)	Tobacco, rape/mustard, pulses
	Reniform nematode (*Rotylenchulus reniformis*)	Cotton
	Stemborer (various species)	Sugar cane
	Downy mildew (*Sclerospora graminicola*)	Pearl millet
	Tobacco caterpillar (*Spodoptera litura*)	Groundnut, tobacco
4.	Black arm (*Xanthomonas campestris* pv. *malvacearum*)	Cotton
	Sugar cane planthopper (*Pyrilla perpusilla*)	Sugar cane
	Whitefly (*Aleurolobus barodensis*)	Sugar cane
	Ergot (*Claviceps fusiformis*)	Pearl millet
	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
	Yellow stemborer (*Scirpophaga incertulas*)	Rice
	Shootfly (*Atherigona soccata*)	Sorghum
5.	Grey mildew (*Ramularia gossypii*)	Cotton
	Root rot	Castor
	Leaf miner (*Aproaerema modicella*)	Groundnut
	Hairy caterpillar (*Amsacta* spp.?, *Spilosoma obliqua*?)	Groundnut
	Bug (various species)	Pigeon pea
	Podborer (*Maruca testulalis*)	Pigeon pea
	Podfly (*Melanagromyza obtusa*)	Pigeon pea
	Sterility mosaic virus	Pigeon pea
	White-backed planthopper (*Sogatella furcifera*)	Rice
	Sorghum midge (*Contarinia sorghicola*)	Sorghum
	Red rot (*Glomerella tucumanensis*)	Sugar cane
	Termites (various species)	Wheat
	Black rust (*Puccinia graminis*)	Wheat
	Brown rust (*Puccinia recondita*)	Wheat
	Mango malformation (*Fusarium moniliforme?*)	Mango
	Mango planthopper (*Idioscopus* spp., *Amritodus* spp.)	Mango

Table 19

Pest ranking in India – Zone 14

Rank	Pest	Crops attacked
1.	Downy mildew (*Sclerospora graminicola*)	Pearl millet
2.	White grub (Scarabaeidae)	Pearl millet
	Ergot (*Claviceps fusiformis*)	Pearl millet
	Molya disease (*Heterodera avenae* nematode)	Wheat
3.	Smut	Pearl millet
	Birds (peacock, parrot, pigeon, crow)	Pearl millet, fruits
	Rodents (*Bandicoot bengalensis, Rattus rattus*)	
	Brown rust (*Puccinia recondita*)	Wheat
	Black rust (*Puccinia graminis*)	Wheat
	Termites (various species)	Wheat
	Bollworm (*Helicoverpa armigera*)	Chickpea
	Ascochyta blight (*Ascohyta rabiei*)	Chickpea
	Fusarium wilt (*Fusarium oxysporum* f.sp. *ciceris*)	Chickpea
4.	Mustard aphid (*Lipaphis erysimi*)	Rape/mustard
5.	Rust (*Puccinia penniseti*)	Pearl millet
	Ear cockle (*Anguina triticae* nematode)	Wheat
	Bats	Fruit
	White rot	Rape/mustard
	Grey mould (*Botrytis cinerea*)	Chickpea
	Fruit fly (*Carpomya vesuviana*)	Zizyphus (fruit)

Table 20

Pest ranking in India – Zone 15

Rank	Pest	Crops attacked
1.	Rhinoceros beetle (*Oryctes rhinoceros*)	Coconut
2.	Black-headed caterpillar (*Opisina arenosella*) Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Coconut Rice
3.	Bacterial wilt (*Pseudomonas solanacearum*) Rice blast (*Pyricularia oryzae*)	Vegetables Rice
4.	Stemborer	Rice
5.	Leaf folder (*Cnaphalocrocis medinalis*)	Rice

Table 21

Major weeds in the cropping system zones of India

Zone	Crops affected	Weeds	Rank
1.	Wheat	*Phalaris minor*	1
		Avena spp.	2
		Lolium temulentum	3
		Chenopodium album	4
	Maize, rice	*Echinochloa crusgalli*	
		Echinochloa colonum	
		Echinochloa glabrescens	
	Maize	*Ageratum conyzoides*	
2.	Rice	*Monochoria vaginalis*	
	Tea	*Imperata cylindrica*	
3.	Rice	*Marsilea quadrifolia*	
		Chara spp.	
		Najas spp.	
4.	Rice	*Echinochloa* spp.	
	Wheat	*Phalaris minor*	
		Anagallis arvensis	
		Melilotus indica	
		Melilotus alba	
	All	*Cyperus rotundus*	
5.	Wheat	*Phalaris minor*	
		Anagallis arvensis	
		Melilotus indica	
		Melilotus alba	
		Chenopodium album	
	Rice	*Echinochloa* spp.	
		Trianthema portulacastrum	
6.	Wheat	*Phalaris minor*	
		Avena fatua	
		Avena ludoviciana	
		Lolium temulentum	
		Chenopodium album	
	Rice	*Echinochloa* spp.	
		Ischaemum rugosum	
7.	Rice, others	*Echinochloa* spp.	
		Panicum spp.	
		Trianthema portulacastrum	
	Niger (oilseed)	*Cascuta sinensis* (parasite)	
8.	General	*Echinochloa* spp.	
		Commelina benghalensis	
		Setaria glauca	
		Cyperus spp.	
		Trianthema portulacastrum	

Table 21 (continued)

Zone	Crops affected	Weeds	Rank
9.	Sorghum, cotton, sugar cane	*Echinochloa colonum*	
		Solanum melongena	
	Sorghum	*Striga* sp. (parasite)	
	Sugar cane	*Sorghum halepense*	
		Cyperus spp.	
	All	*Brachiaria* spp.	
		Phyllanthus spp.	
		Corchorus spp.	
10.	Sorghum, cotton, sugar cane	*Echinochloa colonum*	
		Solanum melongena	
	Rice	*Fimbristylis miliacea*	
		Panicum repens	
		Echinochloa spp.	
		Cyperus spp.	
	Plantation crops	*Oxalis corniculata*	
		Bidens pilosa	
		Mimosa pudica	
		Imperata cylindrica	
	Cotton	*Dactylotenium aegyptiacum*	
		Digitaria ciliaris	
	Vegetables, oilseeds, pulses	*Parthenium hysterophorus*	
11.	Rice	*Echinochloa crusgalli*	
		Cyperus rotundus	
		Marsilea quadrifolia	
		Ludwigia spp.	
	Groundnut	*Eleusine indica*	
		Dactylotenium aegyptiacum	
	Plantation crops	*Cyperus rotundus*	
		Rottboellia cochinensis	
	Sorghum, sunflower, black gram	*Solanum elaeagnifolium*	
12.	Rice	*Echinochloa stagnina*	
		Echinochloa crusgalli	
		Fimbristylis miliacea	
		Cyperus spp.	
		Leptochloa chinensis	
		Salvinia molesta	
	Coffee	*Ageratum conyzoides*	
		Ageratina adenophora	
		Bidens pilosa	
13.	Cotton	*Cyperus rotundus*	
		Celosia argentea	
	Groundnut	*Cyperus rotundus*	
		Corchorus aestuans	
		Eclipta alba	
		Trianthema portulacastrum	
	Wheat	*Phalaris minor*	1
		Avena fatua	2
		Anagallis arvensis	3
	Sorghum, cotton, sugar cane	*Echinochloa colonum*	
		Solanum melongena	
14.	Pearl millet	*Striga asiatica* (parasite)	1
		Cynodon dactylon	2
		Portulaca oleracea	3
	Wheat	*Phalaris minor*	1
		Avena fatua	2
		Melilotus indica	3
		Chenopodium album	4
	Oilseeds	*Dactylotenium aegyptiacum*	
		Eragrostis spp.	
		Eleusine indica	
		Cynodon dactylon	
15.		No information	

Table 22 of the main pests in India has been compiled taking account of the pest ranks, the value of the crop attacked (in the case of rice and wheat) and the total value of the crops in the zone (in the case of the other crops).

Rice pests are divided into first and second ranks. The first ranking rice pests and the weeds are judged to be the six most important pests in India.

Table 22

The main pests in India (excluding vertebrates)

	Pest
Non-weed pests	
Rice	1. Blast (*Pyricularia oryzae*) Yellow stemborer (*Scirpophaga incertulas*) Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*) 2. Brown planthopper (*Nilaparvata lugens*) Root nematode (*Hirschmanniella oryzae*) Gall midge (*Orseolia oryzae*) Green leafhopper (*Nephotettix* spp.) combined with Tungro virus
Wheat	Brown rust (*Puccinia recondita*) Loose smut (*Ustilago nuda*)
Sugar cane	Stemborer (various species) Whitefly (*Aleurolobus barodensis, Neomaskellia bergii*)
Cotton	Bollworm (*Pectinophora gossypiella, Earias* spp., *Helicoverpa armigera* – also on other crops) Jassid (*Amrasca biguttula*) Whitefly (*Bemisia tabaci* – also vector of virus on other crops)
Various crops	Root-knot nematode (*Meloidogyne* spp.)
Weeds	
Rice	*Echinochloa* spp.
Rice and other crops	*Cyperus* spp.
Wheat	*Phalaris minor*

Section 7

The cropping systems in Nepal

The regions of Nepal have been extensively and exhaustively mapped physiographically by the Topographical Survey Branch using satellite, aerial and ground truth data. This gives Nepal one of the most comprehensive sets of agro-ecological zone information for research and planning purposes. Data supplied by the Branch were utilized during this study although the classification was somewhat simplified in order to facilitate pest prioritization by collaborating scientists.

The Branch has divided Nepal into five major physiographic regions running in parallel bands northwest to southeast along the length of the country. For the purposes of this study they have been reduced to three by combining the Tarai with the Siwaliks, and the High Himal with the High Mountains (Figure 2). Although the Siwaliks go up to much higher elevations than the Tarai most of the cultivation in the Siwaliks is along the valley bottom. Most of the High Himal is too high for crops which are not grown above 4200 m. The main features of the physiographic regions are summarized in Table 23.

The composition of the vegetation is influenced by climate which is in turn related to physiographic zone. This is affected by a decrease of monsoon rain going westwards and to some extent by the increasing latitudes from east to west.

Over 90% of the population is engaged in agriculture or related activities. The extreme differences in climate and physiography and the many ethnic groups determine the great variations in land use. Public forests and grazing areas are an important part of the farming system. Increasing human and livestock populations are putting extreme pressure on land. Farmers are frequently forced to turn cultivated land with low fertility into temporary pastures.

Table 23

Characteristics of cropping system zones of Nepal

	Zone A		Zone B	Zone C	
	Tarai	Siwaliks	Middle Mountain	High Mountain	High Himal
Elevation	60-330 m	200-1500 m	800-2400 m. Relief 1500 m with isolated peaks to 2700 m	2200-4000 m. High relief 3000 m from valley floor to ridges	4000 m+
Climate	Subtropical	Subtropical (but warm temperate in higher hill spurs)	Warm temperate (but subtropical in lower river valleys and cool temperate on high ridges)	Warm to cool temperate	Alpine to Arctic (snow 6-12 months)
Moisture regime*	Subhumid in FW+MWDR; humid in W+C and EDR	Subhumid in most of the area; humid in N-aspect of W+C+EDR and Dun valleys	Subhumid; humid above 2000 m N-aspects and 1000 m S-aspects	Subhumid N-aspects; humid throughout the region below 3600 m	
Rainfall intensity	High	High	Medium	Low	Low
Vegetation	Sal+mixed hardwoods	Sal+mixed hardwoods+pine forest	Pine forest+mixed hardwood and oak forest	Fir, pine, birch and rhododendron	Open meadows+tundra vegetation
Soils	Ustochrepts, Haplustolls, Haplaquepts, Haplustalfs, Ustifluvents and Ustorthents	Ustochrepts, Haplustolls, Rhodustalfs, Ustothents, Dystrochrepts, Haplaquepts and Ustifluvents	Ustochrepts, Haplustalfs, Rhodustalfs, Haplumbrepts, Ustorthents and Ustifluvents	Eutrochrepts, Dystrochrepts, Haplumbrepts, Cryumbrepts, Cryorthents and Ustorthents	Cryumbrepts, Cryorthents and Rock
Crops	Rice, maize, wheat, mustard, sugar cane, jute, tobacco, cotton, tea	Rice, maize, wheat, millet, radish, potato, ginger, tea	Rice, maize, wheat, millet, barley, pulses, sugar cane, radish, potato, ginger, cardomom	Oat, barley, wheat, potato, buckwheat, yams, amaranthus, medicinal herbs	Grazing (June – Sept)
Horticulture	Mango, litchi, pineapple, jackfruit, imli, palm	Mango, papaya, banana, moringa	Mango, papaya, banana, orange, lime, lemon, peach, plum, aegal, pomegranate	Chestnut, walnut, apple, peach, plum, apricot	

Source: Topographical Survey Branch, Land Use Mapping Project (1987)

Notes: * Development Regions:
FW – Far Western
MW – Mid Western
W – Western
C – Central
E – Eastern
EDR – Eastern Development Region

Section 8

Pest ranking in Nepal

In order to obtain the data, co-operating scientists were asked to identify the important pests (those causing major losses and receiving chemical and cultural control treatment) in the zones in which they had experience and then to rank them in order of importance. The ranks were limited to three. A number of meetings were then held with the scientists in order to bring the pests into one overall ranking. In the pest ranking tables for Nepal, the order of listing within a rank denotes order of pest importance; this is not the case for other countries.

ZONE A – TARAI AND SIWALIKS

The Tarai forms a long strip of alluvial deposits, fed by rivers which fan out from the Siwaliks. It is a continuation of the Indo-Gangetic plain. Although the Tarai represents only 14% of the total land area, it contains approximately 42% of the cultivated land.

The major crops in order of importance are: rice, wheat (which has recently superseded maize in importance), maize, mustard, horticultural crops and pulses.

Overall, cropping is dominated by paddy rice which is grown principally during the monsoon but with double cropping in some areas. The most important winter crop which follows is wheat, although pulses and mustard are also widely grown. Maize is mainly planted early to mature at mid-monsoon and be followed by mustard.

The Siwaliks, the adjoining range of foothills, has little agricultural land. The range is cut through by numerous rivers, and virtually all cultivated land is confined to valleys around these rivers. The main crops are maize, millet, wheat and mustard.

It was generally felt that insects were the most important group of pests followed by rodents and diseases. Weeds were not considered a problem since they were largely controlled through cultural practices; a view widely held by farmers and non-weed agronomists and scientists.

Insects on cotton and nematodes with jute are known to be problems although both crops are relatively unimportant and localized. Pests are ranked in Table 24.

