Results of a Social and Economic Impact Assessment of Integrated Pest Management Strategies in Brassica Vegetable Crops in China

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Australian Centre for International Agricultural Research

Canberra, November 2004

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This series was formerly titled Economic Evaluation Unit Working Paper Series.

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Australian Centre for International Agricultural Research

ISSN 1832-1895

ACIAR's Impact Assessment Unit Working papers are available for downloading and printing from the ACIAR website at: <http://www.aciar.gov.au>.

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Acknowledgments

The CIAD study team expresses its sincere thanks to the Australian Centre for International Agricultural Research (ACIAR) for providing funds for the study. During the design and implementation of the study, Dr Deborah Templeton, the ACIAR project officer, provided valuable professional assistance and advice to the team. During the field survey, Professor Liu Shusheng from Zhejiang University, Mr Zheng Youli, Deputy Director of the Zhejiang Provincial Plant Protection Station, and officials, technicians and farmers from Hangzhou and Wenzhou municipalities and project pilot areas, and from Wencheng County of Wenzhou, provided very valuable data and information, and directly or indirectly participated in the survey and workshop. The research team appreciates their contributions and assistance.

ACRONYMS AND ABBREVIATIONS

ACIAR	Australian Centre for International Agricultural Research
APITC	Agricultural Products Inspection and Testing Center
CGFDC	China Green Food Development Center
CIAD	Center for Integrated Agricultural Development
IPM	integrated pest management
MOA	Ministry of Agriculture
PHTR	pesticides such as organophosphate and organochlorine compounds with high toxicity and residues
PPS	plant protection station
PRA	participatory rural appraisal
SVP	secure vegetable project

IPM techniques

APB	anti-pest boards (sticky traps)
APN	anti-pest nets (netting around crops to exclude pests)
EB	excellent breeds (of vegetables)
IC	intercropping
MCP	manual capture of pests
MS	manual spraying
PAL	pest-attraction lights
RRT	reasonable rotation (of crop types)
SA	sex attractants (pheromone traps)
SBP	soft and biological pesticides

CONVERSION FACTORS

1 mu = 0.07 ha (1 ha =15 mu)
1 yuan RMB = 0.11 USD (1 USD = 8.2 yuan)
1 jin = 0.5 kilogram

Details of projects evaluated

ACIAR project ID	CS2/1992/013 – Improvement of integrated pest management in brassica vegetable crops in China and Australia
Collaborating organisations	University of Queensland (UQ), Brisbane, Australia; Cooperative Research Centre for Tropical Pest Management (CRC–TPR), Brisbane, Australia; Queensland Department of Primary Industries (QDPI), Brisbane, Australia; Hunan Agricultural University (HUA), Hunan, China; Zhejiang Academy of Agricultural Sciences (ZAAS), Hangzhou, China
Project leaders	Professor Myron Zalucki (UQ); Peter Deuter (CRC–TPR); Professor Liu Shu-sheng (ZAAS)
Principal researcher	Professor Yong-nian Chen (HUA)
Duration of project	1 July 1995–30 September 1999
Total ACIAR funding	AUD841,321
Project objectives	1 To determine the current pest management practices of brassica growers and the major factors affecting their choice of strategy. This will indicate opportunities and constraints for improvements. 2 To investigate the major factors affecting the level of pest populations in brassica crops and particularly the role that parasitoids play in suppressing brassica pest populations. This will provide a basis for developing pest forecasting systems and determining practical ways of maintaining and enhancing natural biological control. 3 To determine the effectiveness of pesticide application equipment and safety measures employed in brassica pest management, particularly in China where safety issues are of concern. 4 To explore the impact that the major pests have in causing yield and quality loss in different brassica crops and varieties, providing a basis for determining the degree of tolerance that might be available for achieving acceptable control of the pests, action thresholds and practical decision rules. 5 To assess the performance of different pest management strategies, particularly those which enhance natural control agents, and the factors that affect this performance, including 'soft' and biological insecticides, improved pesticide application technology, and other methods for rational use of chemical and non-chemical insecticides. 6 To integrate the findings above and, with the participation of growers, grower organisations, extension agents and consultants, to explore and develop appropriate means of ensuring that improved practices and decision rules are widely adopted.
Location of project activities	Changjiang Valley, China; southeastern Queensland, Australia

ACIAR project ID	CS2/1998/089 - Improvement of IPM of brassica vegetable crops in China and Australia
Collaborating organisations	University of Queensland (UQ), Brisbane; Department of Primary Industries (QDPI), Brisbane, Queensland, Australia; Zhejiang University (ZU), Hangzhou; Zhejiang Department of Agriculture (ZDA), Hangzhou; Zhejiang Academy of Agricultural Sciences (ZAAS), Hangzhou; Shanghai Academy of Agricultural Science (SAAS), Shanghai, China
Project leaders	Professor Myron Zalucki (UQ); Professor Liu Shu-sheng (ZU)
Linked project(s)	CS2/1992/013
Principal researchers	Bronwyn Holding (QDPI), Wang Jian-xin (ZDA), Guo Shi-jian (ZAAS), Wang Dong-sheng (SAAS)
Duration of project	1 July 1999–30 June 2003
Total ACIAR funding	AUD830,366
Project objectives	The overarching objective was to develop and implement sustainable management strategies for insect pests in brassica vegetable crops that significantly reduce pesticide hazards and are acceptable to growers in the Changjiang River Valley, China and Queensland, Australia. To achieve this objective, several sub-objectives were addressed through research directly linked to practical implementation: 1 To complete investigations of major quantitative factors affecting the numerical changes of pest abundance in brassica crops in the field, and particularly the role that beneficials (parasitoids, predators and pathogens) play in suppressing pest populations. 2 To determine the impact of major pests on yield and quality loss in major brassica crops and varieties under field conditions. 3 To investigate on-farm strategies for improvement of insecticide application and particularly those options that will promote the use of 'soft' insecticides and reduce the total input of insecticides. 4 To assess the performance under farmer-field conditions of different pest management strategies (particularly those which enhance natural control agents). 5 To establish resistance levels to major insecticides used in the brassica production system. 6 To improve the methodologies previously developed for promoting implementation of IPM in brassica vegetable production, and to apply these as widely as possible in the target areas.
Location of project activities	Changjiang River Valley, China and Queensland, Australia

1 Background

As a result of its large population, China is the world's largest producer and consumer of vegetables. The quality of Chinese vegetables affects the demand for them both in China and abroad. How pests are managed during vegetable production directly affects the quality, nutritional characteristics and safety of vegetables. At the same time, given the intensive production patterns, pest management can also have a significant negative impact on the environment. Therefore, issues of pest management in vegetable production have drawn great attention from China's central government, the Ministry of Agriculture (MOA) and local governments at different levels. The accession of China into the World Trade Organization (WTO) makes the adoption of acceptable methods of pest management even more important for vegetable producers and traders. Due to the importance of pest management for food quality and safety, some international agencies have provided assistance to enable Chinese farmers to introduce integrated pest management (IPM) strategies into their production practices. The Food and Agriculture Organization of the United Nations (FAO) assisted several provinces in central China to introduce IPM into rice and cotton production. GTZ, the German technical assistance agency, supported an organic agriculture project in Jiangsu and Anhui provinces.

The Australian Centre for International Agriculture Research (ACIAR) has also funded environmental and resource-management research projects in China. Among these, the ACIAR-funded projects on 'Improvement of integrated pest management of brassica vegetable crops in China and Australia' (CS2/1992/013 and CS2/1998/089) were implemented with significant success. During these projects, technical interventions, training courses and research activities were carried out to promote the adoption of IPM strategies by growers.

Since the end of the ACIAR-funded projects, progress has been made in the extension of IPM strategies among growers of brassica vegetable crops. In Zhejiang Province, the pilot area of the ACIAR-funded projects, communication and dissemination activities such as IPM demonstrations, field days and training courses have been used to promote the adoption of IPM strategies.

In 2000, ACIAR supported the Center for Integrated Agricultural Development (CIAD), China Agricultural University to carry out a study entitled 'Household impact analysis in adoption of IPM strategies in brassica vegetable crops in China'. The main objective of that study was to identify the direct effects of IPM strategies on household decision-making processes and to determine the factors that affect grower adoption of IPM. The study was focused mainly at the household level and concentrated in Hangzhou, one of two pilot areas for the ACIAR projects.

The purpose of the assessment reported here was to extend the earlier analysis by investigating the longer-term impacts ACIAR-funded projects CS2/1992/013 and CS2/1998/089. This report summarises the research procedures used, and the findings on IPM impacts and factors that foster or constrain IPM adoption, and

makes recommendations for improving the IPM adoption rate in different types of production areas. The key issues covered in this assessment are: (1) impacts on vegetable growers in terms of changes in their awareness and use of IPM strategies and how these translate into an economic benefit; (2) impacts at institutional and policy levels; and (3) impacts on quality control and quarantine for market access of vegetable products.

2 The research concept and methodologies

2.1 OBJECTIVE

The overall objective was to assess the social, economic and institutional impacts of the ACIAR-funded projects on 'Improvement of integrated pest management of brassica vegetable crops in China and Australia' (CS2/1992/013 and CS2/1998/089—hereinafter referred as 'the ACIAR-funded IPM projects'), so that well-informed recommendations for the institutionalisation of IPM strategies could be made. More specifically, the following questions were addressed:

- Have the ACIAR-funded IPM projects created sustainable impacts by providing a technically adoptable, economically viable and ecologically friendly IPM strategy that can be used in the current production system in the pilot areas of the projects?
- What kind of changes have the projects' outputs resulted in at the household and community levels? How did such changes affect household incomes and grower attitudes? Are the growers who adopted the proposed IPM strategies better off?
- What are the current and future advantages and disadvantages of using the proposed IPM strategies?
- Have the projects' outputs promoted changes in pest management patterns in a broad area surrounding the project pilot areas?
- Has adoption of IPM strategies led to changes in the natural environment, in marketing of vegetables, or in policy relating to the production and sale of vegetables?

2.2 MAJOR TOPICS AND AREAS STUDIED

To achieve the overall objectives of this assessment and to specifically answer the abovementioned questions, the following data have been collected and compared:

- the area sown to brassicas in the target regions and other regions where the IPM technology could be adopted
- the level of adoption of IPM strategies in brassica vegetable crops in the target region, and higher levels of adoption in other regions that are attributable to the ACIAR-funded IPM projects
- the average size of the farmers' brassica gardens and IPM adoption rates by farm size
- the average yields of brassica vegetables with and without adoption of the IPM technologies.

In addition to collecting the data, major changes in farming practices resulting from the adoption of the IPM strategies were described and analysed, which enabled the factors affecting the changes in farm practices to be identified and ranked in order of importance. A comparison of annual chemical use per unit area with and without the adoption of the IPM technologies was also made. Financial information on the costs of, and returns to, growing brassicas with and without the adoption of the new IPM strategies was analysed. This included identification of the major factors that affect the changes in production costs due to the adoption of the new IPM strategies. This work enabled an estimate to be made of the total economic returns of the ACIAR-funded IPM projects.

Besides these major farm-level topics, the research team also investigated the impact that the research results had at the government level, especially in terms of the changes in government practices and policies relating to IPM and environmentally sound production patterns. In addition, the team examined the impact the project results had on consumer demand for brassica vegetables identified as high-quality products that meet more rigorous nutritional and safety requirements because they were produced using environmentally sound production patterns through the adoption of IPM strategies. Finally, the roles and functions of government institutions and other stakeholders in IPM implementation and marketing of the products were examined.

2.3 RESEARCH PROCESS AND METHODS

2.3.1 Research process

Before finalising the research design, hypotheses relating to the key issues mentioned above were formulated. To verify the hypotheses and meet the objectives of the study, the following research process was undertaken:

1. Information about government policies on IPM, 'green' food production and organic agriculture was collected and reviewed. Policy and project documents, including ACIAR-funded IPM project reports and documents, were systematically reviewed.
2. Secondary data and information were collected on the sown area for brassica crops, households farm sizes for brassicas, average yields of vegetables with and without IPM strategies, market prices with and without IPM, and household average income changes due to IPM adoption. Data were obtained mainly from county agricultural bureaus, statistics bureaus, county price offices, and by market survey.
3. A household survey was made using semi-structured interviews and pre-designed survey questionnaires in 120 households in the two IPM pilot areas, Hangzhou and Wenzhou of Zhejiang Province. Institutional surveys were conducted in the

agricultural bureaus, agricultural extension stations, and market inspection administrations in the pilot counties.

4. Two village workshops and an institutional workshop were held to present the findings, conclusions and recommendations before the completion of the field surveys in Hangzhou and Wenzhou.
5. The data collected and the study findings were systematically analysed then written up.

2.3.2 Research methodology

The research employed qualitative and quantitative methods. Both types of methods have been applied systematically in collecting secondary data and in getting first-hand information from various informants and vegetable growers.

2.3.2.1 Qualitative methods

Various tools and methods of participatory rural appraisal (PRA) were applied during the field survey, both in the household survey and institutional interviews. The tools used included semi-structured household interviews, key informant interviews, community resource mapping, ranking and weighting of the IPM technical interventions, SWOT (strengths, weakness, opportunities, threats) analysis and participatory stakeholder analysis.

2.3.2.2 Quantitative methods

The Microsoft Excel package was used as a quantitative analysis tool in processing the household data collected by questionnaires and secondary data collected from the institutional interviews and public statistics documents.

3 Major findings: adoption levels and project impacts

3.1 PROFILE OF THE INVESTIGATION AREAS

The areas investigated included the Hangzhou and Wenzhou areas of the ACIAR-funded IPM projects and, for comparison, Wencheng County, a non-project area. The following basic information presents a profile of the current situation in the project pilot areas. Besides the direct findings from the institutional survey, the information sources included statistical yearbooks, the government website and government documents.

3.1.1 Project area in Hangzhou Municipality

Jianggan District was the major pilot area for the ACIAR funded-projects. It is located in the suburbs of Hangzhou Municipality, the capital of Zhejiang Province. Hangzhou is an important transport hub on China's east-central coast.

The pilot area for the ACIAR-funded IPM projects has a subtropical, warm and humid climate. The yearly average temperature is about 16.2°C, with an average summer maximum of 28.6°C and winter minimum of 3.8°C. The average annual frost-free period is 230–260 days. Average annual rainfall is 1435 mm and relative humidity 76%. The total area of Hangzhou Municipality is about 16,600 km^2, of which 2.8 million mu (186,000 ha) is cultivated land comprising 2.4 million mu (160,000 ha) of paddy fields and 380,000 mu (25,100 ha) dryland farming area.

As the above data show, both the ecological conditions and the location (in terms of its proximity to an urban market) of the district make it very suitable for vegetable production, which is why the Jianggan District is traditionally a vegetable production base for Hangzhou Municipality.

IPM extension: According to the local counterparts who are responsible for vegetable production, the IPM strategy was adopted on 642,000 mu (42,800 ha) from 2000 to 2002. The main IPM components adopted included soft and biological pesticides (SBP), pest-attraction lights (PAL) and anti-pest nets (APN). IPM technical leaflets and information brochures that had been prepared were reprinted more than 28 times. In total, about 22,400 leaflets and brochures were distributed to vegetable growers. Some 5600 farmers received training in IPM.

3.1.2 Project area in Wenzhou

Wenzhou, the other IPM project area, also has a subtropical, maritime climate. It is moderately hot in summer and relatively warm in winter. Over 80% of the total population of 7.56 million is engaged in agriculture. The total area of Wenzhou is 11,784 km^2. The cultivated land is 2.4 million mu (162,000 ha), comprising 1.9 million mu (125,000 ha) of paddy field and 570,000 mu (38,000 ha) of dryland farming area. The vegetable growing area is more than 800,000 mu (54,000 ha), and the total production is about 1.6 million tonnes. Ouhai and Longwan districts were the major areas investigated during the field survey.

Wenzhou is a modern city in southern China that was developed after the 'opening-up' policy was instigated. Through rapid economic development, Wenzhou has become an industrial and commercial centre in the coastal area of southern China. As a result of this economic development, vegetable growing in Wenzhou started 20 years ago, when local farmers began moving out of more traditional agricultural activities such as grain growing. Indeed, Wenzhou is an important area in the IPM projects because vegetable growing has developed very quickly there in recent years. Nevertheless, insufficient vegetables are grown locally to meet the needs of Wenzhou City, and 60% of the vegetables in the market still come from other provinces. Therefore, the government began to support the development of vegetable growing by providing basic infrastructure such as greenhouse frames, roads, and houses for farmers moving in from other areas. Many farmers from other counties have therefore come to Wenzhou City to grow vegetables at the bases.

IPM extension: According to the local partners interviewed in Wenzhou, the total vegetable growing areas where IPM was adopted reached 54,300 mu (ca 3600 ha) in the period from 2000 to 2002. The major IPM components practised included SBP, PAL and APN. About 28,000 IPM-related technical brochures and leaflets were produced and distributed to vegetable growers. In addition, more than 80 technical training courses were organised, during which more than 10,000 farmers received various types of technical training. There was a mobile vegetable-pest-management service (called the 'vegetable hospital' by local people), as well as technicians providing technical services and advice on plant disease and pest management who visited the growers almost weekly.