Table 24

Pest ranking in Nepal Zone A – Tarai and Siwaliks

Rank	Pest	Crops attacked
1.	Gundhi bug (Rice bug) (*Leptocorisa* sp.)	Rice
	Rice stemborer (*Scirpophaga incertulas*)	Rice
	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
	Armyworm (*Mythimna separata*)	Rice, wheat, maize
	Leaf blight (*Drechslera tritici-repentis, Cochliobolus sativus*)	Wheat
	Brown rust (*Puccinia recondita*)	Wheat
	Rice blast (*Pyricularia oryzae*)	Rice
	Stemborer (*Chilo partellus*)	Maize
	Stalk rot (*Diplodia maydis*)	Maize
	Rat	Maize, wheat
	Late blight (*Phytophthora infestans*)	Potato, tomato
	Orobanche (weed)	Mustard
	Cutworm (*Agrotis* spp., *Mythimna* spp.)	Maize, etc.
	Southern leaf blight (*Cochliobolus heterostrophus*)	
	Leafhopper (*Empoasca* spp.)	Pulses
2.	Bollworm (*Helicoverpa armigera*)	Pulses
	Grey mould (*Botrytis cinerea*)	Pulses
	Red rot (*Glomerella tucumanensis*)	Sugar cane
	Panama wilt (*Fusarium oxysporum*)	Banana
	Wilt (*Pseudomonas solanacearum*)	Tomato
	Parrot	Maize, wheat
	Blister blight (*Exobasidium vexans*)	Tea
	Root-knot nematode (*Meloidogyne* spp.)	Solanaceous and cruciferous vegetables and legumes
	Loose smut (*Ustilago tritici*)	Wheat
3.	Thrips	Wheat
	Wire worm	Wheat
	Black scurf (*Rhizoctonia solani*)	Potato
	Shoot gall	Mango
	Mango leafhopper (*Idioscopus* spp., *Amritodus* spp).	Mango
	Early blight (*Alternaria solani*)	Potato
	Red ant	Potato
	Tuber moth (*Phthorimaea operculella*)	Potato
	White grub (Scarabaeidae)	Potato
	Hopper burn	Rice
	Root nematode (*Hirschmanniella oryzae*)	Rice
	Ear cockle (*Anguina tritici* nematode)	Wheat
	Citrus nematode (*Tylenchulus semipenetrans*)	Citrus

ZONE B – MIDDLE MOUNTAINS

The Middle Mountains are intensively cultivated and have the highest population density in relation to cultivated land. The zone is dissected by many rivers and has great soil and microclimatic variety. These factors affect the farming systems which are diverse. Overpopulation, overgrazing and forest degradation are serious problems.

Most slopes are terraced and support, in order of importance, maize, wheat, finger millet, rice, barley, pulses and horticultural crops.

Maize is planted early in the year and harvested pre-monsoon. Paddy is the main monsoon crop at lower altitudes, with wheat, finger millet, mustard, buckwheat and barley assuming greater importance as altitude increases. This latter group, in the same order, together with potatoes and pulses dominate the post-monsoon and winter periods.

Because of the wide variation in micro-climates and range of cropping systems, no clear pattern of pest grouping emerged (Table 25). (Limited information was available for coffee and vegetables.)

Table 25

Pest ranking in Nepal Zone B – Middle Mountains

Rank	Pest	Crops attacked
1.	White grub (Scarabaeidae)	Maize
	Rice blast (*Pyricularia oryzae*)	Rice
	Stemborer (*Seramia inferens?*)	Maize
	Yellow/stripe rust (*Puccinia striiformis*)	Wheat
	Loose smut (*Ustilago tritici*)	Wheat
	Blast (*Pyricularia setariae*)	Finger millet
	Stemborer (*Chilo* spp.)	Rice
	Sheath blight (*Corticium sasakii*)	Rice
	Cutworm (*Agrotis* spp.)	Maize, etc
2.	Armyworm (*Mythimna separata*)	Maize, wheat
	Late blight (*Phytophthora infestans*)	Potato
	Turcicum leaf blight (*Setosphaeria turcicum*)	Maize
	Thrips	Wheat
	Aphids (*Various species*)	Wheat
	Rat	Maize, wheat, rice
	Bacterial wilt (*Pseudomonas solanacearum*)	Potato
	Citrus greening vectored by psyllid (*Diaphorina citri*)	Citrus
	Citrus canker (*Xanthomonas citri*)	Citrus
	Citrus nematode (*Tylenchulus semipenetrans*)	Citrus
	Root-knot nematode (*Meloidogyne* spp.)	Solanaceous crops, crucifers and legumes
	Alternaria blight (*Alternaria brassicola*)	Crucifers
	Powdery mildew (*Erysiphe cichoracearum*)	Cucurbits
	Blister blight (*Exobasidium vexans*)	Tea
	Aphid	Horticultural crops
3.	Stalk rot (*Diplodia maydis*)	Maize
	Cob rot	Maize
	Smut (*Sphacelotheca* sp.?)	Maize
	Leaf blight (*Drechslera tritici-repentis, Cochliobolus sativus*)	Wheat
	Aphid	Wheat
	Gundhi bug (Rice bug) (*Leptocorisa* sp.)	Rice
	Frog-eye leaf spot (*Cercospora sojina*)	Soyabean
	Parrot	Maize
	Yellow/stripe rust (*Puccinia striiformis*)	Barley
	Early blight (*Alternaria solani*)	Potato
	Red ant	Potato
	White grub (Scarabaeidae)	Potato
	Aphid (*Myzus persicae etc*)	Potato, fruit trees
	Peach leaf curl	Peach
	Chirke virus	Big cardamom
	Mango disease (?)	Mango

ZONE C – HIGH MOUNTAINS AND HIGH HIMAL

The upper limits of cultivation are around 4200 m (14,000 feet) and it is only possible to cultivate one crop a year. The steep slopes are often intensively terraced for agricultural production.

This zone is of limited importance in terms of value of production when compared with the two preceding groups. The major crops cultivated are: potato, barley, buckwheat, maize, finger millet, wheat, upland rice and horticultural crops. Most of the High Himal are too high for cultivation. Generally, pests are not a problem in this zone Table 26.

Table 26

Pest ranking in Nepal Zone C – High Mountains and High Himal

Rank	Pest	Crops attacked
1.	Cob rot	Maize
	Yellow rust (*Puccinia striiformis*)	Barley
	Late blight (*Phytophthora infestans*)	Potato, tomato
	Root rot	Apple
	Peach leaf curl virus	Peach
2.	A range of diseases	Horticultural crops
	A range of insects	Horticultural crops
	Rat	Various crops
	Rice blast (*Pyricularia oryzae*)	Rice
	Stripe disease (*Drechslera gramineum*)	Barley

PEST IMPORTANCE IN NEPAL

Nematodes

The relative absence of nematodes as a group from this review of pest importance may reflect the level of resources that have been applied to this discipline. Plant nematology as a discipline is still in its infancy in Nepal. Various vegetable and legume crops such as tomato, brinjal, okra, chickpea and cowpea have serious problems with *Meloidogyne* spp. Rice is infested with the root nematode, *Hirschmanniella oryzae*, citrus with *Tylenchulus semipenetrans* and wheat with *Anguina tritici*. Other important nematode genera associated with various crop plants are *Pratylenchus, Heterodera, Ditylenchus, Xiphinema, Radopholus, Rotylenchulus* and *Helicotylenchus*.

Weeds

It was not possible to include weeds in the overall ranking. Weeding is widely carried out twice during the growing season in all zones thereby reducing their ability to suppress yields. Important weeds in the two main agricultural zones are listed below in Table 27.

Table 27

Weeds	Crops affected
Tarai	
*Chenopodium album**	Wheat
*Avena fatua**	Wheat
*Phalaris minor**	Wheat
*Ageratum conizoides**	Maize
Brachiarea spp.	Maize
*Cyperus rotundus**	Maize, paddy
*Digitaria adscendens**	Maize
*Echinochloa colonum**	Maize, paddy
*Panicum repens**	Maize
*Commelina benghalensis**	Paddy
Eichhornia crassipes	Paddy
*Ludwigia octovalvis**	Paddy
*Monochoria vaginalis**	Paddy
Putamogilan spp.	Paddy
Sagittaria sagittifolia	Paddy
Lathyrus aphaca	Wheat
Cyperus iria	Paddy
Cyperus difformes	Paddy
Echinochloa crusgalli	Paddy
Echinochloa glabrescens	Paddy
Middle Mountains	
weeds marked with * above	
Oxalis latifolia	

Summary of pest importance in Nepal

Checking for pests common to different zones, the following Non-weed pests emerge as considerably more important in Nepal than the rest. They are:

Rice blast (*Pyricularia oryzae*)	Rice
Yellow stemborer (*Scirpophaga incertulas*)	Rice
Stemborer (*Chilo partellus*)	Maize
Armyworm (*Mythimna separata*)	Rice, wheat, maize

Some of the weeds are probably equally important as the four pests above.

In the Nepal Tarai (lowlands), rice, wheat, maize and other main crops are affected by a pest complex in which the different pest groups approximate to one another in importance. Crops appear to suffer in proportion to their economic importance. The pattern in respect of pest groups is less conclusive, however. A range of diseases and insects dominate the ranking tables (Tables 24-26). Nematodes and vertebrate pests also feature. It is not certain if the lower importance attached is a result of fewer resources devoted to these groups of pests or if they are genuinely less important, similarly with weeds. It has not been possible to rank weeds. They are clearly important, although this is partly obscured by the success of weeding as an integral practice in the farming systems.

These comments apply equally to the cultivation of the Middle Mountains. In the High Mountains, an area responsible for a small proportion of output, pests are not of major importance.

Section 9

The cropping systems in Sri Lanka

ALTITUDE AND RAINFALL CHARACTERISTICS OF THE ZONES

Figure 3 shows the boundaries of the zones, and Table 28 shows their characteristics defined by altitude and rainfall. The four cropping system zones have been formed by amalgamating the 24 agro-ecological zones into which Sri Lanka has been divided.

Table 28

Cropping system zones in Sri Lanka: altitude and rainfall

Altitude (m)	Annual rainfall expected in 3 out of 4 years in sub-zones (mm)	Zone, sub-zones* and rainfall pattern
		Zone 1, Humid Up Country (Sub-zones, WU_1–WU_3, Iu_1, –Iu_3)
>900	1150–1400 to >3175	Western part of zone has drier period during December – March. Eastern part of zone has drier period during February – September broken by a minor rainfall peak in April.
		Zone 2, Humid Mid Country (Sub-zones WM_1–WM_3, to IM_1–IM_3)
300–900	900–1150 to >3175	Western part of zone has drier period during January – February. Eastern part of zone has drier period during February – September with a minor rainfall peak in April. In the southeastern part, this minor peak is more pronounced, creating a definite bimodal pattern.
		Zone 3, Humid Low Country (Sub-zones WL_1–WL_4, IL_1)
<300	1020–1525 to >2540	The rainfall is bimodal, with the heaviest periods of rain during May – July and October – November.
		Zone 4, Dry Low Country (Sub-zones IL_2–IL_3, DL_1–DL_5)
<300	500–775 to 1150–1525	Mean annual rainfall 1270–2160 mm over all except the extreme southeast of the zone. There is a pronounced dry season during October – December/January, and a minor rainy peak in April.

*The sub-zones are the 24 agro-ecological zones into which Sri Lanka has been divided

Sri Lanka receives rain from both the southwest and northeast monsoons. From May onwards, there is some rain shadow effect on the eastern side of the mountains during the southwest monsoon. In all subzones, there are troughs in the rainfall pattern in February and August/September, but in the wetter areas, rainfall is still quite high during the August/September trough. The east coast receives most of its rain from October to January during the monsoon and the inter-monsoonal period which precedes it.

CROPPING PATTERN BY ZONE

Table 2 shows the order of importance of crops in each zone.

Zone 1

High grown tea covers most of the zone except for the area shown in Figure 3, where potato, vegetables and rice predominate. Much of the tea is grown on steep slopes which present erosion hazards if the ground cover is broken due to plants dying or being replanted. Most abandoned and eroded tea estates have been planted with trees.

At the end of 1988, 26% of the tea in Sri Lanka was grown on 150,000 smallholdings with a mean size of 0.39 ha; 74% was grown on 3663 estates with a mean size of 44.5 ha (Sri Lanka Tea Board, 1989). (These figures refer to the whole island, not just Zone 1).

Zone 2

Rice is grown as a monocrop in narrow valleys. The major part of the remaining cultivated area (not under tea and rubber) supports a multi-storey system of mixed cropping which gives good protection against erosion and makes maximum use of solar energy. This is typified by the 'Kandy home gardens', with a mixture of tree crops, banana and root crops. Most of the rubber is grown to the east and north of Kandy (Figure 6).

Zone 3

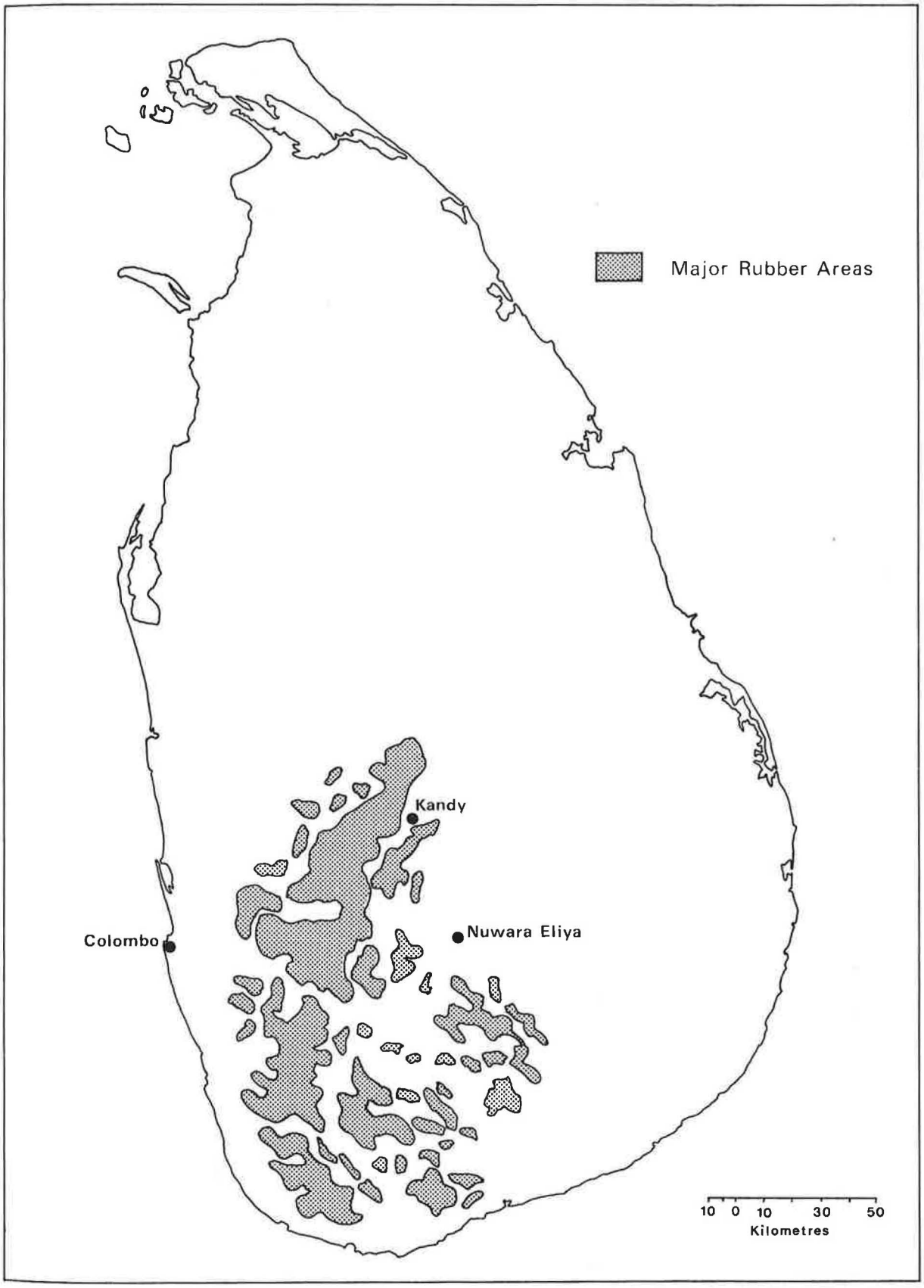
The elevation in this zone is lower than in the previous zones and the valleys open out into wide expanses of rice. There are denser areas of coconut with less intercropping, particularly in the northwest where there is less rainfall. Most of the tea is grown in the south part of the zone. The area under rubber is shown in Figure 6. Multiy-storey mixed cropping is still common in much of the zone.