3.1.3 Non-project area in Wencheng County

Wencheng County is a non-project area located in the southern mountain region of Wenzhou. Its area is 1294 km^2 and population 372,000. The county town is 110 km from Wenzhou City. The major traditional crop grown in the county is rice. Vegetable production has been increasing quite rapidly in the recent years, with the total vegetable-growing area reaching 64,000 mu (ca 4300 ha) in 2003.

IPM extension: Although the IPM projects were not implemented in Wencheng County, the IPM strategy and some of the IPM techniques have been adopted by vegetable growers there.

3.2 SOCIOECONOMIC CHARACTERISTICS OF THE VEGETABLE GROWERS INTERVIEWED

3.2.1 The distribution and profiles of vegetable-growing households in which interviews were conducted

During the field investigation, the research team conducted interviews in 143 farm households: 18 in Jianggan District of Hangzhou Municipality, 91 in the Ouhai and Longwan districts in suburban Wenzhou City, and 34 in Wencheng County of Wenzhou City. The profiles of the vegetable-growing households in each area were as follows:

3.2.1.1 Households in Jianggan District, Hangzhou

The average age of farmers engaged in vegetable production was 50 years. Around 22% had graduated from junior middle school. The proportion of male to female farmers was 2:1. The average land area for vegetable growing was 1.15 mu/household, varying between 0.3 and 3 mu/household.

3.2.1.2 Households in Ouhai and Longwan districts in Wenzhou

The average age of the farmers interviewed was 41.4 years, with almost 40% of them having graduated from junior middle school. The ratio of male to female farmers was 4.4:1. The average land area for growing vegetable was 5.7 mu, varying between 2 and 10 mu. Vegetables are an important subsistence and cash crop in the Ouhai and Longwan districts.

3.2.1.3 Households in Wencheng County, Wenzhou

The average age of the farmers interviewed in Wencheng County was 48.4 years. Just over half of them had graduated from junior middle school. The ratio of male to female growers was 4.7:1. The average land area for growing vegetable was 4.6 mu, varying between 1 and 10 mu. Vegetable production is this county is important to the growers' incomes.

Table 1 summarises the general characteristics of the vegetable-growing households in which interviews were conducted.

Table 1. Profile of the households interviewed in the ACIAR-funded IPM project areas

Locations	Number of households	Average age of growers	Average land area (mu)[a]	Percentage of farmers who had received middle school education	The ratio of male to female farmers
Hangzhou	18	50.0	1.2	22.2	2:1
Wenzhou	91	41.4	5.7	39.6	4.4:1
Wencheng County	34	48.4	4.6	52.9	4.7:1

[a] 1 mu = 0.07 ha.

3.2.2 The socioeconomic characteristics of different types of vegetable growers

According to the area of farmland allocated to vegetable production, the farm households could be grouped into several categories, as follows:

3.2.2.1 Small-scale, sideline producers in Hangzhou

All the farmers interviewed were small-scale producers who lived in Sanbao Village, Jianggan District, a suburb of Hangzhou City. The average land area for vegetable growing was only 1.15 mu/household, and the smallest was 0.3 mu. The reason for the small farm size was the conversion of farmland to non-agricultural purposes. The land area devoted to agriculture was declining rapidly, due to urbanisation.

Since Sanbao Village is so close to Hangzhou, most young people had migrated to urban area to get jobs in non-agricultural sectors. Vegetable production was therefore taken over by the older people. The farm size for vegetable production was also very small compared with the other two areas studied. Because of these circumstances, the vegetable production in Jianggan had become a sideline activity for income generation, but the only source of income from agriculture. These socioeconomic features led to the farmers being relatively uninterested in adopting IPM strategies.

3.2.2.2 Small-scale producers in Wenzhou

According to vegetable-growing area, 21 households were classified as small producers. These households had, on average, 3.6 mu of farmland (varying from 2 to 4 mu) devoted to vegetable production, which amounted to almost 100% of their available farmland. Vegetable production accounted for almost 100% of the growers' incomes. Due to the importance of vegetable production for sustaining their livelihoods, these farmers were receptive to the IPM technologies.

3.2.2.3 Medium–size producers in Wenzhou

In Wenzhou, 47 of the households in which interviews were conducted were classified as medium-size vegetable producers. They had an average of 5.32 mu farmland for vegetable production (varying from 4.5 mu to 6 mu). These households were highly specialised in vegetable production and had a relatively high input of labour. For these households, the average annual income from vegetable production was about 24,000 yuan (ca 3000 USD) (Table 2).

3.2.2.4 Large-scale producers in Wenzhou

In Wenzhou, 23 of the households interviewed were classified as highly specialised, large-scale vegetable producers. The average household land area for vegetable production was 8.25 mu, with a range from 7 to 10 mu. Most of these households were large families with enough labour and extensive experience in vegetable production. In contrast to the other types of households, young people with higher educational qualifications provided most of the labour engaged in vegetable production. These people were highly receptive to the new IPM technologies and were more innovative in adopting the new cultivation techniques.

3.2.2.5 Producers in Wencheng County, a non-project area

In the non-project area, 31 households were interviewed as a control group for the assessment. The household landholding varied from 1 to 10 mu, with the average land area per household around 4.6 mu and the average vegetable-growing area about 4.3 mu. Vegetable production in this area had begun in recent years. Most of the farmers were moving their arable land from rice-growing into vegetable production. As a non-project area, farmers still used traditional vegetable-growing techniques. The results of interviews indicated that they were less receptive to the IPM-related techniques than were farmers in the project areas.

Table 2. Basic statistics on farm households in the IPM project and non-project areas

Item	Producers in Hangzhou	Small-scale producers in Wenzhou	Medium-size producers in Wenzhou	Large-scale producers in Wenzhou	Producers in Wencheng county, a non-project area
Number of households interviewed	18	21	47	23	31
Average age of growers	49.9	43.9	42.5	37	48.7
Average number of people	4.0	4.1	3.9	4.4	4.7
Average labour force	2.6	2.3	2.3	2.6	1.9
Average labour in vegetable growing	1.6	2	2	2.4	1.7
Average land area (mu)[a]	1.15	3.6	5.33	8.43	4.62
Average vegetable-growing area (mu)	1.15	3.6	5.32	8.25	4.3
Average annual income from vegetables (yuan)[b]	10,833	16,750	23,940	33,520	14,081
Average annual income per mu (yuan)	9,420	4,333	4,502	4,214	3,145
Average cost per mu (yuan)	3,640	2,322	2,046	1,968	883

[a] 1 mu = 0.07 ha

[b] 1 yuan = 0.11 USD

3.3 ADOPTION LEVELS AND IMPACTS OF THE ACIAR-FUNDED IPM PROJECTS AT THE HOUSEHOLD LEVEL IN HANGZHOU AND WENZHOU

During this investigation, the incidences of use of the following IPM techniques served as indicators of different levels of IPM adoption by the different categories of farmers:

- soft and biological pesticides (SBP)
- anti-pest nets (APN)
- sex attractants (SA)
- intercropping (IC), such as intercrops of other vegetables, taro and fruit
- pest-attraction lights (PAL)
- anti-pest boards (APB)
- manual spraying (MS)
- excellent breeds (EB) of vegetables
- reasonable rotation (RRT) of crops
- manual capture of pests (MCP).

These technical indicators were incorporated into the checklist for semi-structured household interviews, group interviews and workshops to verify the adoption levels of the IPM strategy in the project areas and to ascertain farmers' attitudes to the various IPM techniques. The major findings on the adoption of IPM techniques and the impact of the ACIAR-funded IPM projects at household level are described in the following sections.

3.3.1 Adoption levels of IPM strategies in the two project areas

3.3.1.1 IPM adoption in the Hangzhou project area

According to the field investigation, 13 (ca 70%) of the 18 producers interviewed in Sanbao Village in Hangzhou had adopted IPM strategies. Households had adopted an average of 3.7 of the 10 IPM techniques listed above. The major IPM techniques adopted in the Hangzhou project area were SBP, PAL, APN, RRT and EB. As mentioned earlier, because urbanisation has created a shortage of farmland, vegetable production was the only agricultural activity in the village. However, it was usually undertaken as a sideline activity, because off-farm employment in the area has allowed income diversification. Therefore, although Sanbao Village was located in the IPM project area, vegetable growers interviewed were somewhat less amenable to adoption of IPM technologies than were growers in Wenzhou.

3.3.3.2 IPM adoption in Wenzhou project area

Most of the farm households interviewed in the Wenzhou project area specialised in vegetable production. The average growing areas of small, medium and large growers were all significantly larger than those in Hangzhou. Most of farmers' incomes, even of the small producers, were from vegetable production. Therefore, it is not surprising that the overall level of awareness of IPM technologies and their adoption rate were higher than in Hangzhou. Results from both the household interviews and questionnaires showed that all growers interviewed in

Wenzhou were responsive to the IPM recommendations made by the ACIAR-funded projects on IPM in brassica vegetable crops. Table 3 compares adoption levels of the various IPM techniques by the different categories of producers.

Table 3. Comparison of adoption levels of various IPM techniques by different categories of farm households in Wenzhou

	IPM technique	Small producers		Middle producers		Large producers	
		Percentage	Ranking	Percentage	Ranking	Percentage	Ranking
1	Soft and biological pesticides (SBP)	100	1	98	1	95	1
2	Anti-pest nets (APN)	38	6	36	7	50	6
3	Sex attractants (SA)	0	10	0	10	9	9
4	Intercropping (IC)	33	7	30	8	27	7
5	Pest-attractant lights (PAL)	62	5	62	5	59	5
6	Anti-pest boards (APB)	10	9	2	9	0	10
7	Manual spraying (MS)	100	2	91	2	95	2
8	Excellent breeds (EB)	71	4	74	4	73	4
9	Reasonable rotation (RRT)	76	3	85	3	77	3
10	Manual capture of pests (MCP)	33	8	43	6	23	8

3.3.2 Analysis of farmers' priorities in adoption of IPM techniques

Figure 1 plots the results in Table 3.

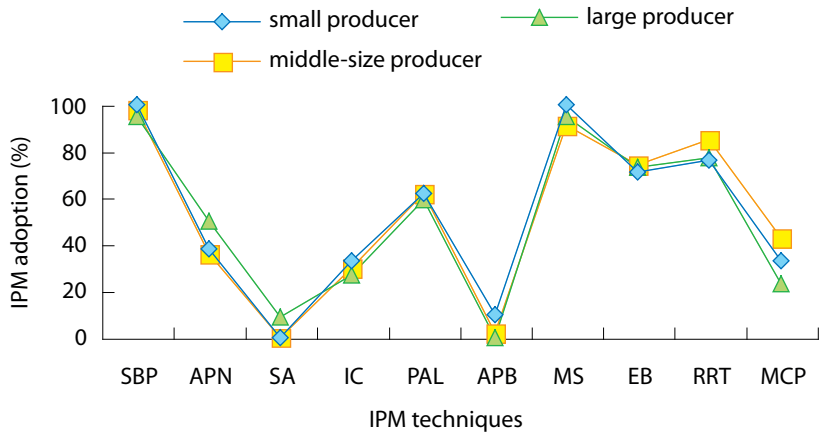

Figure 1. Farmers' priorities in adoption of IPM techniques

Figure 1 shows that, of the 10 IPM techniques, the following five were ranked first by all three categories of growers: SBP, MS, RRT, EB and PAL.

The average adoption rates for all five techniques were above 60%. Since there were no significant differences in IPM adoption preference between the categories of vegetable growers, it can be concluded that there was no link between farm size for vegetable production and the level of adoption of different IPM techniques.

The economic importance of vegetable production to household livelihood might have been an important factor influencing farmers' attitudes to the IPM strategy.

3.3.2.1 Interpretation of the priorities for adoption of IPM techniques

Soft and biological pesticides (SBP) are environmentally sound. There are three reasons for the high adoption rate of SBP: (1) government policy promoting the use of lower toxicity pesticides, and a ban on the use in vegetable production of the high toxicity pesticides that were previously used; (2) SBPs are available in the pesticides market, and their prices are acceptable to growers; (3) SBPs are easy to apply, and their use requires no additional labour inputs over those needed for conventional pesticides.

Manual spraying (MS) is a simple technique and, since the spray volume is very small, there is less wastage of pesticide. Farmers adopt MS because it can save pesticides (reduce costs) and improve the effectiveness and efficiency of pest control.

Reasonable rotation (RRT) of cropping is a production-pattern change for avoiding pest infestation due to long years of growing the one type of vegetable or other crop. It is easy to adopt and can be applied with different vegetables. It can also be combined with other cash crops. An additional advantage of RRT is that it can prevent pest infestation without increasing labour inputs.

Using EB vegetables with characteristics of high quality, high yields and high resistance to pests and therefore increased productivity was a choice of individual farmers. Farmers, especially the large growers in Wenzhou, could afford to buy high-quality, EB vegetable seeds. There were three preconditions for adopting the EB approach: a vegetable seed breeding system needed to be in place; there must be market supervision to guarantee the high quality of seeds in the market; the adoption of EB must bring higher profit levels

Pest-attraction lights (PAL) is a physical control IPM technique. It is effective and has no negative impact on the surrounding environment. Most of the farmers interviewed ranked PAL as an effective IPM approach for controlling pests of vegetables, but some farmers complained that if PAL were installed near their farmland, some of the many pests attracted into the area would inevitably attack their crops, unless they could then be controlled by other IPM techniques. It was therefore recommended that PAL be used in conjunction with other IPM approaches and in a collective way among neighbouring growers.

3.3.2.2 Key factors for ranking the IPM techniques

Farmers ranked the IPM techniques according to the following factors:

- the adoption of an IPM technique did not require additional labour and/or time
- the technique was practical and easy to apply (the techniques had to be easy to apply by farmers with relatively low levels of education)
- there needed to be increased economic returns from adopting IPM technologies, through reduced total pesticide costs because of a fall in the amounts of pesticide used and higher prices gained for the vegetables because of the higher quality resulting from the IPM production strategy.

3.3.2.3 Reasons for lower adoption rate of SA and APB

SA and APB, two important IPM techniques, had low adoption rates. The reasons expressed by interviewed farmers were as follows:

- The two techniques were not treated as important extension objectives by the IPM projects, and the government in the Wenzhou area did not recommended these two techniques as key approaches.
- SA and APB required increased investment by farmers.
- After pests were attracted by SA and APB, the traps needed to be cleaned, which increased labour inputs.

As to the other kinds of IPM strategies, the farmers showed no great interest in adopting them. The reasons for this were the same as those given above.

3.3.2.4 Findings from questionnaires

According to responses to the questionnaires, farmers evaluated the different IPM techniques as follows:

- **SBP**: Five people gave their evaluation. One of them believed that this kind of pesticide is suited to vegetable growing and management. Another respondent thought that SBPs were useless because they did not kill the pests, but they had to use them because the traditional pesticides were banned and they could no longer buy them in the pesticide market. The other three farmers stated that SBPs were useful, but not as effective as the traditional pesticides.
- **APN:** Four people gave their comments. One believed it was a very good method for avoiding the damage of pests; another thought that there were too many pests and the APN could not kill them all; the remaining two respondents thought the technique too expensive.
- **PAL:** Most of the 13 people who had used it stated that it was useful and that its effect had been satisfactory to that time. However, as PAL was public property and belonged to the village, maintenance was not always timely and the equipment was often destroyed or stolen by some villagers.
- **MS:** Most of the farmers used this kind of portable equipment to conduct field pest management. The adoption level was around 95%. It was very popular in the vegetable-growing area in Zhejiang Province.
- **Other strategies:** There was no unified perception about the effectiveness and efficiency of the other IPM techniques because the adoption rates were very low or zero.

3.3.3 The main outcomes of IPM adoption

3.3.3.1 Project areas

Most of IPM project activities, training and demonstrations were focused in the project areas in Hangzhou and Wenzhou, with the following outcomes:

- Overall awareness and recognition of IPM technologies had increased. As the interview and questionnaire results showed, most of the IPM techniques had been recognised and accepted by most of the farmers in the project area. Even

though some farmers were not clear about the concept and philosophy of IPM, they had adopted IPM-related technologies in their vegetable-production practices.

- The findings also showed that almost all vegetable growers were aware of the hazards of high-toxicity pesticides to human health and the environment. This was not only because of the direct impact of technical demonstrations and training carried out by the IPM projects, but also because the IPM projects changed government policy on the production and marketing of pesticides. For example, as a result of the IPM projects, pesticide manufacture and market policies and regulations were put into effect by the local government. Highly toxic pesticides such as PHTR (e.g. organophosphate and organochlorine compounds) were banned from use on brassica crops. Therefore, 5 years after the completion of the IPM projects in the project areas, farmers no longer used PHTR on their vegetables.
- The IPM projects led to attitudinal changes among government officials and technicians. All officials and technicians interviewed recognised the necessity of implementing IPM strategies and establishing an environmentally sound vegetable-production system. These changes were preconditions for institutional capacity-building and implementation of the IPM strategy in the whole supply chain from production to marketing, including the manufacture of inputs such as pesticides.