Zone 4

This covers the north and east of the island and is much the largest zone. There are many dams, some of them very ancient. Most of the rice is irrigated. Coconut is grown near the coast particularly on the Kalpitiya peninsular and around Jaffna. The cropping pattern reflects the much drier climate of this zone.

Figure 6

Rubber growing areas of Sri Lanka (1990)



SOURCE: Rubber Research Institute of Sri Lanka.

Section 10

Pest ranking in Sri Lanka

Pests are ranked in Tables 29-32.

The pests of rice and tea are the most important overall, reflecting the status of these crops. Pests of rubber are important in Zone 3, the main zone for rubber production, but they are not as numerous as those of rice and tea. All the major pests of rubber are pathogens. White root disease (*Rigidoporus lignosus*) causes 3-4% loss of rubber trees per annum. In the 1970s, the losses were 8-10%. *Corynespora* leaf fall disease kills trees by repeated defoliation and is considered to do more damage than white root disease (Personal communication, Dr N. I. S. Liyanage, Rubber Research Institute, Sri Lanka).

The pests of coconut were not thought by the Coconut Research Institute to have much effect on yield and so, in Zone 3, the main zone for coconut cultivation, they are not ranked higher than fourth and fifth. Most of the coconut pests are kept under control by predators and parasites – either naturally occurring or released by the Coconut Research Institute. The institute scored a notable success in the early 1970s when it brought the coconut leaf miner (*Promecotheca cumingi*) under control after the pest had been imported on some coconut leaves used for packing. At first it caused extensive damage, but the institute identified, introduced and released a number of parasites which now keep the pest under control without the use of insecticides. The most effective parasites are *Dimmockia javanica* and *Pediobus parvulus*, which attack the larval and early pupal stages.

Amongst tea pests, wood rot syndrome is a first rank pest in all three tea zones. Termites are in the first rank in the three tea zones too, but the species differ between zones. Red rot is important in Zones 1 and 2 and shot-hole borer in Zones 2 and 3.

Gall midge, leaf folder, Gundhi bug (rice bug), brown planthopper and rice blast are the most important rice pests in the country as a whole. Interestingly wild boars are in the second or third ranks in Zones 1, 2 and 4. The countries security situation has resulted in a ban on firearms which has stopped people hunting them, resulting in considerably increased numbers in recent years.

In Sri Lanka, respondents ranked outstanding weed species in relation to other pests. It was felt that they were able to make a fair comparison, so weeds have been kept in the ranking lists rather than being treated separately. This procedure also brings out the importance of weed species in relation to each other. Overall, *Cynodon dactylon* and *Cyperus* spp. are the worst weed problems. *Panicum repens* is a serious pest of tea in Zones 1 and 2 and *Echinochloa* spp. and *Ludwigia* spp. in rice in Zones 3 and 4.

Table 33 summarizes the main pests in Sri Lanka, taking account of the pest ranks and crop values. In the case of rice, the value of the crop was used and in the case of other crops the total value of all crops in the zone was used. For tea, a panel of scientists at the Tea Research Institute in Sri Lanka gave their estimate of the most important tea pests in the country as a whole.

Table 29

Pest ranking in Sri Lanka – Zone 1

Rank	Pest	Crops attacked
1.	*Pratylenchus loosi* nematode	Tea
	Up-country live wood termite (*Postelectrotermes militaris*)	Tea
	Red root disease (*Ganoderma philippii*)	Tea
	Wood rot syndrome	Tea
	Blister blight (*Exobasidium vexans*)	Tea
	Panicum repens (weed)	Tea, potato, etc.
2.	Leaf-eating caterpillar (*Homona coffearia* etc.)	Tea
	Mite (*Brevipalpus californicus, Olygonychus coffeae, Hemitarsonemus latus, Calacarus carinatus*)	Tea
	Potato cyst nematode (*Heterodera rostochiensis*)	Potato
	Bacterial wilt (*Pseudomonas solanacearum*)	Potato
	Cynodon dactylon (weed)	Various
	Cyperus spp. (weed)	Various
3.	White grub (Scarabaeidae)	Tea
	Late blight (*Phytophthora infestans*)	Potato
	Wild boar (*Sus scrofa*)	Arable crops
	Tuber moth (*Phthorimaea operculella*)	Potato
	Club root (*Plasdmodiophora brassicae*)	Crucifers
	Leaf-eating caterpillar	Crucifers
4.	Root-knot nematode (*Meloidogyne incognita, Meloidogyne javanica, Meloidogyne arenaria*)	Vegetables, etc.
	Root-nematode (*Meloidogyne brevicauda*)	Tea
	Cutworm (*Agrotis* spp.)	Vegetables, potato
	Early blight (*Alternaria solani*)	Solanaceous crops
	Beanfly (*Ophiomyia phaseoli*)	Bean
	Rodents	Rice in field, potato in store
5.	Riceblast (*Pyricularia oryzae*)	Rice
	Sheath blight (*Corticium sasakii*)	Rice
	Scab (*Venturia pyrini*)	Pear
	Cardamom borer (*Dichocrocis punctiferalis*)	Cardamom
	Leaf curl (unknown etiology)	Tomato

Table 30

Pest ranking in Sri Lanka – Zone 2

Rank	Pest	Crops attacked
1.	Shot-hole borer (*Xylosandrus compactus*)	Tea
	Wood rot syndrome	Tea
	Red root disease (*Ganoderma philippii*)	Tea
	Burrowing nematode (*Radopholus similis*)	Tea, black pepper (slow wilt)
	Panicum repens (weed)	Tea
	Cyperus spp. (weed)	Various
	Cynodon dactylon (weed)	Various
	Gundhi bug (Rice bug) (*Leptocorisa* sp.)	Rice
	Leaf folder (*Cnaphalocrocis medinalis*)	Rice
2.	Scavenging termites (*Odontotermes horni, Odontotermes ceylonicus, Coptotermes ceylonicus, Hospitalitermes monoceros*)	Tea
	Gall midge (*Orseolia oryzae*)	Rice
	Sheath blight (*Corticium sasakii*)	Rice
	Rice blast (*Pyricularia oryzae*)	Rice
	Wild boar (*Sus scrofa*)	Rice, banana, root crops
	Oriental fruit fly (*Bactrocera dorsalis*)	Fruit crops
	Soil-borne fungi (*Sclerotium rolfsii, Pythium* spp.)	Vegetables, turmeric, ginger
	Banana unthriftiness (unknown aetiology)	Banana
	Rodents (mostly bandicoots)	Rice in field
3.	Nematode (*Pratylenchus loosi*)	Tea
	Reniform nematode (*Rotylenchulus reniformis*)	Tea
	Thrips (*Stenchaetothrips biformis*)	Rice
	Root-knot nematode (*Meloidogyne* spp.)	Vegetables
	Banana weevil (*Odoiporus longicollis*)	Banana (pseudostem)
	Mango leafhopper (*Idioscopus* spp., *Amritodus* spp.)	Mango
	Quick wilt (*Phytophthora piperis*)	Black pepper
	Helopeltis bug (*Helopeltis antonii, Helopeltis ceylonensis, Helopeltis theivora*)	Cocoa
	Squirrel	Cocoa
	Yellow spotted locust (*Aularches miliaris?*)	Kandy gardens
	White root disease (*Rigidoporus lignosus*)	Rubber
	Corynespora leaf fall disease (*Corynespora cassiicola*)	Rubber
4.	Whorl maggot (*Hydrellia* sp.)	Rice
	Brown planthopper (sporadic) (*Nilaparvata lugens*)	Rice
	Berry borer (*Hypothenemus hampei*)	Coffee
	Die-back (*Cryphonectria cubensis*)	Clove
	Leaf-cutting weevil (*Deporaus marginatus*)	Mango
	Melon fly (*Bactrocera cucurbitae*)	Pumpkin, cucumber, bitter gourd
	White grub (Scarabaeidae)	Tea
	Banana weevil (*Cosmopolites sordidus*)	Banana
	Imperata cylindrica (weed)	Tea, particularly abandoned areas
	Phytophthora panel rot (*Phytophthora palmivora*)	Rubber
5.	Unidentified virus	Luffa
	Didymella spp.	Fruits
	Powdery mildew (*Oidium heveae*)	Rubber

Table 31

Pest ranking in Sri Lanka – Zone 3

Rank	Pest	Crops attacked
1.	Low country live-wood termites (*Glyptotermes dilatatus, Neotermes greeni*)	Tea
	Wood rot syndrome	Tea
	Stem canker	Tea
	Gall midge (*Orseolia oryzae*)	Rice
	Sheath blight (*Corticium sasakii*)	Rice
	White root disease (*Rigidoporus lignosus*)	Rubber
	Corynespora leaf fall disease (*Corynespora cassiicola*)	Rubber
	Cyperus spp. (weed)	Rice, arable crops
	Cynodon dactylon (weed)	Rice, arable crops
	Echinochloa spp. (weed)	Rice
	Ludwigia spp. (weed)	Rice
	Chromolaena odorata (weed)	Coconut
2.	Shot-hole borer (*Xylosandrus compactus*)	Tea
	Scavenging termites (*Odontotermes horni, Odontotermes ceylonicus, Coptotermes ceylonicus, Hospitalitermes monoceros*)	Tea
	Leaf folder (*Cnaphalocrocis medinalis*)	Rice
	Gundhi bug (Rice bug) (*Leptocorisa* sp.)	Rice
	Rodents	Rice
	Banana weevil (*Cosmopolites sordidus*)	Banana
	Papaya mosaic (virus)	Papaya
	Phytophthora panel rot (*Phytophthora palmivora*)	Rubber
3.	Thrips (*Stenchaetothrips biformis*)	Rice
	Brown planthopper (*Nilaparvata lugens*)	Rice
	Yellow stemborer (*Scirpohaga incertulas*)	Rice
	Pineapple wilt	Pineapple
	Mealybug (*Dysmicoccus brevipes*)	Pineapple
	Root-knot nematode (*Meloidogyne* spp.)	Vegetables
	Wilt (*Pythium* spp., *Pseudomonas solanacearum*)	Vegetable nurseries, ginger, turmeric
	Bunchy top	Banana
	Panama disease (*Fusarium oxysporum* f. sp. *cubense*)	Banana
	Sweet potato weevil (*Cylas formicarius*)	Sweet potato
4.	Blister blight (*Exobasidium vexans*)	Tea
	Borreria (weed)	Tea
	Whorl maggot (*Hydrellia* sp.)	Rice
	Rice blast (*Pyricularia oryzae*)	Rice
	Grain spotting	Rice
	Yellow sigatoka (*Mycosphaerella musicola*)	Banana
	Oriental fruit fly (*Bactrocera dorsalis*)	Fruits
	Melon fly (*Bactrocera cucurbitae*)	Cucumber, melon
	Black-headed caterpillar (*Opisina arenosella*)	Coconut
	Virus (Passion fruit woodiness virus?, Cucumber mosiac virus?)	Passion fruit
	Powdery mildew (*Oidium heveae*)	Rubber
5.	Rhinocerus beetle (*Oryctes rhinoceros*)	Coconut
	Red weevil (*Rhynchophorus ferrugineus*)	Coconut
	Vine girdler (*Sthenias grisator?*)	Passion fruit

Table 32

Pest ranking in Sri Lanka – Zone 4

Rank	Pest	Crops attacked
1.	Brown planthopper (*Nilaparvata lugens*)	Rice
	Cyperus spp. (weed)	Rice, arable crops
	Cynodon dactylon (weed)	Rice, arable crops
	Echinochloa spp. (weed)	Rice
	Ludwigia spp. (weed)	Rice
2.	Gall midge (*Orseolia oryzae*)	Rice
	Gundhi bug (Rice bug) (*Leptocorisa* sp.)	Rice
	Leaf folder (*Cnaphalocrocis medinalis*)	Rice
	Rice blast (*Pyricularia oryzae*)	Rice
	Rodents	Rice, sugar cane
	Bollworm (*Helicoverpa armigera*)	Pulses, chilli, tomato, cashew, cotton, maize
	Podborer (*Maruca testulalis*)	Pulses
	Tobacco caterpillar (*Spodoptera litura*)	Chilli, maize
	Yellow mosaic virus	Black gram, green gram
3.	Thrips (*Stenchaetothrips biformis*)	Rice
	Yellow stemborer (*Scirpophaga incertulas*)	Rice
	Sheath blight (*Corticium sasakii*)	Rice
	Wild boar (*Sus scrofa*)	Many crops
	Leaf miner (*Phyllocnistis citrella*)	Citrus
	Scab (*Elsinoe fawcettii*)	Citrus
	Canker (*Xanthomonas campestris* pv. *citri*)	Citrus
	Powdery mildew (*Oidium* sp.)	Green gram
	Stemborer (*Chilo partellus, Sesamia inferens*)	Maize
	Bunchy top virus	Banana
	Banana weevil (*Cosmopolites sordidus*)	Banana
	Smut (*Ustilago scitaminea*)	Sugar cane
	Mango leafhopper (*Idioscopus* spp., *Amritodus* spp.)	Mango
	Mango bark borer (*Hypocryphalus mangiferae?*)	Mango, cashew
	Root-knot nematode (*Meloidogyne* spp.)	Vegetables
4.	Tungro virus	Rice
	Beanfly (*Ophiomyia phaseoli*)	Cowpea
	Okra mosaic virus (whitefly vector)	Okra
	Cucurbit virus (Water melon mosiac? cucumber mosaic?)	Cucurbits,including gerkins
	Podborer (*Leucinodes orbonalis*)	Brinjal
	Oriental fruit fly (*Bactrocera dorsalis*)	Fruits, particularly mango and orange
	Melon fly (*Bactrocera cucurbitae*)	Cucurbits
	Bacterial wilt (*Pseudomonas solanacearum*)	Solanaceous crops
	Collar rot (*Corticium rolfsii*)	Legumes, vegetables
	Damping off (*Rhizoctonia* spp., etc)	Vegetable seedlings etc
	Elephant (*Elephas indicus*)	Surgar cane, rice
5.	Leafspot (*Cercospora* spp.)	Groundnut
	Bud necrosis	Groundnut
	Black-headed caterpillar (*Opisina arenosella*)	Coconut
	Chilli narrow leaf disorder (unknown aetiology, but associated with soil)	Chilli

Table 33

The main pests in Sri Lanka (birds excluded)

Crops attacked	Pest
Non-weed pests	
Rice	Gall midge (*Orseolia oryzae*) Leaf folder (*Cnaphalocrocis medinalis*) Gundhi bug (Rice bug) (*Leptocorisa* sp.) Brown planthopper (*Nilaparvata lugens*) Rice blast (*Pyricularia oryzae*)
Tea	Wood rot syndrome *Pratylenchus loos* nematode Up-country termite (*Postelectrotermes militaris*) Red root disease (*Ganoderma philippi*) Blister blight (*Exobasidium vexans*)
Rubber	White root disease (*Rigidoporus lignosus*) Corynespora leaf fall disease (*Corynespora cassiicola*)
Various crops	Rodents Wild boar (*Sus scrofa*)
Weeds	
Rice	*Cyperus* spp. *Cynodon dactylon* *Echinochloa* spp. *Ludwigia* spp.
Tea	*Panicum repens*
Coconut	*Chromolaena odorata*

Section 11

The cropping systems in Bangladesh

All of Bangladesh, except for the Chittagong hills in the southeast, is a low-lying alluvial plain.

From about June to August, flooding rivers and monsoon rain inundate most of the land. Annual rainfall increases from 1200 mm in the west to as much as 6000 mm in the east. The rains begin in March in the northeast and in May in the west, starting later moving from east to west. The rainfall pattern in the middle of the country (Joydebpur) is:

November – February	Dry
March – April	Pre-monsoon (light rains)
May – October	Monsoon (heavy rains)

The maximum temperature in the same area is 30-33°C from mid-March to mid-April. To flower properly rice requires temperatures above 20°C. This is an important determining factor for the pattern of rice seasons and the condition prevails at Joydebpur from about 10 April to mid-October. The result is that rice cannot be seeded in August and September. With dry season irrigation it can be seeded at any other time of the year in Bangladesh. Average temperatures in January fall to between 17.5 and 20°C.

The human population in 1990 was about 115 million with population density very high – about 7.8 persons per hectare of crop in 1987 and rising. As only rice and jute can be grown in flooded land and priority must be given to the provision of staple food, rice dominates the cropping pattern more than in any other zone in the region (and probably any other country in the world). Over 80% of the cropped area is planted with rice. The features of the main rice crops are summarized in Table 34. Jute, which contributes 5% to the total value of crop production, is an alternative to aus rice. Most of the remaining crops are grown in the boro rice season, either on residual moisture or under irrigation. Sugar cane occupies the ground for 12 months or more and is planted and harvested in the dry winter season. It is often intercropped during the boro season in its early stages of growth. In the northwest of the country it alternates with rice in a two-year rotation. The relative importance of crops is given in Table 3.

Typical rice cropping sequences over 12 months are:

Direct-sown aus — Transplanted aman
(usually grown in separate areas, direct-sown aus on higher ground and transplanted aman on lower ground)

Boro — fallow — transplanted aman

Fallow — transplanted aus — transplanted aman
(the aus is transplanted early using irrigation)

Deep-water areas:

Single boro
Single deep-water rice
Boro – transplanted deep-water rice

One of the major strategies for agriculture in Bangladesh has been the introduction of pumps to enable suitable land under irrigation in the dry winter

Table 34

Features of the main rice crops grown in Bangladesh

Million ha	Rice crop	Planting	Harvesting	Ground flooded	Planting elevation	Remarks
3	Aus	March to early May	June – August	Towards maturity	Higher ground	Direct seeded. Occasionally transplanted where rains come later. Sometimes mixed with sesame or chilli. Competes with jute, which is more tolerant of flooding near maturity. Problems: – drought pre-monsoon, then low solar radiation in monsoon – possible submergence at ripening. Yields 1-2 t/ha.
1.8	Deep-water rice (DWR) – also known as broadcast aman	March – April (can also be transplanted April – May after boro harvest)	November – December	May – September (or lesser period)	Lower ground	Direct seeded. Floods to 1-5 m. 'Floating rice' can grow up to 30 cm in 24 hours. Yields 1.5-2.5 t/ha.
4	Transplanted aman	Wet nurseries June – July Transplanted July – September	November – December	July – September	Middle elevation ground	Modern high yielding varieties increasingly used. Depth of water <1 m. In coastal low-lying areas, crop inundated twice a day by effect of tide. Problems: – danger of flash flood submergence after transplanting – if late planted, the lower temperatures in later part of growing period reduce yield.
1.5	Boro	Wet nurseries November – December Transplanted January – February	April – June	Irrigated crop	Lower ground	Traditionally transplanted into puddled mud of receding flood, then irrigated manually by scoops and other lifting devices. Boro area expanding fast with spread of irrigation pumps. Nearly whole area planted with modern, high-yielding varieties. Six month crop with long vegetative phase due to low temperatures. Late planting reduces yields. Yields high.

season to grow boro rice or other crops. This is a logical policy because it is the only way of increasing the cropped area. With high solar radiation and good water control, high yields can be obtained. However, the advantage of a break in availability of host plants is lost and the potential threat from rice pests is much increased. The dangers of relying solely on chemical control in such a situation are evident to agricultural planners in Bangladesh and the national policy gives higher priority to integrated pest management.

In the Chittagong hill tracts, rice farming following the systems described above is practised in the valleys, whilst on the hill slopes shifting cultivation is usual. Tea is grown on the benchlands between hill and plain in Sylhet and Chittagong districts.

In 1983-84 the mean size of farm was 0.9 ha. In 1981 82.5% of the land was owner-operated and 17.5% was tenant-operated. A greater poverty problem than small farm size is landlessness. In 1983-84, 56.5% of rural households were landless (including those with <0.02 ha of land).

Section 12

Pest ranking in Bangladesh

As rice accounts for 77% of the production value (Table 3) rice pests fill the first three ranks and half the fourth rank (Table 35). With rice so dominant few pests of other crops are sufficiently important overall to be ranked. Pests not ranked may include some which are important in relation to a single crop.

Insect pests of rice were ranked in Bangladesh in 1977 (Bangladesh Rice Research Institute, 1977). Diseases of rice were ranked as well, but virus, bacterial, fungal and nematode diseases were ranked separately. These rankings are reproduced in Tables 36 and 37. Comparing them with Table 35, there appears to have been a great increase in the importance of the brown planthopper (*Nilaparvata lugens*), which has risen from seventeenth most important insect pest to the first rank amongst rice pests as a whole. Hispa (*Dicladispa armigera*) has also increased in importance, but not as dramatically as the brown planthopper. Gall midge and rice bug are now ranked as less important. Less change can be discerned amongst rice diseases, but less importance is now given to foot rot/bakanae.

One might ask whether the differences in rankings reflect a real change in pest importance, or just differences in perception between different reporters. Minor differences may be unrelated to the real pest situation but it is unlikely that such a big change as that of the brown planthopper is spurious. The rise in the importance of the brown planthopper as a rice pest in Asia is a well-known phenomenon.

Some respondents drew particular attention to the brown planthopper and hispa having overtaken stemborers in importance in the last ten years. Some still put stemborers in the first rank, whilst others said that whilst stemborers affected large areas of rice they caused little yield loss.

The brown planthopper and hispa are particularly serious in boro rice. If the boro crop is badly attacked by the brown planthopper, then it is likely to be a problem pest in the succeeding aus and aman crops. The increase in boro rice may partly explain the rise in importance of these two pests. Brown planthopper may have also been encouraged by the increase in pesticide spraying interfering with the pest/predator balance. Hispa attack is sporadic. It tends to be worse in the southern and coastal areas. Rice blast disease is another problem which is worse in the boro than in the other crops.

The boro crop tends to suffer more from pests because over 75% of it is planted with high-yielding varieties which are more susceptible to pests than the traditional varieties. More than 80% of the aus and aman crops are planted with traditional varieties.

Ufra disease, caused by the nematode *Ditylenchus angustus*, is primarily a pest of deep-water rice (broadcast aman), but it is increasing in the boro and transplanted aman crops.

The transplanted aman crop tends to be attacked by stemborers in September/October before flowering. Ear-cutting caterpillars (*Mythimna separata*) are sporadic pests, most frequently attacking the half ripe ears of the aman crop in November.

Table 35

Pest ranking in Bangladesh

Rank	Pest	Crops attacked
1.	Hispa (*Dicladispa armigera*)	Rice
	Brown planthopper (*Nilaparvata lugens*)	Rice
2.	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
	Sheath blight (*Corticium sasakii*)	Rice
	Rice blast (*Pyricularia oryzae*)	Rice
3.	Stemborer, particularly yellow stemborer (*Scirpophaga incertulas*)	Rice
	Tungro virus and green leafhopper (*Nephotettix virescens*)	Rice
	Ufra disease (*Ditylenchus angustus*)	Rice, particularly deep-water
	Rodents	Rice, particularly deep-water; wheat
4.	Leaf folder (*Cnaphalocrocis medinalis*)	Rice
	Caseworm (*Nymphula depunctalis*)	Rice
	Sheath rot (*Sarocladium oryzae*)	Rice
	Ear-cutting caterpillar (*Mythimna separata*)	Rice
	Swarming caterpillar (*Spodoptera mauritia*)	Rice
	White-backed planthopper (*Sogatella furcifera*)	Rice
	Yellow mite (*Polyphagotarsonemus latus*)	Jute
	Red rot (*Glomerella tucumanensis*)	Sugar cane
	Stem and shoot borer (various species)	Sugar cane
	Root-knot nematode (*Meloidogyne* spp.)	Vegetables, rice, etc.
5.	Gundhi bug (Rice bug) (*Leptocorisa* sp.)	Rice
	Bacterial leaf streak (*Xanthomonas campestris* pv. *oryzicola*)	Rice
	Gall midge *Orseolia oryzae*	Rice
	Mealybug (*Ripersia oryzae*)	Rice
	Thrips (*Thrips oryzae*)	Rice
	Brown spot (*Cochliobolus miyabeanus*)	Rice
	Stem rot (*Magnaporthe salvinii*)	Rice
	Bakanae foot rot (*Gibberella fujikuroi*)	Rice
	Birds	Rice, wheat, tomato
	White tip nematode (*Aphelenchoides besseyi*)	Rice
	Jute apion (*Apion corchori*)	Jute
	Stem rot	Jute
	Yellow mosaic virus	Jute
	Hairy caterpillar (*Dasychira securis*)	Jute
	Semi-looper (*Anomis sabulifera*)	Jute
	Root borer (*Emmalocera depressela*)	Sugar cane
	White grub (Scarabaeidae)	Sugar cane
	Ratoon stunting (*Clavibacter xyli*)	Sugar cane
	Wilt (*Gibberella fujikuroi* var. *subglutinans*)	Sugar cane
	Termites (various species)	Sugar cane, wheat
	Late blight (*Phytophthora infestans*)	Potato, tomato
	Cutworm (*Agrotis* spp.)	Potato, cabbage, cauliflower
	Viruses (Potato leaf roll virus, Potato virus X, potato virus Y)	Potato
	Tuber moth (*Phthorimaea operculella*)	Potato (particularly Bogra and non cold storage)
	Bacterial wilt (more in non-flooded areas) (*Pseudomonas solanacearum*)	Potato, brinjal, tobacco
	Bollworm (*Helicoverpa armigera*	Tobacco, chickpea
	Downy mildew (*Peronospora* spp.)	Rape/mustard, lathyrus
	Blight (*Stemphylium* spp.)	Lentil
	Rust (*Uromyces viciae-fabae*)	Lentil
	Mustard aphid (*Lipaphis erysimi*)	Rape/mustard, crucifers for seed
	Leaf spot (*Alternaria brassicae*)	Rape/mustard, tomato, crucifers
	Collar/stem/bulb rot (*Corticium rolfsii*)	Groundnut, lentil, chickpea, lathyrus, brinjal, cucurbits, onion, garlic
	Powdery mildew (*Oidium* spp.)	Mango, cucurbits, zuzubae
	Banana beetle (*Nodostoma subcostatum*)	Banana
	Mango leafhopper (*Idioscopus* spp., *Amritodus* spp.)	Mango
	Black rot	Cabbage, cauliflower, radish
	Turcicum leaf blight (*Setosphaeria turcica*)	Maize
	Sugar cane mosaic virus	Maize
	Wilt (*Fusarium oxysporum* f.sp. cubense= Panama wilt on banana)	Banana, chilli etc.

Table 36

Insect pests in Bangladesh, ranked in order of importance by the Bangladesh Rice Research Institute in 1977

Common name	Scientific name
Major pests	
Stemborer	*Scirpophaga incertulas, Chilo polychrysa, Sesamia inferens*
Rice green leafhopper	*Nephotettix virescens, Nephotettix nigropictus*
Ear-cutting caterpillar	*Mythimna separata*
Rice gall midge	*Orseolia oryzae*
Rice hispa	*Dicladispa armigera*
Rice bug	*Leptocorisa acuta*
Rice leaf folder	*Cnaphalocrocis medinalis*
Rice swarming caterpillar	*Spodoptera mauritia*
Rice caseworm	*Nympula depunctalis*
Rice mealy bug	*Ripersia oryzae*
Rice whorl maggot	*Hydrellia* sp.
Minor pests	
Rice grasshopper	*Hieroglyphus banian, Oxya velox*
Rice thrips	*Thrips oryzae*
Orange-headed leafhopper	*Thaia oryzivora*
Field cricket	*Brachytrupes portentosus*
Rice leaf beetle	*Leptispa pygmoea*
Brown planthopper	*Nilaparvata lugens*
Rice hairy caterpillar	*Dasychira securis*
Rice leaf butterfly	*Melanitis ledaismena*
Rice skipper	*Pelopidas agna*

Source: Bangladesh Rice Research Institute (1977)

Bangladesh Rice Research Institute (1977) gives diagrams of the seasonal importance of rice pests and diseases. They are not reproduced here as seasonality of attack is likely to have been modified significantly by the increase in the boro crop. They show January – March to have been the months with the fewest diseases and January – February the months with the fewest insect pests.

Table 38 lists the most important pests in Bangladesh. The rice pests are divided into two ranks of importance.

In 1989–90, the Bangladesh Rice Research Institute started regular sampling surveys in farmers' fields. These surveys show the relationship of pest attack to rice yield in regression analysis. Previous surveys measured the incidence of pest attack. The new survey series should generate better information on the relative importance of rice pests.

Apart from weeds, the worst pre-harvest pests attacking other crops are yellow mites (jute), red rot and stem and shoot borers (sugar cane) and different species of root-knot nematode attacking vegetables, rice, etc.

The late blight attack on the potato crop is usually heaviest in the Munshiganj and Comilla areas. The farmers tend to have insufficient fungicide to control it properly. Bacterial wilt is the worst pest of the certified potato seed crop as it is difficult to control; certified seed production is being shifted to areas which flood for two months and are less affected. *Myzus persicae* aphids, the vectors of potato leaf roll virus and potato virus Y, feed on the potato crop in January, but certified seed is produced satisfactorily by controlling the aphids with insecticide.

Table 39 shows the distribution of pesticide from 1977 to 1985. Insecticides were used far more than other pesticides. Until 1974 pesticides were supplied to farmers by the government free of cost. In 1974 the subsidy was reduced to 50% and in 1979 it was abolished and pesticide marketing was turned over to the private sector. This appears to have caused a sharp fall in pesticide use in 1979, but it has gradually recovered.

Table 37

Diseases of rice in Bangladesh ranked in 1977 by the Bangladesh Rice Research Institute in order of importance within each group

Disease	Causal agent
Virus diseases	
Tungro	Rice tungro virus
Yellow dwarf	Mycoplasma-like organism (PPLO)
Bacterial diseases	
Bacterial leaf blight	*Xanthomonas oryzae (Xanthomonas campestris* pv. *oryzae)*
Bacterial leaf streak	*Xanthomonas translucens* f. sp. *oryzicola (Xanthomonas campestris* pv. *oryzicola)*
Fungal diseases	
Sheath blight	*Thanatephorus cucumeris*
Foot rot and bakanae	*Gibberella moniliforme*
Blast	*Pyricularia oryzae*
Brown spot	*Cochliobolus miyabeanus*
Sheath rot	*Acrocylindrium oryzae*
Leaf scald	*Rhynchosporium oryzae*
Stem rot	*Magnaporthe salvinii*
Seedling blight	*Corticium rolfsii*
Stack burn	*Alternaria padwickii*
Narrow brown leaf spot	*Sphaerulina oryzina*
False smut	*Claviceps oryzae-sativae*
Black kernel or bunt	*Tilletia barclayana*
Leaf and grain spot	*Curvularia lunata*
Grain spot	*Phoma glumarum*
Grain spot	*Pyrenochaeta oryzae*
Grain spot	*Cladosporium* sp.
Miniature leaf and grain spot	*Nigrospora oryzae*
Leaf smut	*Entyloma oryzae*
Sheath spot	*Ophiobolus* sp.
Nematode diseases	
Ufra	*Ditylenchus angustus*
Root-knot	*Meloidogyne* sp.
White tip	*Aphelenchoides besseyii*
Stunting and root discoloration	*Hirschmaniella mucronatus*
Stunting and general declining	*Tylenchorhynchus* sp., *Pratylenchus* sp., *Helicotylenchus* sp., *Criconemoides* sp. *Xiphinema* sp.