3.3.3.2 Impacts and changes in the non-project area

According to the results of interviews of local officials and 31 farmers in Wencheng County, although the interventions of IPM projects were not implemented in this area, the IPM projects did have some indirect effects. The main ones can be summarised as follows:

- Since the government strengthened quality control of vegetables in the marketplace, the overall quality of vegetables in the local and outside markets improved. This created conditions favourable for obtaining competitive market prices for green vegetables. More and more farmers therefore began to grow vegetables in an environmentally sound manner. Most farmers gave up the traditional rice production and changed to green vegetable production.
- Even without systematic knowledge of IPM, many vegetable producers adopted SBP.
- While nearly no-one was familiar with the concept of IPM, they believed that their vegetables would sell well in the market if they used lower-toxicity pesticides (SBP).
- Even though it is a relative remote county, Wencheng was strongly affected by the high-quality vegetable production projects initiated by the municipal government. In the initiation phase of vegetable-sector development, the government provided essential support to producers.
- In providing government support for green food production, IPM-linked technologies were introduced into production practices at the household level. These included the following:
  - The government provided essential facilities to farmers for vegetable growing, such as the frames and plastic covers for greenhouses, and APN.

– The government trained farmers in the techniques of vegetable growing. This covered growing and management techniques, including some IPM practices.

– The government required that vegetables meet health and safety standards. The farmers were told that chemical pesticides and fertilisers with high toxicities were forbidden. To replace the high-toxicity pesticides, IPM technologies were recommended to farmers.

3.3.4 Economic viability of the adoption of IPM

3.3.4.1 The income viability of IPM strategy

The potential economic return is one of most important factors affecting a farmer's decision on whether to adopt IPM approaches or stay with a conventional approach to pest control. The main factors determining the economic benefit of adopting the innovative IPM approaches are:

- changes in production management costs
- changes in direct input costs
- changes in the market price obtained for products grown under an IPM approach.

Where the other non-IPM factors remain unchanged, the marginal efficiency of the adoption of IPM innovations will depend mostly on changes in the three abovementioned factors.

Tables 4–7 give some examples of input/output changes caused by IPM adoption. The calculations draw on household survey and statistics bureau data, a market sample survey and a study report on IPM profit carried out in the Wenzhou project area.

Table 4. Economic contribution of IPM practice to saving agricultural inputs in Wenzhou

Year	Reduction of pesticide application (times)	Pesticide reduction (unit/ha)	Pesticide unit cost/ha (yuan[a])	Reduction in management cost/ha (yuan)
2000	1.5	4.5	37.5	(1.5×225)+(4.5×37.5)=506.5
2001	1.7	5.0	51.0	(1.7×225)+(5.0×51)=637.5
2002	1.4	4.0	52.5	(1.4×225)+(4.0×52.5)=525.0

[a] 8.2 yuan = 1 USD.

Table 5. Contribution of IPM to reducing production and economic losses

Year	Production loss avoided (tonne/ha)	Product value (yuan/tonne[a])	Economic loss avoided (yuan/ha)
2000	0.4	800	320
2001	0.5	800	400
2002	0.6	800	480

[a] 8.2 yuan = 1 USD.

Table 6. Net increase in the value of production resulting from application of IPM techniques (sum of benefits from Tables 4 and 5)

Year	2000	2001	2002
Net production value increase (yuan/ha)[a]	826.25	1037.5	1005.0

[a] 8.2 yuan = 1 USD.

Table 7. Calculated economic benefits resulting from application of IPM in the Wenzhou project area

Year	Growing area with IPM strategy (ha)	Saved input costs ('000 yuan[a])	Production loss avoided (tonne)	Economic loss avoided ('000 yuan)	Total increase in value ('000 yuan)
2000	7,100	3,594.4	2,840	2,272	5,866.4
2001	18,900	10,248.8	9,450	7,560	17,808.8
2002	28,300	14,857.5	16,980	13,584	28,441.5
Total	54,300	28,700.7	29,270	23,416	52,116.7

[a] 8.2 yuan = 1 USD.

Notes on the calculation of economic benefits

- All data in Tables 4–7 are the net increase calculated using the basic data from non-IPM minus the data from using the IPM approach.
- The management costs saved include a reduction in both the frequency of pesticide application and total amounts (dosages) used.
- The cost of labour and machinery input is estimated at 15 yuan/mu/spray (225 yuan/ha/spray).
- The reduction in pesticide cost is calculated on the basis of dosage unit (the normal recommended dosage is one unit) multiplied by the pesticide price in the year.
- Because farmers often mix several kinds of pesticides, or use too much pesticide in a spray mix, the saved pesticide unit (dosage) costs are more significant than the reduction in application frequency.
- The price premium for IPM-produced vegetables has not been accounted for in the calculations.

3.3.4.2 The correlation between production costs, income and IPM adoption

Correlations of production cost and IPM adoption

In general, the adoption of IPM led to higher production costs (Figure 2). There was, however, no statistically significant correlation between production costs and IPM, since the marginal production costs are related not only to the IPM, but also to the scale of production, the application of non-IPM technologies etc. It is difficult to separate the IPM-related costs from those linked to use of non-IPM technologies.

Figure 2 shows that, on average, larger producers adopted fewer IPM technologies than medium and small-scale producers, because IPM adoption will increase their production costs. If there is no market price premium for safe and healthy vegetables over vegetables produced by traditional methods, the increased costs will reduce final profit.

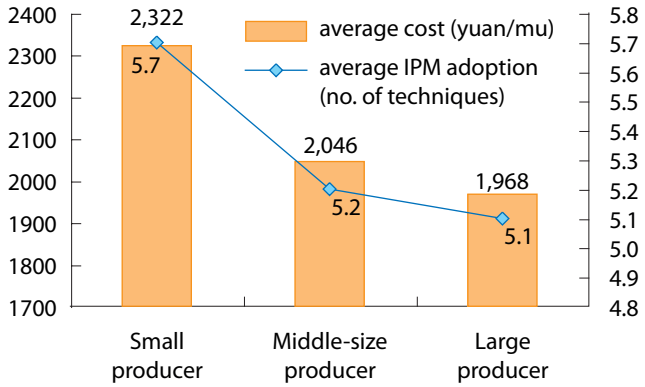

Figure 2. Relationship between production cost and IPM adoption

Relationship between income and IPM adoption

According to the results of field investigations, there was no significant correlation between farmers' household incomes and the level of adoption of IPM (Figure 3).

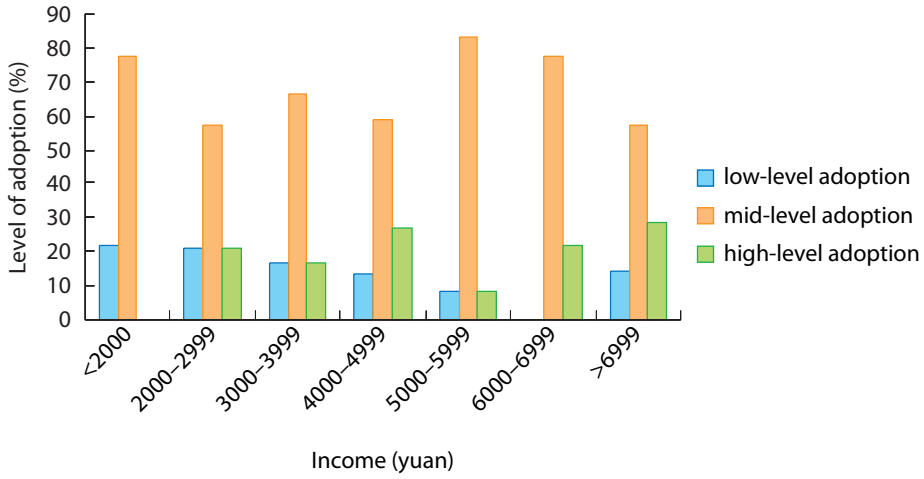

Figure 3. Relationship between household income and level of IPM adoption

Taking the total number of the IPM technologies adopted by the farmers as the independent variable, the average income per mu as the dependent variable (*Y*), and using a 'double logarithm function', regression analysis of the data from 91 households in the project area was carried out using EVIEWS, an economic statistics software package.

The estimated model: Log$Y = C(1) \times \text{Log}(IPM) + C(2)$

where:
Y = expected economic income (Yuan)/mu
IPM = the number of IPM technologies adopted
$C(1)$ = coefficient between IPM adoption rate and expected incomes
$C(2)$ = a constant.