Source: Bangladesh Rice Research Institute (1977)

Table 38

The most important pests in Bangladesh

Crops attacked	Pest
Non-weed pests	
Rice	1. Rice hispa (*Dicladispa armigera*) Brown planthopper (*Nilaparvata lugens*) 2. Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*) Sheath blight (*Corticium sasakii*) Rice blast (*Pyricularia oryzae*)
Weeds	
Rice	*Cyperus* spp. *Echinochloa* spp.

Table 39

Distribution of pesticides, Bangladesh

Financial year	Insecticides (t)	Soil-treating insecticides (t)	Acaricides (t)	Fungicides (t)	Rodenticides (t)	Herbicides (t)	Total (t)
1977	3004	49	3	81	5	21	3161
1978	2454	18	–	202	8	15	2696
1979	1406	16	–	85	3	2	1513
1980	1779	106	5	199	4	12	2106
1981	2217	44	20	14	2	2	2297
1982	1766	36	6	13	4	5	1829
1983	2400	26	20	62	3	36	2547
1984	2798	30	16	61	3	46	2954
1985	2826	29	42	70	5	70	3041

Source: BBS, *Yearbooks of Agricultural Statistics* 1982, 1983 and 1986; Navin and Khalil (1988)

Rats are the worst vertebrate pests. They cause most damage to deep-water rice, which is the only food available during deep floods. They are also a problem in wheat. Golden jackals chew sugar cane and eat water-melons.

The main weeds in rice are:

Upland rice (usually aus)
Echinochloa colona
Eleusine indica
Cyperus difformis
Cyperus iria

Transplanted rice
Monochoria spp.
Sphenoclea spp.
Echinochloa glabrescens
Echinochloa crusgalli
Cyperus difformis
Cyperus iria

Weed problems are worst in upland rice. With abundant and cheap labour, weeding is usually thorough and three to four weedings are done, although landlords with large farms sometimes neglect weeding. Weeding comprises a substantial proportion of rice production costs.

Broomrape (*Orobanche aegyptica*) is a parasitic weed of mustard and tobacco.

Section 13

The cropping systems in Pakistan

The seven cropping system zones into which Pakistan has been divided for the purpose of this study are shown in Figure 4.

Zones A, B and B_2 are plains with an elevation of less than 300 m. Zone C is an area of plains and low hills rising to about 1000 m. The remaining zones are areas of mountain and plateau rising to high elevation, interspersed with some lower elevation valleys. Irrigation is important in all zones except C. Rainfall is less than 500 mm in all zones except D, and over most of zones A, B, and F it is less than 250 mm.

Pakistan experiences great variation in temperature between winter and summer. In the plains, the temperature rises from 40 to 50°C in summer, but winters are cold and there are light frosts in Zones B, B_2 and C. In Zones D, E and F elevation is the most important factor determining temperature and cropping pattern; in winter, crops can only be grown in the lower valleys.

The relative importance of crops is given in Table 4. The basis of calculating production values is given in Appendix 2.

ZONE A

The western part borders Zones 13 and 14 in India. It is a sandy desert with little cultivation. Most of the remaining area is irrigated by an extensive canal system distributing the water from the River Indus. There are salinity problems in a number of areas, particularly in the south. Most of the groundwater is too saline for tubewells.

In the northern part of the zone lowest mean monthly temperatures fall to 2°C in winter; in summer, maximum temperatures reach 45–50°C. In the southern part of the zone temperatures are a little higher in winter and lower in summer.

With irrigation, crops can be grown the whole year round. Two crops a year are usually grown but with crops of shorter duration three crops per year are possible.

Table 4 shows the relative importance of crops. Wheat, rice, cotton and sugar cane are the most important. Cotton and rice are grown in the summer, wheat in the winter and sugar cane occupies the land in both seasons. The zone is the main producer of mango and chilli.

The number* of net sown hectares per tractor by province in 1984 was:

Punjab	82
North West Frontier Province	149
Sind	190
Baluchistan	215

* An approximation obtained by dividing the 1983–84 net sown area by the 1984 number of tractors (Government of Pakistan, 1988).

Nearly all Zone A is in Sind. Animals as well as tractors are used for draught power in this zone.

Population density in the irrigated areas is about 100–500 persons km^{-2}.

The level of input use is generally high. Table 40 shows the percentage of area sprayed by crop in the Sind. In Zone A and the rest of Pakistan, cotton, fruit and vegetables, and sugar cane are the main crops receiving plant protection measures.

Table 40

Percentage of cropped area covered by plant protection measures*, 1986–87

	Ground measures				Aerial spray
	Sind	Punjab	North West Frontier Province	Pakistan	Pakistan
Rice	2.4	4.9	5.9	3.9	3.9
Cotton	41.3	59.2	–	54.7	0
Sugar cane	16.6	8.3	23.9	12.2	14.3
Maize	–	4.4	1.3	2.6	0
Oilseeds	9.0	–	1.8	2.4	0
Fruit/Vegetables	26.8	38.8	58.5	39.2	10
Tobacco	–	–	32.7	17.9	0
Others	0.2	0.7	1.9	0.9	0
All crops	9.1	10.0	5.0	9.3	0.9

* 1–4 sprays applied to the areas given above.

ZONES B_1 AND B_2

The desert area of Zone A, bordering Indian Zone 14, extends north into the southeast part of Zone B_1. There is also a desert area between the Jhelum and the Indus rivers, west of Jhang. Most of the rest of B_2 is irrigated by a canal system with headworks on the Indus and its four large tributaries. There are also many tubewells. Zone B^2 is irrigated by canals from the Indus, Swat and Kabul rivers. In the Punjab, in 1986–87, 7.96 million hectares were irrigated by canal and 3.51 million hectares by tubewell, the major part of which was in Zone B_1.

Most cultivation work is done by tractor, although oxen and and buffaloes are also used. In 1984, there were approximately 82 net sown hectares per tractor in the Punjab, and the figure for Zone B_1 would be similar. This is also a zone of high input use. Plant protection measures for the Punjab, similar to those for B_1 are shown in Table 40. Cotton is the principal crop sprayed. The relative importance of crops is shown in Table 4. In B_1 the same four crops predominate as in Zone A, but both wheat (winter crop) and cotton (summer crop) are of greater importance. In Zone B_2, which covers Mardan, Peshawar, Swabi and Nowshera districts of the North West Frontier Province and the northern part of Attock district of the Punjab, sugar cane, maize, tobacco and fruit trees are more important and there is little cotton or rice.

Outside Lahore and the desert areas, population density is about 250–800 persons km^{-2}—the two most densely populated zones in Pakistan.

ZONE C

Zone C is a rainfed area. The annual rainfall is 750–1000 mm in the north west along the border with Kashmir, but it declines rapidly moving southwest to less than 250 mm in the long arm south of D.I. Khan. The relative importance

of crops is given in Table 4. Wheat is the main crop grown in the winter. This is the most important zone in Pakistan for chickpea.

Population density is 500–800 persons km^{-2} in the eastern extremity of the zone, decreasing to 70–130 in the southwest.

ZONE D

This covers Hazara and Malakand Divisions. Conditions are similar in the part of Kashmir under *de facto* Pakistani control along the eastern border of the zone. It is an area of mountains, hill slopes and valleys with a rainfall of over 750 mm in the southeast to 375–500 mm along the northeastern boundary with the northern areas (Zone E). Most of the valley bottoms are irrigated. In the upper reaches of the river valleys irrigation channels on the lower hill slopes are fed by melting snow from the high mountains. In Hazara and the lower Swat valley, crops grown on hill slopes are usually rainfed. Table 4 gives the relative importance of crops.

In summer, rice is the main crop in the lower valley, giving way to maize at higher altitude. Maize can be grown up to an altitude of about 2300 m. Potato is grown from about 1800–2600 m; the upper Swat valley is the largest area in the zone for potato cultivation. The upper Kaghan valley is important for seed potato.

Apple is the most important fruit crop; persimmon, apricot and plum are the other main fruits. Apple is grown at higher elevation and persimmon at lower elevation. Tomato, grown up to about 1500 m, is the most important vegetable in the other vegetable group. Turnip has been increasing in popularity in recent years as an alternative crop to potato.

Wheat is the main winter crop in the lower valleys. In winter the higher valleys are snow covered and only a summer crop can be grown.

Mean farm size is smaller than in Zones A and B. At higher elevations most holdings are 0.4 ha or less. Ploughing is usually done by tractor. Over most of the zone the population density is 150–250 persons km^{-2}, but in Chitral in the north of the zone, it is only 15–35 persons km^{-2}.

ZONE E

This is divided into two halves (Figure 4). There is some overlap of the north eastern half with Indian Zone 1; part of Zone E and India Zone 1 are disputed territory. Annual precipitation over most of this half of the zone is 125–250 mm. The southwestern half covers most of the tribal areas of the North West Frontier Province and the more populated part of Baluchistan; from the Parachinar salient to the northeastern border of this half of the zone annual precipitation is 125–375 mm. Over the whole zone some of the precipitation falls as snow in winter.

Most of the zone is above 1500 m. In the southern half, crops are cultivated up to about 2300 m, the limit of slope or irrigation facility. In the northern half, most of which is too high for crops, cultivation goes up to about 3200 m. In the northern half, channels fed from melting snow and glaciers are the main source of irrigation water. In Baluchistan, electric tubewells provide most of the irrigation. Their installation has lowered the water table so much that many of the ancient Kareze underground irrigation tunnels have run dry.

Table 4 shows the relative importance of crops. It is calculated from the crop production statistics of the relevant districts of the North West Frontier Province and Baluchistan as no statistics are published for the northern half of the zone. However, cropping patterns in both zones are fairly similar.

There were uncertainties over the area or price of crops so the table is not very reliable. However, it indicates correctly that Zone E is important for

temperate fruits, nuts and vegetables. The main growing areas of the North West Frontier Province/Baluchistan half of the zone for certain crops are indicated below:

Crop	Main growing area
Wheat	All
Maize	North West Frontier Province
Sugar cane	North West Frontier Province
Apple	Quetta Division
Almond	Quetta Division
Grape	Quetta Division
Apricot	Quetta Division
Potato	Kalat, Quetta Division
Onion	Kalat, Quetta Division

In Baluchistan many holdings are tenant operated.

Orchard crops have been displacing other crops in recent years, but as the latter (usually vegetables) are grown as an intercrop for three years after planting orchards, the full effect of the expansion of orchards on the cropping pattern is not yet apparent. Onion is often grown mixed with cumin.

The population density in Quetta Division and Kalat District of Baluchistan is 35–250 persons km^{-2}; in North West Frontier Province it is 70–300, and in the rest of the zone it is <15.

ZONE F

Elevation varies from sea level to 1800 m. Most of the zone is below 1000 m. Annual rainfall is <125 mm in the northwest and between 125 and 250 mm in the rest of the zone. The importance of dates reflects this semi-desert climate. Karachi occupies the southern tip of the zone. Elsewhere the population density is <15 persons per km^{-2}. This zone is of minor agricultural importance and little information was collected.

Section 14

Pest ranking in Pakistan

Pests are ranked by zone in Tables 41 to 47. Weeds are ranked separately in Table 48.

Respondents gave little importance to nematodes. The general low ranking or absence of nematodes may reflect the small input of nematologists and respondents lack of knowledge about this type of pest, rather than the true importance of nematodes.

Important pests in Pakistan as a whole include brown and yellow rust of wheat, bollworms and sucking insects of cotton, stemborers of various species in rice and sugar cane, aphids as sucking insects and virus vectors on wheat, vegetables and fruit trees, and termites, sparrows, parakeets, rats and wild boars (Table 49). Weeds are important in all zones and all crops, especially wheat.

Table 41

Pest ranking in Pakistan—Zone A

Rank	Pest	Crops attacked
1.	Brown rust (*Puccinia recondita*)	Wheat
	White-backed planthopper (*Sogatella furcifera*)	Rice
	Stemborer (*Scirpophaga incertulas,* etc.)	Rice
	Bollworm (various species)	Cotton (*H. armigera* other crops also)
	Sucking insects as a group:	
	whitefly (*Bemisia tabaci*, also vector of tomato leaf curl virus)	
	thrips (*Thrips tabaci, Scirtothrips dorsalis*)	
	jassid (*Amrasca biguttula*)	Cotton
2.	Stemborer (various species)	Sugar cane
	Aphid (*Rhopalosiphum maidis, etc*)	Wheat
	Wild boar (*Sus scrofa*) (more important than rodents)	Various
	Rodents (particularly *Bandicota bengalensis*)	Wheat, rice, sugar cane
3.	Damping off (*Pythium* spp.)	Chilli, vegetables
	Fruit fly (*Bactrocera* spp.)	Fruit trees, melon, mango, vegetables
	Sparrow (*Passer domesticus*)	Wheat, rice
4.	Root-knot nematode (*Meloidogyne* spp.)	Vegetables, banana, etc
	Burrowing nematode *(Radopholus similis)*	Banana
	Ratti disease	Rice
	Bacterial leaf blight (*Xanthomonas campestris* pv. oryzae)	Rice
	Leaf folder (*Cnaphalocrocis medinalis*)	Rice
	Whip smut (*Ustilago scitaminea*)	Sugar cane
	Mango leafhopper (*Idioscopus* spp., *Amritodus* spp.)	Mango
	Mealybug (*Drosicha mangiferae*)	Mango
	Collar rot (*Phytophthora capsicae*)	Chilli
	Aphid (various species)	Vegetables
	Bacterial leaf streak (*Xanthomonas campestris* pv. *oryzicola*)	Rice
	Tomato leaf curl virus	Chilli, tomato
	Parakeet (*Psittacula kremeri*)	Mango and other fruit

Table 41 (continued)

Rank	Pest	Crops attacked
5.	Wheat stemfly (*Atherigona* spp.)	Wheat
	Rice mealybug (*Ripersia oryzae*)	Rice
	Sugar cane planthopper (*Pyrilla perpusilla*)	Sugar cane
	Sugar cane viruses as a group: mosaic, streak, grassy stunt	Sugar cane
	Mite (*Eutetranychus orientalis*)	Cotton
	Scale (various species)	Mango, date
	Stem rot/black rot (*Oidium* sp.)	Banana
	Stemborer (*Batocera* spp.?)	Date
	Mosaic virus	Chilli
	Diamond-back moth (*Plutella xylostella*)	Crucifers
	Powdery mildew (*Oidium* sp.)	Guar
	Fusarium wilt (*Fusarium oxysporum*)	Guar

Table 42

Pest ranking in Pakistan—Zone B_1

Rank	Pest	Crops attacked
1.	Brown rust (*Puccinia recondita*)	Wheat
	Yellow rust (*Puccinia striiformis*)	Wheat
	Bollworm (various species)	Cotton
	Sucking insects as a group:	Cotton
	whitefly (*Bemisia tabaci*, also vector of cotton leaf curl and tomato leaf curl viruses)	
	thrips (*Thrips tabaci, Scirtothrips dorsalis*)	
	jassid (*Amrasca biguttula*)	
	Stemborer (*Scirpophaga incertulas*, etc.)	Rice
	Rodents (particularly *Bandicota bengalensis*)	Wheat, sugar cane, rice
2.	Sparrow (*Passer domesticus*)	Wheat, rice
	Termites (various species)	Wheat, sugar cane, chilli, chickpea
	Root rot/foot rot (*Cochliobolus sativus, Fusarium* spp.)	Wheat
	Aphid (*Rhopalosiphum maidis,* etc.)	Wheat (particularly southern Punjab)
	Green peach aphid (*Myzus persicae*)	Potato, wheat, fruits, vegetables
	Bacterial leaf blight (*Xanthomonas campestris* pv. *malvacearum*)	Cotton
	Root rot (various species)	Cotton
	Boll rot (*Colletotrichum gossypii*)	Cotton
	Leaf folder (*Cnaphalocrocis medinalis*)	Rice
	Leaf and planthoppers (*Nephotettix* spp.? *Nilaparvata lugens*?, *Sogatella furcifera*?)	Rice
	Soil fungi as a group:	Various
	Rhizoctonia spp., *Fusarium* spp., *Phytophthora* spp., *Macrophomina* spp.	
	Stemborer (various species)	Sugar cane
	Fruit fly (*Bactrocera* spp.)	Fruit, vegetables, melon
	Wild boar (*Sus scrofa*)	Wheat, rice, sugar cane
3.	Loose smut (*Ustilago nuda*)	Wheat
	Flag smut (*Urocystis agropyri*)	Wheat
	Rice blast (*Pyricularia oryzae*)	Rice (particularly Basmati 385)
	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
	Whitefly (*Aleurolobus barodensis*)	Sugar cane
	Sugar cane planthopper (*Pyrilla perpusilla*)	Sugar cane
	Red rot (*Glomerella tucumanensis*)	Sugar cane
	Sugarcane mosaic virus	Sugar cane
	Gurdaspur borer (*Raphimatophus ablutella*)	Sugar cane

Table 42 (continued)

Rank	Pest	Crops attacked
4.	Karnal bunt (*Tilletia indica*)	Wheat
	Mite (various species)	Cotton, vegetables, citrus
	Stem rot (*Magnaporthe salvinii*?)	Rice
	Brown leaf spot (*Cochliobolus miyabeanus*)	Rice
	False smut (*Ustilaginoidea virens*)	Rice
	Top borer (*Scirpophaga nivella*)	Sugar cane
	Smut (*Ustilago scitaminea*)	Sugar cane
	Red stripe (*Pseudomonas rubrilineans*)	Sugar cane
	Root borer (*Emmalocera depressela*)	Sugar cane
	Pokkahboeng (*Fusarium moniliforme*)	Sugar cane
	Porcupine	Sugar cane, maize, mango
	Parakeet (*Psittacula kremeri*)	Citrus, sunflower, mango, fruits
	Citrus greening (*Diaphorina citri* vector)	Citrus
	Red pumpkin beetle (*Rhaphidopalpa foveicollis*)	Vegetables, melon
	Downy mildew (*Peronospora* spp.)	Cucurbits, rape/mustard
	Powdery mildew (*Oidium* spp.)	Cucurbits, mango
	Stemborer (*Chilo partellus*)	Maize
	Ascochyta blight (*Ascochyta rabiei*)	Chickpea
	Cutworm (*Agrotis* spp.)	Various
	Canker (*Xanthomonas citri*)	Citrus
	Cabbage butterfly (*Crocidolomia binotalis*)	Crucifers
	Powdery scab (*Spongospora subterranea*)	Potato
	Common scab (*Streptomyces scabies*)	Potato
5.	Citrus psyllid (*Trioza erytreae*)	Citrus
	Leaf miner (*Phyllocnistis citrella*)	Citrus
	Tristeza virus	Citrus
	Citrus nematode (*Tylenchulus semipenetrans*) and die-back complex	
	Late blight (*Phytophthora infestans*)	Potato
	Virus (Potato leaf roll, potato virus X, potato virus Y	Potato
	Collar rot (*Phytophthora capsicae*)	Chilli
	Tomato mosaic virus	Tomato, chilli, brinjal
	Tomato leaf curl virus (whitefly, *Bemisia tabaci*, vector)	Chilli, tomato
	Brinjal fruit borer (*Leucinodes orbonalis*)	Brinjal
	Mango malformation (*Fusarium moniliforme*)	Mango
	Mango leafhopper (*Idioscopus* spp., *Amritodus* spp.)	Mango
	Mango decline	Mango
	Mango mealybug (*Drosicha mangiferae*)	Mango
	Root rot	Vegetables, chickpea
	Fusarium wilt (*Fusarium oxysporum* f. sp. *ciceris*)	Chickpea
	Mustard aphid (*Lipaphis erysimi*)	Rape/mustard
	Diamond-back moth (*Plutella xylostella*)	Crucifers

Table 43

Pest ranking in Pakistan—Zone B_2

Rank	Pest	Crops attacked
1.	Aphid (*mainly Myzus persicae, Rhopalosiphum maidis—M. persicae* a vector of potato leaf roll virus and potato virus Y)	Tobacco, fruit trees, wheat, maize, vegetables, potato
	Stemborer (various species)	Sugar cane
	Termites (various species)	Sugar cane, wheat, fruit
	Whitefly (*Bemisia tabaci*, also vector of leaf curl virus)	Maize, leaf curl of tobacco and tomato
	Cutworm (*Agrotis* spp.)	Tobacco, vegetables, potato
2.	Stemborer (*Chilo partellus,* etc.)	Maize
	Brown rust (*Puccinia recondita*)	Wheat
	Yellow rust (*Puccinia striiformes*)	Wheat
	Ratoon stunting disease (*Clavibacter xyli*)	Sugar cane
	Wilt (*Fusarium moniliforme*)	Sugar cane
	Trunk borer (*Sphenoptera laferei*)	Fruit trees
	Leaf blight (*Helminthosporium* spp.)	Maize
	Rodents (particularly *Bandicota bengalensis*)	Sugar cane, wheat, maize
	Wild boar (*Sus scrofa*)	Sugar cane, wheat, maize
3.	Birds as a group:	
	sparrow (*Passer domesticus*)	Wheat
	parakeet (*Psittacula kremeri*)	Fruit, maize
	Fruit fly (*Batrocera* spp.)	Fruit trees
	Mite (*Oligonychus indicus?, Schizotetranychus andropogoni?*)	Sugar cane
	Whip smut (*Ustilago scitaminea*)	Sugar cane
	Stemfly (*Atherigona* spp.?)	Maize, wheat
	Stalk rot (*Diplodia maydis*)	Maize
	Bollworm (*Helicoverpa armigera*)	Tobacco, maize
	Black shank (*Phytophthora nicotianae* v. *nicotianae*)	Tobacco
4.	Scale (various species)	Fruit trees
	Black rust (*Puccinia graminis*)	Wheat
	Loose smut (*Ustilago nuda*)	Wheat
	Tobacco mosaic virus	Tobacco
		Sugar cane
	Sugar cane planthopper (*Pyrilla perpusilla*)	Sugar cane
	Red rot (*Glomerella tucumanensis*)	Sugar cane
	Red pumpkin beetle (*Rhaphidopalpa foveicollis*)	Cucurbits
	Downy mildew (*Peronospora* spp.)	Vegetables
5.	Powdery mildew	Vegetables
	Root rots	Vegetables
	Cabbage butterfly (*Crocidolomia binotalis*)	Vegetables
	Armyworm (*Spodoptera* spp.)	Wheat
	Thrips (*Thrips tabaci*)	Onion, garlic

Table 44

Pest ranking in Pakistan—Zone C

Rank	Pest	Crops attacked
1.	Brown rust (*Puccinia recondita*)	Wheat
	Yellow rust (*Puccinia striiformis*)	Wheat
	Termites (various species)	Wheat, maize, groundnut
	Ascochyta blight (*Ascochyta rabiei*)	Chickpea
	Birds (particularly sparrow, *Passer domesticus*)	Cereals
2.	Flag smut (*Urocystis agropyri*)	Wheat
	Loose smut (*Ustilago nuda*)	Wheat
	Fusarium wilt (*Fusarium oxysporum*)	Chickpea, guar, etc.
	Mustard aphid (*Lipaphis erysimi*)	Rape/mustard, brassica
	Smut (*Spacelotheca* spp., *Tolyposporium ehrenbergii?*)	Sorghum
	Downy mildew (*Sclerospora graminicola*)	Pearl millet
	Leaf blight and stalk rot (various species)	Maize, sorghum, pearl millet
	Leaf spot (*Mycosphaerella arachidis, Mycosphaerella berkeleyi*)	Groundnut
	Fruit fly (*Batrocera* spp.)	Melon, fruits, vegetables
	Rodents as a group:	
	bandicoot rat (*Bandicota bengalensis*)	Groundnut, wheat
	short-tailed mole rat (*Nesokia indica*)	Wheat, groundnut
	gerbil (*Tatera indica*)	Wheat, groundnut, rice
	porcupine (*Hystrix indica*)	Maize, groundnut
3.	Bollworm (*Helicoverpa armigera*)	Chickpea, pigeon pea
	Foot rot (*Cochliobolus sativus, Fusarium* spp.)	Wheat
	Charcoal rot (*Macrophomina phaseolina*)	Sorghum, black gram, green gram
	Stemborer (*Chilo partellus*)	Maize, sorghum
4.	Wild boar (*Sus scrofa*)	Wheat, groundnut, sugar cane
	Shootfly (*Atherigona* spp.)	Maize
	Grasshopper	Sorghum, pearl millet
	Whitefly (*Bemisia tabaci*) vector of viruses	
	Yellow mosaic virus	Black gram, green gram
	Tomato leaf curl virus	Solanaceous crops
5.	Downy mildew (*Peronospora* spp.), powdery mildew (*Oidium* spp.)	Melon, cucurbits
	Tomato mosaic virus	Tomato, brinjal
	Sorghum aphid (*Rhopalosiphum sacchiri*)	Sorghum
	Diamond-back moth (*Plutella xylostella*)	Crucifers
	Cabbage butterfly (*Pieris brassicae* or *rapae*)	Crucifers
	Powdery mildew	Guar

Table 45

Pest ranking in Pakistan—Zone D

Rank	Pest	Crops attacked
1.	Stemborer (*Chilo partellus?*)	Maize
	Codling moth (*Cydia pomonella*)	Apple
2.	Turcicum leaf blight (*Setosphaeria turcica*)	Maize
	Cutworm (*Agrotis* spp.)	Maize, potato, vegetables
	Bollworm (*Helicoverpa armigera*)	Vegetables, maize
	Late blight (*Phytophthora infestans*)	Potato
	Aphid (*Myzus persicae* and vectored viruses)	Potato, fruit trees
	Scale (*Quadraspidiotus perniciosus*, etc.)	Fruit trees
	Root rot (various species)	Fruit trees
	Powdery mildew (*Podosphaera leucotricha*)	Fruit trees
	Stemborer (*Zeuzera* sp.?)	Apple and deciduous fruit trees
3.	Stalk rot (*Diplodia, Fusarium* spp.)	Maize
	Smut (*Ustilago zeae*)	Maize
	Brown rust (*Puccinia recondita*), yellow rust (*Puccinia striiformis*)	Wheat
	Scab (*Venturia inaequalis*)	Apple
	Mites (various species)	Fruit trees
	Citrus leaf miner (*Phyllocnistis citrella*)	Citrus
	Citrus psyllid (*Trioza erytreae*)	Citrus
	Stemborer (*Scirpophaga incertulas*, etc)	Rice
	Grasshopper	Rice
	Rice blast (*Pyricularia oryzae*)	Rice
	White-backed planthopper and others (*Sogatella furcifera*, etc)	Rice
	Tomato leaf curl virus (whitefly, *Bemisia tabaci*, vector)	Tomato
	Tomato mosaic virus	Tomato
	Root-knot nematode (*Meloidogyne* spp.)	Vegetables
	Mustard aphid (*Lipaphis erysimi*)	Rape/mustard and other brassicas
4.	Woolly aphid (*Eriosoma lanigerum*)	Apple
	Rodent (*Pika rufimeculata*)	Apple
	Fruit fly (*Bacracera* spp.)	Fruits and vegetables
	Powdery mildew (*Erysiphe graminis*)	Wheat
	Wild boar (*Sus scrofa*)	Wheat
	Bulb nematode (*Ditylenchus dipsaci*)	Onion
	Potato cyst nematode (*Globodera rostochiensis, Globodera pallida*)	Potato (5 km of valley north of Utrore in Upper Swat)
	Porcupine (*Hystrix indica*)	Maize, etc

Table 46

Pest ranking in Pakistan—Zone E

Rank	Pest	Crops attacked
1.	Codling moth (*Cydia pomonella*)	Apple
	Powdery mildew (*Podosphaera leucotricha*)	Apple
	Red spider mite (*Tetranychus cinnabarinus*)	Apple, tree crops, vegetables
	Scale (various species)	Almond, peach, plum
	Fusarium wilt (*Fusarium oxysporum*)	Potato, tomato, onion, cumin, cucurbits
2.	Stem canker (*Nectria galligena*)	Apple, tree crops
	San José scale (*Quadraspidiotus perniciosus*)	Apple
	Leaf miner (*Gracillaria zachrysa*)	Apple (particularly northern areas)
	Aphid (*Myzus persicae*) and vectored viruses	Tree crops, potato, vegetables
3.	Black aphid (*Pterochlorides persicae*)	Apple
	Jassid (various species)	Apple, grape, many field crops
	Sparrow (*Passer domesticus*)	Grape, sorghum, wheat
	Thrips (*Thrips tabaci*)	Onion
	Early blight (*Alternaria solani*)	Potato, chilli, brinjal
	Cutworm (*Agrotis* spp.)	Cucurbits, potato, tomato
	Powdery mildew (*Erysiphe* spp.)	Cucurbits
	Fruit fly (*Myiopardalis pardalina, Bactrocera cucurbitae, Bactrocera zonatus*)	Melon, fruits
4.	Lagomorph *(Pika rufimeculata)*	Apple (particularly Ziarat)
	Powdery mildew (*Uncinula necator*)	Grape
	Mealybug (*Planococcus citri*)	Grape
	Tomato leaf curl virus (whitefly, *Bemisia tabaci*, vector)	Tomato
	Tomato mosaic virus	Tomato
	Stemborer (*Chilo suppressalis, Sesamia inferens*)	Maize, sorghum
	Turcicum leaf blight (*Setosphaeria turcica*)	Maize
	Grain smut (*Sphacelotheca* spp?, *Tolyposporium ehrenbergii?)*	Sorghum
	Complete (Hill) bunt (*Tilletia laevis)*	Wheat
	Yellow rust (*Ustilago striiformis*)	Wheat
	Smut (*Ustilago* spp.)	Barley, wheat
	Bollworm (*Helicoverpa armigera*)	Various
5.	Porcupine (*Hystrix indica*)	Vegetables, potato, maize
	Potato tuber moth (*Phthorimaea operculella*)	Potato
	Rhopalosiphum maidis and other aphids	Cereals
	Brown rust (*Puccinia recondita*)	Wheat
	Gerbil (*Tatera indica*)	Wheat
	Jird (*Meriones hurrianae*)	Wheat
	Wild boar (*Sus scrofa*)	Wheat, maize
	Loose smut (*Ustilago nuda*)	Barley
	Fruit rot (*Zythia versoniana*)	Pomegranate

Table 47

Pest ranking in Pakistan—Zone F

Rank	Pest	Crops attacked
1.	Scale	Date
	Stemborer (*Batocera* spp.)	Date
2.	Complete (Hill) bunt (*Tilletia laevis*)	Wheat
	Yellow rust (*Ustilago striiformis*)	Wheat
	Powdery mildew (*Erysiphe graminis*)	Wheat
	Sun pest (*Eurygaster integriceps*)	Wheat
	Thrips (*Thrips tabaci*)	Onion
	Fusarium wilt (*Fusarium oxysporum*)	Onion
	Grasshopper	All
3.	Fruit flies (*Batrocera* spp.)	Curcurbits
4.	Whitefly (*Bemisia tabaci*)	Banana, vegetables
	Rodents	Various