The result is as shown in Table 8.

Table 8. The relationship between income and IPM adoption

Variable	Coefficient	Std error	*t*-statistic	Prob.
Log (IPM)	0.286653	0.176726	1.622020	0.1083
C	7.737788	0.287458	26.91798	0.0000

Vegetable entering the market

The regression result gives the relationship between income and IPM adoption. The *t*-statistic value of 1.62 suggests that the correlation between actual IPM adoption and the average income per unit area was not significant. In other words, the adoption of IPM had not significantly affected the farmers' incomes under the market pricing policies in force; there was no significant price difference between IPM products and traditional products.

3.3.4.3 Interpretation of the results of the economic viability analysis

Farmers and other stakeholders gave different reasons for the lack of economic benefits from the adoption of IPM technologies.

Farmers' interpretations

Figure 4 gives an analysis of farmers' views as gathered by questionnaires and interviews.

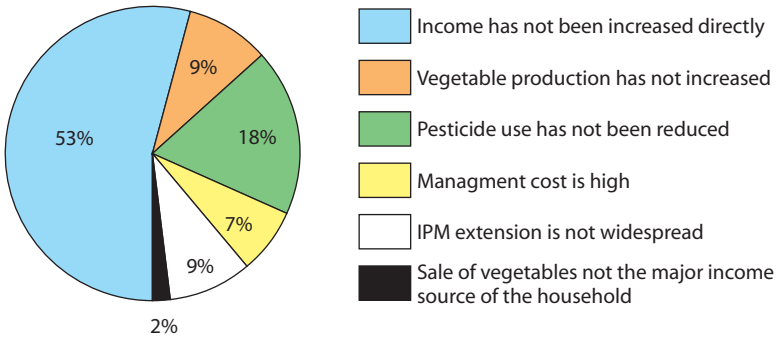

Figure 4. Farmers' interpretations of the reasons for the lack of economic viability of IPM adoption

During this investigation, 45 farmers gave their own interpretations of the reasons for the low economic impact of the adoption of the IPM strategy. The interpretations of farmers can be summarised as follows:

- More than half the farmers believed that the IPM strategy could not directly contribute to increasing their income.
- 10% of farmers believed that their vegetable production had not increased, even if they were using IPM.
- 20% of farmers stated that IPM had not reduced the overall amount of pesticides used, i.e. the cost of pesticides had not significantly fallen under IPM.
- 7% of farmers thought that labour management costs increased under IPM, and they did not have enough labour to apply IPM.
- 9% of farmers thought that the IPM strategy had not been extended widely, and that therefore any potential effects of large-scale adoption of IPM were not yet evident.
- 2% of farmers said that income from vegetables was not the major income source for their households, and that therefore the potential advantages of the IPM would be difficult to detect in their household finances.

Other economic factors relating to IPM adoption

Whereas most of the 91 farmers in our investigation thought that the adoption of IPM had yielded insignificant economic returns, a government economic assessment indicated that the application of IPM strategy had brought overall economic benefits to a large region. In addition to farmers' interpretations, as given above, some other factors can be considered:

- Farmers' land area for vegetable production, especially in Hangzhou, is very limited, and the income increase per mu and total income increase resulting from IPM adoption was not so attractive to smallholder vegetable growers. Therefore, they were not so receptive to innovation and IPM technologies.
- There was a problem with overall policy administration and market supervision for IPM versus traditional products**.** While 'safe' vegetables and vegetables qualified as 'green' food were increasingly being recognised and accepted by consumers, only those vegetables from large farms or vegetable-growing bases could obtain quality control and be sold at higher prices. The vegetables produced by small-scale producers who had adopted IPM, or from normal producers, were not yet systematically supervised according to the standard. It was therefore difficult for smallholders who used IPM to sell their products at higher prices.

3.3.5 Growers' needs for techniques and services for vegetable production

Farmers' needs for vegetable-production-related techniques and services were investigated through household survey and questionnaires. Sixty-five vegetable growers interviewed in Wenzhou prioritised what they would like to have in terms of techniques and services (Figure 5).

Their needs, in order of priority from highest to lowest, were:

- new cultivation techniques
- new types of pesticides
- more labour, especially labour with qualifications and skills

- funds to increase their scale of production and enable them to adopt the new technologies
- greater ability to weather natural disasters
- improvement of basic production conditions
- policy support from government
- market information.

These needs should be considered in formulating local-government strategy and policy for promoting the development of the vegetable-production sector.

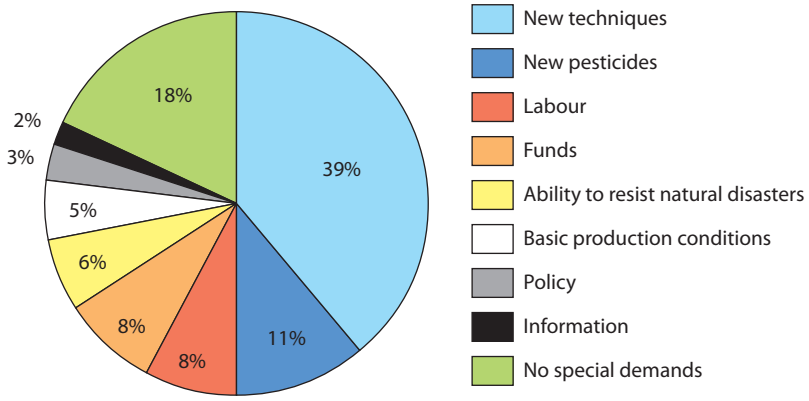

Figure 5. The stated needs of Wenzhou farmers for vegetable-production techniques and services

3.3.6 Farmers' access to techniques

Farmers' access to information about and technical support for IPM-related techniques is an important factor in extension of IPM technologies. Figure 6 shows the results of asking farm households about how they gained access to IPM techniques.

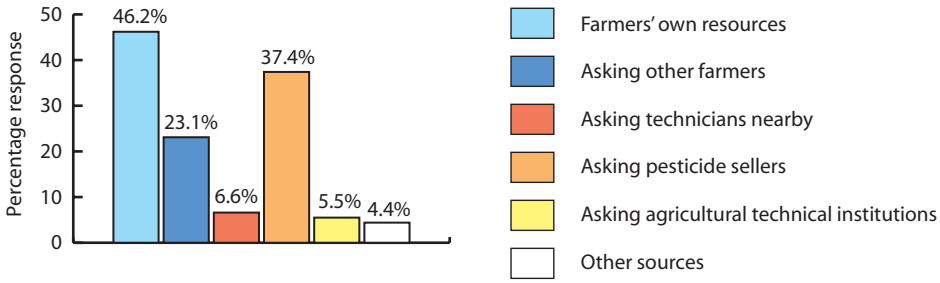

Figure 6. How farmers accessed IPM techniques. As some farmers get technical support from several sources, the total adds up to more than 100%.

The results indicated the following:

- almost half of the farmers interviewed solved their problems using their own resources

- some 40% of farmers asked pesticide sellers for advice. When buying pesticides, farmers can ask what kinds of pesticide are better and which pesticides should be used for particular types of pest infestations—this kind of information is relatively convenient to obtain and is usually correct
- some 20% of farmers sought advice from their neighbours and experienced farmers
- 12% of farmers sought advice directly from technicians, or visited technical institutions for consultations.

The following conclusions can be drawn:

- Farmers depended mainly on their own resources, pesticide sellers and their neighbours to resolve their production problems. As a result, the levels of their qualifications and skills will directly influence the effectiveness of the technical treatments they apply.
- Agricultural extension and other technical service institutions were not yet playing important roles in promoting IPM and technical innovation.
- Given these circumstances, it would seems valid to recommend that government technical service institutions should play a stronger role in training farmers and pesticide sellers in IPM technologies and pest-management strategy. Furthermore, it could be recommended that local government provide capacity-building support to the service institutions.

3.3.7 Factors affecting the adoption and extension of IPM

The factors affecting the adoption and extension of IPM include the characteristics of the IPM techniques, the attributes and attitudes of farmers and external factors.

3.3.7.1 The IPM techniques

The characteristics of the IPM techniques were analysed in section 3.3.3. They are major factors affecting IPM adoption and extension. If the technique is easy to learn and apply, requires few additional inputs and is highly effective in controlling pests, farmers will readily adopt it. On the other hand, farmers will be unwilling to adopt techniques that are too complicated or need high levels of additional inputs such as money and labour.

3.3.7.2 The individual growers

The farmers' own characteristics may also significantly affect levels of IPM adoption. These include the age of the grower, the education level of major labourers, gender, social capital of the individual and so forth. However, according to the analysis in this particular investigation, there was no significant statistical correlation between the characteristics of individual growers and their propensity to adopt IPM techniques.