Table 48

Ranking of the most important weeds in Pakistan

Rank	Weed	Principal crops affected
Zone A		
1.	*Convolvulus arvensis*	Wheat
	Phalaris minor	Wheat
	Cyperus rotundus	Rice, cotton, sugar cane, vegetables
2.	*Trianthema monogyna*	Cotton, vegetables, sugar cane
	Chenopodium album, Chenopodium murale	Wheat
	Echinochloa spp.	Rice
	Cynodon dactylon	Rice
	Asphodelus tenuifolius	Wheat
	Fimbristylis littoralis	Rice
Zone B_1		
1.	*Phalaris minor*	Wheat (in wheat/rice system)
	Avena fatua	Wheat
	Cyperus spp. (particularly *Cyperus rotundus*)	Cotton, rice, sugar cane, vegetables, maize
	Trianthema monogyna	Cotton, sugar cane, vegetables, potato, maize
2.	*Convolvulus arvensis*	Wheat
	Chenopodium album, Chenopodium murale	Wheat, chickpea
	Sorghum halepense	Cotton
3.	*Fumeria* spp.	Wheat
4.	*Echinochloa* spp.	Rice
	Fimbristylis littoralis	Rice
	Asphodelus spp.	Vegetables, rape/mustard
Zone B_2		
1.	*Avena fatua*	Wheat
	Lolium spp.	Wheat
	Perennial grasses	Sugar cane
2.	*Digitaria* spp.	Maize
	Orobanche sp.	Tobacco
	Carthamus oxycantha	Wheat
Zone C		
1.	*Carthamus oxycantha*	Wheat
2.	*Convolvulus arvensis*	Wheat
	Sorghum halepense	All, particularly summer crops
Zone D		
1.	*Cyperus rotundus*	Annual crops
2.	*Sorghum halepense*	Annual crops
Zone E		
1.	*Alhagi maurorum*	All crops
2.	*Orobanche aegyptica*	Solanaceous crops and cucurbits
	Cuscuta spp.	Onion, grape, alfalfa
	Bellevalia spp.	Various, particularly Loralai area

Table 49

The main pests in Pakistan

Crops attacked	
Non-weed pests	
Wheat	Brown rust (*Puccinia recondita*) Yellow rust (*Puccinia striiformis*)
Cotton	Bollworm (various species) Sucking insects as a group: jassid (*Amrasca biguttula*) thrips (*Thrips tabaci, Scirtothrips dorsalis*) whitefly (*Bemisia tabaci*—also transmits virus on tomato and chilli)
Rice	Yellow stemborer (*Scirpophaga incertulas*)
Sugar cane	Stemborer (various species)
Various crops	Bandicoot rat (*Bandicota bengalensis*) Wild boar (*Sus scrofa*) Sparrow (*Passer domesticus*) and parakeets (*Psittacula kremeri*) Aphid (various species) Termites (various species)
Weeds	
Wheat	*Phalaris minor*
Cotton, sugar cane, vegetables, maize	*Cyperus rotundus*—also in rice *Trianthema monogyna*—also in potato

Section 15

The relative importance of rice pests across zones

The basic methodology for this study was to treat each zone separately. It would also be useful, however, to get an overview of the pest situation in the whole region or in one large part of it, such as India. It is possible to do this by converting pest ranks into scores, weighting those scores by the value of the zonal production of the crop attacked, aggregating the weighted scores and then comparing them. The weakness of such a scheme is that the scoring system has to assume that in all zones pests of the same rank have the same economic cost expressed as a percentage of the zonal crop production value. In fact there is some variation.

For most classes of pests this scoring and weighting procedure was thought to be too inaccurate to attempt, but it was considered worthwhile with rice. Rice pests being relatively more common, the greater number of weighted scores making up each aggregate score will reduce the effect of variation in percentage economic importance of pests in the same rank. The system is considered to be valid as a means of 'crude' ranking in which large differences in aggregate scores will reflect real differences in importance, but is not suitable for 'fine tuning' and small differences in aggregate scores would not be significant.

The system starts by converting the ranks which reflect ranking amongst all pests to ranks which reflect ranking amongst rice pests only. The highest ranking rice pest is given a rank of one. If its original rank amongst all pests is x, then $x-1$ is subtracted from the rank of all other rice pests to give their rank amongst rice pests only. Scores are then assigned from 5 to 1, the first rank scoring 5 and the fifth rank 1. The example of Indian Zone 15 illustrates the procedure:

	Rank amongst all pests	**Rank amongst rice pests**	**Score**
Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	2	1	5
Rice blast (*Pyricularia oryzae*)	3	2	4
Yellow stemborer (*Scirpophaga incertulas*)	4	3	3
Leaf folder (*Cnaphalocrocis medinalis*)	5	4	2

These scores are then weighted by the value of rice production in the zone in millions of Indian rupees.

Results of this procedure are shown in Tables 50–52; Table 52 gives the detailed calculations. It is emphasized that weeds are excluded from the analysis. The results for South Asia (Table 50) show that four pests have scores considerably higher than the rest. These are rice blast, yellow stemborer, bacterial leaf blight and brown planthopper (*Nilaparvata lugens*). The rice blast and yellow stemborer scores are higher than the other two. On the basis of these scores, we can say with considerable confidence that rice blast, yellow

stemborer, bacterial leaf blight and brown planthopper are the four most serious rice pests in South Asia and that rice blast and yellow stemborer are probably the worst two.

The rest of the table shows the importance of the other pests with large differences in score indicating real differences in importance. However, there were considerable differences between respondents in their rankings which reduce confidence in the comparisons within this part of the table. Green leafhopper/tungro, rice hispa and gall midge receive widespread support as important pests but leaf folder, sheath blight and rice root nematode were not ranked at all by some important respondents in India, as explained below.

Table 51, the ranking list for India, is headed by the same four pests which are ranked most highly in South Asia as a whole. They are in the same order, with rice blast and yellow stemborer ranked considerably higher than the other two. However, brown planthopper has lost some importance as in Table 50 220 of its 617 points were accounted for by its place in the first rank in Bangladesh.

There were seven respondents ranking rice pests in India*. The differences between two of the important sets of respondents were analysed by calculating pest aggregate ranking scores separately for each set. These two sets were the ICAR panel revising the Directorate of Plant Protection (DPP)'s rankings, and the Directorate of Rice Research Panel (DRR). Both sets agreed that the most serious five pests were the four leading pests in Table 51, plus the gall midge. The ICAR/DPP panel ranked the gall midge fifth, and the DRR panel ranked it fourth with the brown planthopper in fifth place. Neither ranked the rice root nematode highly. The ICAR/DPP panel made no mention of the rice root nematode, leaf folder, brown leaf spot, sheath rot, false smut, or sheath blight, all of which were ranked by the DRR panel. The fewer rice pests included by the ICAR/DPP panel in comparison to those ranked by the DRR panel can partly be accounted for by the ICAR/DPP panel ranking all crops, in contrast to the DRR panel of rice specialists ranking rice pests only. The high ranking of the rice root nematode in Table 51 depended almost entirely on the assessment of the IARI Department of Nematology.

The Directorate of Rice Research reported that rice blast was not confined to rainfed upland rice but was also important in rainfed lowland and irrigated rice in several zones.

A safe interpretation of Table 51 would be that in India rice blast, yellow stemborer and bacterial leaf blight are the three most serious pests and the brown planthopper and gall midge are amongst the next three most important pests. The remaining rankings in Table 51 are subject to considerable differences between the various respondents and so are considered less reliable.

It should be remembered that weeds are also highly important pests of rice, both in terms of yield loss and the cost of control. *Echinochloa* spp. are the most important weeds of rice in both India and South Asia as a whole.

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*Directorate of Plant Protection (DPP) panel
Indian Council of Agricultural Research (ICAR) panel
Directorate of Rice Research (DRR) panel
Plant Protection Training Institute panel
Indian Agricultural Research Institute (IARI), Pathology Department (Diseases)
Indian Agricultural Research Institute (IARI), Nematology Department (Nematodes)
Central Rice Research Institute, Cuttack (suggested revised insect pest rankings by letter after being sent synthesis of other respondents rankings)

Table 50

Relative importance of rice pests in South Asia

Pest	Aggregate weighted score
Rice blast (*Pyricularia oryzae*)	880
Yellow stemborer (*Scirpophaga incertulas*)	846
Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	709
Brown planthopper (*Nilaparvata lugens*)	617
Greenleaf hopper (*Nephotettix virescens*) or Tungro virus or green leafhopper + tungro	411
Rice hispa (*Dicladispa armigera*)	395
Leaf folder (*Cnaphalocrocis medinalis*)	366
Gall midge (*Orseolia oryzae*)	362
Sheath blight (*Corticium sasakii*)	322
White-backed planthopper (*Sogatella furcifera*)	315
Root nematode (*Hirschmanniella oryzae*)	299
Ufra disease (*Ditylenchus angustatus*)	275
Sheath rot (*Sarocladium oryzae*)	251
Brown leaf spot (*Cochliobolus miyabeanus*)	220
Gundhi bug (Rice bug) (*Leptocorisa* sp.)	190
False smut (*Ustilaginoidea virens*)	153
Root-knot nematode (*Meloidogyne* spp.)	131
White tip nematode (*Aphelenchoides besseyi*)	114

Table 51

Relative importance of rice pests in India

Pest	Aggregate weighted score
Rice blast (*Pyricularia oryzae*)	670
Yellow stemborer (*Scirpophaga incertulas*)	659
Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	510
Brown planthopper (*Nilaparvata lugens*)	362
Root nematode (*Hirschmanniella oryzae*)	299
Gall midge (*Orseolia oryzae*)	298
Green leafhopper (*Nephotettix virescens*)/tungro	257
Leaf folder (*Cnaphalocrocis medinalis*)	229
White-backed planthopper (*Sogatella furcifera*)	206
Rice hispa (*Dicladispa armigera*)	175
Brown leaf spot (*Cochliobolus miyabeanus*)	165
Sheath rot (*Sarocladium oryzae*)	163
Ufra disease (*Ditylenchus angustatus*)	143
False smut (*Ustilaginoidea virens*)	142
Root-knot nematode (*Meloidogyne* spp.)	131
Sheath blight (*Sarocladium oryzae*)	127
Gundhi bug (Rice bug) (*Leptocorisa* sp.)	126
White tip nematode (*Aphelenchoides besseyi*)	70

Table 52

Calculation of scores indicating relative importance of main rice pests:
— in India
— in India + Bangladesh + Pakistan + Sri Lanka

Zone	Zonal weighting* (billion Indian rupees)	Rice blast		Bacterial leaf blight		Brown planthopper		Rice hispa		Yellow stemborer		Green leafhopper/ tungro		Gall midge		Root nematode	
		S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W
India																	
1	2.3	5	11.5	4	9.2			4	9.2	4	9.2						
2	12.4	5	62					5	62	5	62					2	24.8
3	18.5	5	92.5	5	92.5	4	74	5	92.5	5	92.5	4	74			3	55.5
4	16.4	5	82	5	82					5	82	5	82			2	32.8
5	7.8			5	39					4	31.2					3	23.4
6	17.4	5	87	4	69.6					3	52.2					2	34.8
7	22.2	5	111	2	44.4	5	111			4	88.8	2	44.4	5	111	2	44.4
8	2.0			5	10									5	10		
9	1.8			5	9					5	9						
10	11.0	4	44	3	33	3	33	1	11	5	55			4	44	2	22
11	25.7	5	128.5	4	102.8	4	102.8			5	128.5	1	25.7	4	102.8	2	51.4
12	10.2	5	51	1	10.2	4	40.8			4	40.8	3	30.6	3	30.6	1	10.2
13	1.5			5	7.5					5	7.5						
14	0																
15	0.07	4	0.28	5	0.35					3	0.21						
Total for India			669.78		509.55		361.6		174.7		658.91		256.7		298.4		299.3
Bangladesh	44	4	176	4	176	5	220	5	220	3	132	3	132	1	44		
Sri Lanka																	
1	0.3	5	1.5														
2	1	4	4			2	2							4	4		
3	1.2	2	2.4			3	3.6			3	3.6			5	6		
4	2.5	4	10			5	12.5			3	7.5	2	5	4	10		
Pakistan																	
A	3.2			2	6.4					5	16						
B	5.6	3	16.8	3	16.8	3	16.8			5	28	3	16.8				
Total for India, Bangladesh, Pakistan and Sri Lanka			880		709		617		395		846		411		362		299

Table 52 (continued)

Zone	Zonal weighting* (billion Indian rupees)	White-backed planthopper		Ufra disease		Root-knot nematode		Brown leaf spot		False smut		Leaf folder		Sheath rot		White tip nematode	
		S	W	S	W	S	W	S	W	S	W	S	W	S	W	S	W
India																	
1	2.3	4	9.2														
2	12.4			5	62	1	12.4										
3	18.5			3	55.5	2	37							2	37		
4	16.4							4	65.6	4	65.6						
5	7.8	4	31.2					5	39	4	31.2						
6	17.4	4	69.6					3	52.2	2	34.8	3	52.2	3	52.2		
7	22.2	4	88.8			2	44.4					3	66.6	1	22.2	1	22.2
8	2.0							4	8					4	8		
9	1.8																
10	11.0					1	11					3	33	2	22	2	22
11	25.7			1	25.7	1	25.7					3	77.1			1	25.7
12	10.2									1	10.2			2	22		
13	1.5	5	7.5														
14	0																
15	0.07												0.14				
Total for India			206.3		143.2		130.5		164.8		141.8		229.04		163.4		69.9
Bangladesh	44	2	88	3	132			1	44			2	88	2	88	1	44
Sri Lanka																	
1	0.3																
2	1											5	5				
3	1.2											4	4.8				
4	2.5											4	10				
Pakistan																	
A	3.2	5	15.6									2	6.4				
B	5.6	1	5.6					2	11.2	2	11.2	4	22.4				
Total for India, Bangladesh, Pakistan and Sri Lanka			315		275		131		220		153		366		251		114

Table 52 (continued)

Zone	Zonal Weighting* (billion Indian rupees)	Sheath blight S	Sheath blight W	Gundi bug (Rice bug) S	Gundi bug (Rice bug) W
India					
1	2.3				
2	12.4				
3	18.5				
4	16.4			5	82
5	7.8				
6	17.4	4	69.6		
7	22.2			2	44.4
8	2.0				
9	1.8				
10	11.0	1	11		
11	25.7	1	25.7		
12	10.2	2	20.4		
13	1.5				
14	0				
15	0.07				
Total for India			127		126
Bangladesh	44	4	176	1	44
Sri Lanka					
1	0.3	5	1.5		
2	1	4	4	5	5
3	1.2	5	6	4	4.8
4	2.5	3	7.5	4	10
Pakistan					
A	3.2				
B	5.6				
Total for India, Bangladesh, Sri Lanka and Pakistan			322		190

S = Score determined by rank W = Weighted scores
*Zonal weight equals value of rice production in the zone in billions of Indian rupees
Source: Surbey by A.M.W. Geddes, NRI, January/February 1990 of respondents ranking estimates

Section 16

The relative importance of wheat pests across zones

The relative importance of wheat pests across zones was analysed using the same methodology as for rice pests (Section 15). Table 55 shows the calculations and Tables 53 and 54 the weighted scores by which the importance of pests was compared between India and South Asia. Weeds are excluded.

For India, brown rust and loose smut stand out clearly as the two most serious pests, followed by termites and karnal bunt (Table 53). The remaining pests, led by ear cockle (caused by the nematode *Anguina tritici*) and yellow rust, have a fairly steady reduction in scores down to flag smut, leaving powdery mildew and hill bunt of little importance for India as a whole. Amongst the ear cockle to flag smut group, differences in score will be less reliable as indicators of real difference in importance.