3.3.7.3 External factors

The following external factors, either promoting or constraining the adoption of IPM, were identified in the household and institutional surveys:

- *IPM projects*: IPM project implementation and technical interventions were the most important factors for promoting IPM technology adoption by the farmers in the project areas. Compared with the non-project areas, in the project pilot areas, farmers had the readiest access to the new IPM technology.
- *Extension institutions*: Extension institutions can provide IPM technology services to the farmers. The extension agencies can be involved in the whole project implementation cycle. They can provide regular field technical guidance, daily technical advice, and technical and market information to growers. However, as discussed earlier, the government technical services available had not met farmers' demands.
- *Input-supply companies*: This kind of service is provided mainly by the retail and wholesale trading companies providing agribusiness inputs. The most important of these are the pesticide retailers. Farmers can often get technical suggestions or guidance from pesticide traders. Sometimes when the farmers have problems in vegetable growing, the most convenient way to get technical support is from the pesticide traders.
- *Interaction between growers*: When some farmers in a community adopt IPM technology, other farmers in the same community will learn from them. The pioneer adopters are the innovative vegetable-growing farmers in the local area. This kind of interactive learning and knowledge-sharing mechanism is an internal dynamic for long-term extension of the IPM techniques.

Government policy and market forces also affect IPM extension as follows:

- *Government policy*: government policies on environmentally sound and safe vegetable production, the use of less-toxic pesticides in production, and market control are very important external factors fostering and promoting the extension of IPM at the production level. Farmers have to follow these policies. The direct result is that farmers have to use SBP instead of traditional pesticides that have more toxic residues. Also, they have to try to use other IPM technologies to improve the quality of their products to meet official quality standards.
- *Market forces*: environmentally sound vegetable production practices, and vegetables qualified as 'green' and organic food, have been gradually recognised and accepted by the market and consumers. This kind of vegetable can attract a price premium. At the same time, vegetables with high-toxicity residues resulting from production by traditional means are gradually being forbidden access to the formal vegetable market. High-quality vegetables are more likely to be sold in supermarkets in big cities at relatively higher prices. The market is driving farmers to adopt an IPM strategy in order to increase the quality of their vegetable products and obtain higher incomes.

In conclusion, the IPM adoption rate is affected by a multitude of interlinked factors. The survey results show that project activities driven by government are the most important forces for IPM extension. Internal factors within the communities and households are secondary and are stimulated by the outside factors.

Pricing policy and market access control are very important factors for IPM extension.

3.3.8 Case study—IPM practice at Zhou's Safety Vegetable Farm

3.3.8.1 Basic information

Zhou's Safety Vegetable Farm is located in Longwan District, Wenzhou City. The farm began to grow vegetables in 1996 and adopted its current name in 1999. The total area of the farm is 373 mu (25 ha) and the greenhouse area more than 100 mu (7 ha). The total investment in the farm is 1.4 million yuan. The product is certified and branded 'Zhennong Vegetable', meaning 'prosperous agriculture'. There are about 30 contract farmers. The main products include brassica vegetables and other kinds of vegetables such as celery, spinach, haricot bean, cowpea, cucumber, tomato and eggplant. The total annual production is 27,750 tonnes valued at 2.74 million yuan (334,000 USD). The vegetables are all qualified as meeting food health and safety requirements. Most of the production is sold in the large vegetable markets in Longwan District and Wenzhou City.

3.3.8.2 IPM application

According to the interview with Mr Zhou Zhenlin, the manager of the farm, the farm has practised IPM approaches since its establishment.

- The IPM strategy was adopted systematically, the techniques applied being SBP, PAL and APN.
- Organic and specialised vegetable fertilisers are used.
- The farm tests new vegetable varieties and breeds, and introduces and extends them to other growers nearby.
- It cooperates with professionals and specialists in vegetable cultivation, plant protection, soils and fertilisers to give advice or provide technical training.
- A water-saving irrigation system has been introduced into the intensive greenhouse-production facility in combination with IPM practices.

3.3.8.3 Factors promoting the IPM adoption

The following factors were seen as encouraging the adoption of IPM at Zhou's farm:

- *Project improvements*: This farm participated in the ACIAR-funded IPM projects (CS2/1992/013 or CS2/1998/089), and many specialists have carried out their technical trials and experiments on the farm within the ACIAR-funded project areas. This facilitated IPM application on the farm.
- *Policy requirement*: The farm is certified as a production base for safe vegetables. The quality of the vegetable products is guaranteed by application of the IPM strategy.
- *Market-driven mechanism*: The vegetables have to carry a warranty that they meet food health and safety standards for vegetables. The brand 'Zhennong' is certified and recognised by the market. The products can thus be sold in the supermarkets in Wenzhou.

- *The owner's interest in innovation*: The owner of the farm is interested in introducing new techniques, and seeks to be innovative in order to increase the competitiveness of the farm's products.
- *The roles of qualified technicians in IPM adoption*: Two technicians who graduated from Zhejiang University with bachelors degrees in 2002 work on the farm. They are responsible for technical management and conducting trials.

4 Institutional and policy impacts of the implementation of the IPM projects

4.1 THE POLICY IMPACTS

The research team carried out an institutional survey to identify what effects implementation of the IPM projects had had on different institutions and stakeholders.

The institutions and stakeholders visited during the survey included the Department of Agriculture and Agricultural Bureaus at lower levels, the Agricultural Technical Extension Center, the Plant Protection Stations at different levels, the vegetable processing and marketing companies, the Market Inspection Bureau, the Technical Supervision Bureau and the policy formulating institutions.

It was found that the implementation of the ACIAR-funded IPM projects (CS2/1993/013 and CS2/1998/089) had had a marked effect on the local policy environment on food quality. With the development of the local economy and changes in the consumption behaviour of the urban population, the policy and institutional frameworks for promotion of production and marketing of high-quality food had been established at different levels of the province.

Zhejiang Province had formulated and implemented a series of policies and regulations for controlling the quality of vegetable products. These were based on national policies and local circumstances. The most important policy impact stimulated by the ACIAR-funded IPM projects was the formulation and implementation of the following policies and regulations:

- Provincial Governmental Document 'Strengthening the quality control of agricultural products and quality standardization'
- Regulations on certification and notification of pesticide safety management and forbidding the use of pesticides with high toxicity and chemical residues, 2002

- Regulations for certifying agro-products produced in environmental sound agricultural production bases, 2002
- Regulations for certifying green food, 2002.

The ACIAR-funded IPM projects had promoted policy formulation, and the resulting government policies provided an environment conducive to the further implementation of the IPM strategies. The policies provided a good regulatory basis for the testing and inspecting departments to conduct the market inspections needed. At the same time, the regulations and policies also provided institutional and technical guidelines for technical service institutions and vegetable growers.

In that context, ACIAR-funded IPM projects had contributed to the institutionalisation of strategies of green food production and environmentally sound agricultural practices.

4.2 INFLUENCE OF THE ESTABLISHMENT OF A QUALITY-CONTROL MECHANISM FOR MARKET ACCESS OF VEGETABLE PRODUCTS

4.2.1 Regulations for market access and quality control

As awareness of vegetable quality matters increased, the provincial government formulated regulations covering market access and quality control of vegetable products. These regulations banned the use of high-toxicity, residual pesticides in vegetable production.

A series of associated regulations and policies relating to vegetable production and marketing was also formulated and put into effect. The following were the most important directives relating to vegetable quality:

- The sale of pesticides with high toxicity and harmful residues was forbidden.
- Growers were forbidden to use any high-toxicity and high-residue pesticides in their vegetable production.
- Vegetable products sold in the market were to be inspected daily. That meant that market administration and inspection authorities had to conduct vegetable quality checks and inspections regularly.
- Special vegetable inspections were conducted by the Agricultural Products Inspection and Testing Center (APITC), particularly of vegetables grown on the large-scale, special vegetable farms.

In principle, all vegetables had to be tested and inspected before entering the market.

4.2.2 Operational structure and impacts of the quality-control system

Figure 7 is a flow diagram showing market quality-control steps for vegetable products in Zhejiang Province.