The respondents ranking wheat pests in India were the same as those who responded for rice pests, with the Wheat Project Directorate (IARI) substituted for the Directorate of Rice Research (see Section 15). There was rather less disagreement over the ranking of wheat pests than for rice pests.

Table 54 shows the relative importance for South Asia with brown rust and loose smut once again the predominant pests. Termites, yellow rust and karnal bunt form a clear group next in importance. The remaining pests have steadily declining scores, with powdery mildew, hill bunt and birds of minor importance.

Rodents have some importance as wheat pests in Bangladesh and the main Pakistan wheat zone B, but respondents did not mention them in India. It seems probable that they were overlooked in India and so the importance of rodents (chiefly rats) is probably under-rated.

The analysis above excludes weeds but they are very important pests of wheat. *Phalaris minor* is the most serious overall.

Table 53

Relative importance of wheat pests in India

Pest	Weighted score
Brown rust (*Puccinia recondita*)	378
Loose smut (*Ustilago nuda*)	311
Termites (various species)	208
Karnal bunt (*Tilletia indica*)	178
Ear cockle (*Anguina tritici*)	130
Yellow rust (*Puccinia striiformis*)	124
Stemborer (*Sesamia inferens*)	105
Climbing cutworm (*Mythimna spp.*)	92
Black rust (*Puccinia graminis*)	82
Molya disease (*Heterodera avenae*)	71
Leaf blight (*Alternaria triticina*)	71
Foot rot/root rot (*Fusarium* spp., *Cochliobolus sativus*)	66
Flag smut (*Urocystis agropyri*)	57
Powdery mildew (*Erysiphe graminis*)	13
Hill (or complete) bunt (*Tilletia laevis*)	13

Table 54

Relative importance of wheat pests pests in South Asia

Pest	Weighted score
Brown rust (*Puccinia recondita*)	498
Loose smut (*Ustilago nuda*)	374
Termites (various species)	269
Yellow rust (*Puccinia striiformis*)	227
Karnal bunt (*Tilletia indica*)	213
Foot rot/root rot (*Cochliobolus sativus, Fusarium* spp.)	143
Ear cockle (*Anguina tritici*)	130
Flag smut (*Urocystis agropyri*)	118
Stemborer (*Sesamia inferens*)	105
Climbing cutworm (*Mythimna* spp.)	92
Aphid (*Rhopalosiphum maidis*)	85
Black rust (*Puccinia graminis*)	82
Rodents	73
Molya disease (*Heterodera avenae*)	71
Leaf blight (*Alternaria triticina*)	71
Wild boar (*Sus scrofa*)	45
Powdery mildew (*Erysiphe graminis*)	15
Hill (or complete) bunt (*Tilletia laevis*)	15
Birds	10

Table 55

Calculation of scores indicating relative importance of main wheat pests (excluding weeds)

Zone	Weighting (billion Indian rupees)	Loose smut		Brown rust		Yellow rust		Powdery mildew		Hill blunt		Molya disease	
		S	W	S	W	S	W	S	W	S	W	S	W
India													
1	2.58	5	12.9	4	10.3	4	10.3	5	12.9	5	12.9	4	10.3
2	0.36												
3	1.16			4	4.6								
4	12.13	3	36.4	5	60.7								
5	18.48	5	92.4	5	92.4								
6	28.53	5	142.7	4	114.1	4	114.1					2	57.1
7	0.60												
8	13.36	2	26.7	5	66.8								
9	3.24			5	16.2								
10	0.33												
11	–												
12	–												
13	1.93			5	9.7								
14	0.73			4	2.9							5	3.7
15	–												
Total for India			311.1		377.7		124.4		12.9		12.9		71.1
Bangladesh	2.51												
Pakistan													
A	3.7			5	18.5								
B_1	17.64	3	52.9	5	88.2	5	88.2						
B_2	0.43												
C	2.11	4	8.4	5	10.6	5	10.6						
D	0.52			4	2.1	4	2.1	4	2.1				
E	0.33	4	1.3	4	1.3	5	1.7			5	1.7		
F	0.1												
Total for Bangladesh and Pakistan			62.6		120.7		102.6		2.1		1.7		0
Total for South Asia			373.7		498.4		227		15		14.6		71.1

Table 55 (continued)

Zone	Weighting (billion Indian rupees)	Leaf blight		Ear cockle		Karnal bunt		Termites		Stemborer		Climbing cutworm	
		S	W	S	W	S	W	S	W	S	W	S	W
India													
1	2.58												
2	0.36												
3	1.16	5	5.8										
4	12.13	4	48.5	3	36.4								
5	18.48			2	37	5	92.4	3	55.4	2	37	2	37
6	28.53			1	28.3	3	85.6	2	57.1	1	28.3	1	28.3
7	0.60												
8	13.36			2	26.7			5	66.8	3	40.1	2	26.7
9	3.24	5	16.2					5	16.2				
10	0.33												
11	–												
12	–												
13	1.93							5	9.7				
14	0.73			2	1.5			4	2.9				
15	–												
Total for India			70.5		129.9		178		208.1		105.4		92
Bangladesh	2.51												
Pakistan													
A	3.7												
B_1	17.64					2	35.3	3	52.9				
B_2	0.43												
C	2.11							4	8.4				
D	0.52												
E	0.33												
F	0.1												
Totals for Bangladesh and Pakistan			0		0		35.3		61.3		0		0
Total for South Asia			70.5		129.9		213.3		269.4		105.4		92

Table 55 (continued)

Zone	Weighting (billion Indian rupees)	Flag smut		Foot rot/root rot		Black rust		Aphid		Birds		Rodents		Wild boar	
		S	W	S	W	S	W	S	W	S	W	S	W	S	W
India															
1	2.58														
2	0.36														
3	1.16														
4	12.13														
5	18.48														
6	28.53	2	57.1												
7	0.60														
8	13.36			4	53.4	4	53.4								
9	3.24			4	13	5	16.2								
10	0.33														
11	–														
12	–														
13	1.93					5	9.7								
14	0.73					4	2.9								
15	–														
Total for India			57.1		66.4		82.2		0		0		0	0	
Bangladesh	2.51									4	10	5	12.5		
Pakistan															
A	3.7							4	14.8			2	7.4		
B_1	17.64	3	52.9	4	70.6			4	70.6			3	52.9		
B_2	0.43														
C	2.11	4	8.4	3	6.3										
D	0.52														
E	0.33														
F	0.1														
Totals for Bangladesh and Pakistan			61.3		76.9		0		85.4		10		72.8		
Totals for South Asia			118.4		143.3		82.2		85.4		10		72.8		

S = Score determined by rank W = Weighted score

Section 17

Conclusion

THE MAIN PESTS IN SOUTH ASIA

Summaries of the main pests in each country are given at the end of Sections 6, 8, 10, 12 and 14. Taking account of the pest ranks and the value of crops, and using the same process of analysis as in the country summaries, Table 56 shows the main pests in South Asia as a whole.

Table 56

The main pests in South Asia*

	Pest	Crops attacked
1.	The most serious pests in South Asia	
	Rice blast (*Pyricularia oryzae*)	Rice
	Yellow stemborer (*Scirpophaga incertulas*)	Rice
	Bacterial leaf blight (*Xanthomonas campestris* pv. *oryzae*)	Rice
	Brown planthopper (*Nilaparvata lugens*)	Rice
	Echinochloa spp. (weed)	Rice
	Cyperus spp. (weed)	Rice, other crops
	Phalaris minor (weed)	Wheat
2.	The second most important group of pests in South Asia	
	Non-weed pests	
	Green leafhopper (*Nephotettix* spp.) combined with tungro virus	Rice
	Rice hispa (*Dicladispa armigera*)	Rice
	Leaf folder (*Cnaphalocrocis medinalis*)	Rice
	Gall midge (*Orseolia oryzae*)	Rice
	Brown rust (*Puccinia recondita*)	Wheat
	Loose smut (*Ustilago nuda*)	Wheat
	Bollworm (*Helicoverpa armigera* and other species)	Cotton (*H. armigera* also other crops)
	Jassid (*Amrasca biguttula*)	Cotton
	Whitefly (*Bemisia tabaci*, also virus vector infecting other crops)	Cotton
	Stemborer (various species)	Sugar cane
	Root-knot nematode (*Meloidogyne* spp.)	Various
	Weeds	
	Trianthema monogyna, T. portulacastrum	Various
	Chenopodium album, C. murale	Wheat
	Avena fatua, A. ludoviciana	Wheat

*Excludes rodents, wild boar and birds

FUTURE WORK

Revision and updating of this study

This study could be further refined by obtaining ranking assessments from a wider range of experienced informants. Accordingly, reactions to this *Bulletin* are invited; a format for suggesting changes to the rankings is included as Appendix 3. Such changes could either be suggested because the original

assessment is considered incorrect or because a change in the actual pest situation has occurred. If enough revisions accumulate a revised edition of the *Bulletin* will be issued. Until that time any readers who wish to update can write to the Head of Pest and Vector Economics Section, at the Natural Resources Institute.

Further studies

This was a regional study with a wide scope carried out in a short time. Individual countries may wish to pursue the study in greater depth in a manner directly related to their national concerns. Selected respondents could be asked to review research in various fields before making rankings and the study directors could carry out a general literature review. After some initial analysis of rankings, respondents could be given the chance to resolve major differences of judgement and an attempt made to get a closer consensus before making the final synthesis. The pest situation could also be related more directly to different farming systems and classes of farmer and to the control measures and their effectiveness. More attempts could be made to investigate how and why the pest situation has been changing and to predict future trends. Pests could also be ranked for each crop separately as well as in combination, as some detail of rankings applicable to an individual crop tends to be lost in ranking across all crops and the minor crops receive inadequate coverage. The study could be extended to post-harvest pests and the importance of vertebrate pests investigated more thoroughly.

It is the intention that the Natural Resources Institute extends this series of studies to Southeast Asia. The initial area of study will be Indonesia.

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Appendices

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Discussions with representative of the Central Cotton Research Institute, Multan, M. Rafiq Attaque, Entomologist.
Discussions with representative of Agricultural Research Institute, Sariab, Baluchistan, Abdul Hakim Khan, Entomologist.

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APPENDIX 2 CALCULATION OF ZONAL CROP PRODUCTION VALUES IN PAKISTAN

General

Values were calculated as far as possible from 1985–86 production figures multiplied by 1987 prices, the most up to date statistics available. Production figures were taken from the Government of Pakistan (1987) and the price figures from the Government of Pakistan (1988) part J, using the price at the nearest buying centre to the zone. The actual prices used are shown in Table A. When prices were not quoted for a crop, a 'guestimate' was used, based in some cases on the price of similar crops.

In the case of maize, sorghum and pearl millet, values based on the price of grain were multiplied by 1.3 to allow for the greater value of plant residue for fodder compared to other crops.

Production values as percentages of the total zonal production value of crops listed are shown in Table 4. Crops with production values less than 1% of the zonal total were omitted.

Zone A

Sind Province production figures were used to represent the zone, ignoring any differences in relative importance of crops between Sind and the two Baluchistan districts, Nasirabad and Kachhi. As the latest provincial statistics available are more recent than the district statistics, 1987–88 production figures were used.

Zone B_1

Production was calculated by subtracting Rawalpindi Division figures from those of Punjab Province.

Zone B_2

The figures for Peshawar Division were used, ignoring the small part of the zone in northern Attock District.

Zone C

Production was calculated as the sum of the production of Rawalpindi, Kohat and D. I. Khan Divisions, plus Khusab and Mianwali Districts. The production statistics for D. G. Khan and Rajanpur were not used as they included too much production from the irrigated areas near the Indus river outside the zone. Staff of the Pakistan Agricultural Research Council familiar with the zone, advised that the sorghum and pearl millet production figures were much too low. These were increased from 142 to 469 million rupees for sorghum and from 117 to 346 million rupees for pearl millet to give percentages considered to reflect their importance.

Zone D

Production was calculated as the sum of the figures for Hazara and Malakand Divisions.

Zone E

As no statistics are available for the northern areas, production was calculated by adding the figures for the tribal areas of NorthWest Frontier Province to the relevant parts of Baluchistan, i. e. , Quetta Division minus Chagai District, plus Kalat, Khuzdar and Kohlu Districts. As the sorghum production figures were considered to be too low they were increased to give the same production value as wheat.

Zone F

Production was calculated by adding the figures for Mekran Division and Kharan, Lasbella and Chagai Districts. Chagai figures are used in both Zones E and F as the district is split between the two zones.

Table A

Prices (in Rs/kg) used in calculating value of zonal crop production in Pakistan

Crop	A	B_1	B_2	C	D	E	F
Wheat	2.11	2.245	2.107	2.245	2.107	1.92	1.92
Rice (Basmati)	—	6.625	7.34	6.63	7.34	—	—
Rice (IRRI and other)	2.51	2.9	2.99	2.9	2.99	2.38	2.38
Maize	3.33	2.5	2.088	2.088	2.088	3.33	—
Sorghum	3.33	—	—	2.088	—	3.33	3.33
Pearl millet	3.33	—	—	2.088	—	—	—
Barley	—	—	2.107	2	2.107	1.92	—
Chickpea	3.45	—	3.93	3.93	3.44	—	—
Black gram	—	7.55	—	7.55	8.25	—	—
Green gram	5.5	6.15	—	6.15	6.17	6.15	—
Lathyrus	5.5	—	—	—	—	—	—
Other pulses	4.25	—	—	—	—	—	—
Potato	—	2	2	2	2.5	2.5	2.5
Other vegetables	3	3	3	3	3	3	—
Sugar cane	0.3	0.288	0.288	0.288	0.288	0.288	0.3
Chilli	16	—	—	—	—	16	—
Garlic	—	—	10	—	10	—	—
Onion	2.34	2.9	2.9	2.9	2.9	2.76	2.76
Rape/mustard	5	5	4	4	4	5	—
Groundnut	—	6.15	6.15	6.15	—	—	—
Castor	—	—	—	—	—	—	3
Tobacco (RS/ha)	—	—	22870	—	22870	22870	—
Mango	2	2	2	—	—	—	2
Citrus	2	2	2	—	2	2	2

Table A (continued)

Crop	A	B_1	B_2	C	D	E	F
Banana	2	2	2	—	—	—	2
Guava	—	—	—	—	—	—	2
Date	5	—	—	—	—	5	5
Apple	—	—	—	—	10	10	—
Apricot	—	—	—	—	—	8	—
Grape	—	—	—	—	—	8	—
Pomegranate	—	—	—	—	—	7	—
Peach	—	—	—	—	—	8	—
Plum	—	—	—	—	—	7	—
Almond	—	—	—	—	—	22	—
Other fruits not valued separately in the zone	—	2	8	—	8	—	—

APPENDIX 3 FORMAT FOR SUGGESTED CHANGES IN PEST RANKINGS

NRI Bulletin No. 39 *The relative importance of crop pests in South Asia*

1. Name and address of proposer.
2. Position held by proposer.
3. Brief summary of experience relevant to the pest and the cropping system zone.
4. Suggested change, mentioning zone, pest and crop. This can be the addition or deletion of a pest or a change in the ranking of a pest already listed, or a change in the crop it affects.
5. Amplifying remarks. Include whether the original assessment in the *Bulletin* is considered to have been incorrect, or if the change proposed is made as a result of a change in the actual pest situation. If the latter, indicate how this change has developed over time and any ideas on the cause.

   Give the reason for proposing a change in pest rankings. Give the proper reference for any literature suggesting the changed assessment.

   Send a suggested change to:

   Head of Pest and Vector Economics Section
   Natural Resources Institute
   Central Avenue
   Chatham Maritime
   Kent ME4 4TB
   United Kingdom

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