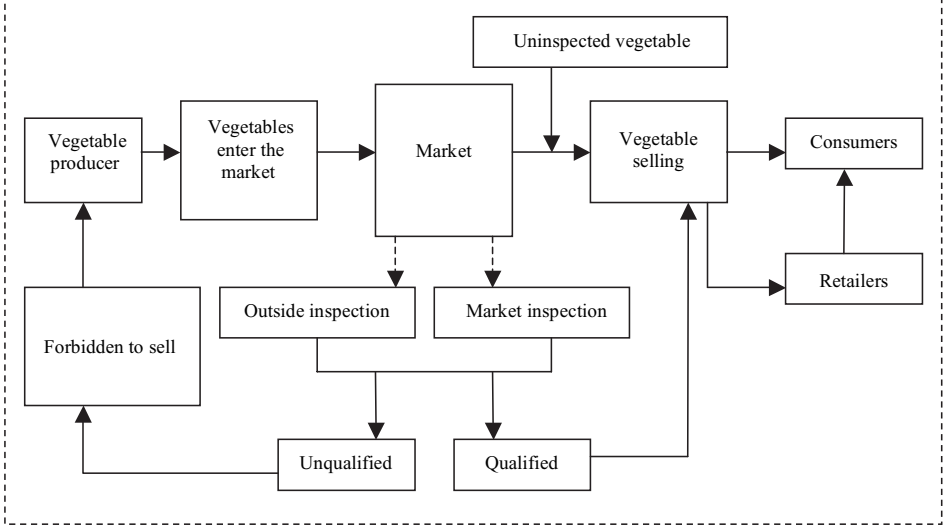

Figure 7. Product flow in the Zhejiang Province vegetable market showing inspection steps for quality control

There are two main types of tests and inspections:

4.2.2.1 Market inspection

Every large vegetable market has a quality test and inspection department. In general, the test and inspection department takes random samples from all kinds of vegetables sold in the market. Since the samples are taken at random, theoretically every farmer's products might be sampled. If the vegetable tested is found to not meet quality specifications, then the owner is not allowed to sell that batch of vegetables, and may be further penalised.

In general, each kind of vegetable must be tested by the market test and inspection department every day, but brassica vegetables are tested more frequently. There is special testing laboratory for brassicas. According to the test and inspection department of Shuxin Market, by using quick testing methods, usually 40–50 batches of vegetables will be tested in the market every day. Normally, the test results are publicised daily. By publicising the results, unqualified producers will lose their reputation in the marketplace. Therefore, on-site market quality control is an important instrument to force the producers or traders to deliver and sell qualified products.

4.2.2.2 Outside quality inspection

The main quality inspection from outside the market is by APITC. APITC tests are much more accurate, but they are quite expensive, and it takes several days to get the results. Such tests are therefore suitable for only the vegetable production bases and other large vegetable farms. The quality test is normally combined with an inspection of growing conditions, cultivation patterns, methods of pesticide application etc. Such systematic testing and inspection are beyond the resources of small-scale vegetable farms.

The quality inspection and quarantine system is an important instrument to guarantee the quality of vegetables during production and marketing. It is also a basis for price differentiation between vegetables produced under IPM and conventional control. Through the inspection system, farmers will gradually build-up their awareness of the importance of vegetable quality and environmental protection.

5 Recommendations for ensuring the impacts of the IPM projects will be sustained

5.1 Strengthening IPM-related institutional and policy enforcement

From this research, it can be concluded that an effective institutional and policy environment is a very important precondition for institutionalising the IPM strategies over the whole production chain. The research team found that the basic policy framework and regulatory system for implementing the IPM strategy had been established primarily in Zhejiang Province. However, the institutional capacity for effectively implementing the policy and regulations over larger areas needed to be further strengthened.

The IPM strategy should be introduced into vegetable production practices in non-project areas through developmental planning of the vegetable sector. In approving new vegetable production bases, IPM and environmental-protection strategies should be made two important criteria for ensuring high-quality production and conservation of the local environment. IPM should be an integrated technical component for production of vegetables qualified as 'green food' or 'safe food'. Physical and biological pest-management technologies can be applied even in organic food production. Therefore, converting conventional production pattern into 'green food' and 'organic food' production patterns will provide more opportunities for adoption of IPM technologies.

To encourage farmers to adopt IPM and other environmentally sound cultivation techniques, a pricing policy that awards a premium to green food and high-quality products should be formulated and implemented in the agri-products market.

5.2 STRENGTHENING PRODUCT QUALITY CONTROL FOR ACCESS TO THE MARKET

Quality inspection before a product enters the retail or wholesale market is the way to keep products of unsatisfactory quality out of the market. Quality inspection is a pathway for producers entering the market, and a guarantee for consumers. The following actions are recommended:

- Technical standards for quality inspection should be set up according to the national agri-product inspection regulations.
- A green food or food-safety certification system for regulating production procedures and pest-management methods should be implemented to ensure acceptable quality before products can access the market.
- A vegetable-quality inspection system should be set up and administered effectively. Test results should be publicised, higher prices set for qualified products and penalties introduced for disqualified products. Price differentials can protect the economic interest of growers who adopt an IPM strategy. The price differentials should be large enough to compensate the increased input costs required for IPM. To ensure that this occurs, a system should be also established to monitor prices.
- Accreditation of vegetable traders would encourage them to purchase only high-quality products from certified producers.
- Last, but not least, a qualified market administrative and technical inspection team should be built up by providing policy and technical training. Equipment and facilities for market inspection should be improved, and local governments should provide financial support for capacity-building in this area.

5.3 SUPPORTING HOUSEHOLDS IN ADOPTING THE IPM AND OTHER ENVIRONMENTALLY SOUND TECHNOLOGIES

The following steps are recommended:

- Agricultural extension services at different levels, such as plant protection stations, agricultural technical extension centers and farmers' vegetable production associations, should play a more active role in providing technical services to farmers seeking to adopt IPM techniques. The services should include field demonstrations and on-site advice, distribution of technical handbooks, and broadcasting market information and news of pest and disease infestations etc. In addition to the technical services, extension officers should help farmers decide on whether or not they should adopt IPM. In order to help farmers make the decision, input/output analyses for different types of farmers should be carried out.
- Using participatory training methodology, IPM-related technical and management training should be provided to farmers. A two-way communication model should be adopted in the training, and farmers' indigenous knowledge and experience of IPM practices should be the basis of case studies used in the training.
- Traders and other stakeholders in the market, such as agricultural production materials companies and supply cooperatives, and pesticide retailers, should

be allowed and encouraged to provide IPM-related technical guidance and advice while selling their products.

- Large vegetable farms should be allowed and encouraged to play more effective roles in demonstrating IPM production patterns and adoption of different IPM technologies.
- A community education campaign to increase farmers' awareness of the need for environmental protection should be implemented. Posters with cartoons should be shown in community public places, and IPM leaflets should be distributed to vegetable growers and other farmers.

5.4 RESEARCH AND DEVELOPMENT OF IPM-RELATED TECHNOLOGIES

The following steps are recommended:

- Research and development (R&D) of IPM technologies is the source of IPM-related know-how. Research on IPM technologies and production methods should be strengthened. The technical and economic criteria identified during this survey as the ones used by farmers for selecting IPM technologies should be the indicators for designing the IPM R&D program. Agricultural universities and research institutions should play greater roles in IPM R&D. They should also establish partnerships with extension services for disseminating the IPM technologies developed.
- Farmers should be involved in the whole process of IPM R&D, and their indigenous knowledge on pest control without environmental and product pollution should be integrated into the IPM packages.
- In addition, a participatory IPM impact monitoring system should be established for assessing the long-term effects and sustainability of the IPM strategy.

5.5 REGULATING THE PESTICIDE MARKET

As mentioned in the previous chapter, an important reason that high-toxicity, high-residue pesticides are still being used in production practices is the presence of illegal and unqualified pesticide producers who are still manufacturing these chemicals. There is therefore a need to develop and implement an effective pesticide market inspection system. Pesticide quality testing and on-site sampling inspection should be carried out. Disqualified producers and traders should be penalised and their production or marketing licences revoked.

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Annexes

A1. SURVEY ITINERARY

Stage	Time	Activities	Location
First survey	August 20–30, 2003	Preparation of study at CIAD	CIAD, Beijing
	August 31– September 1, 2003	Travel to Hangzhou Interview the IPM participators in PPS of Zhejiang province	Hangzhou
	September 2, 2003	Interview plant protection officers at provincial level Arrangement of the later survey tasks with the local participants	Hangzhou
	September 3–5, 2003	Interviews with the related institutions Interviews with Jianqiao markets	Hangzhou
	September 5–7, 2003	Interviews with the households in Sanbao Village, Jianggan District	Hangzhou
	September 8, 2003	Back to Beijing	
Second survey	September 8–16, 2003	Review the first survey and prepare for the second survey	CIAD
	September 18, 2003	Team travel to Wenzhou	Wenzhou
	September 19, 2003	Interviews with the local participants in PPS of Wenzhou Arranging the survey schedule Farmers' household interviews in Sanbao village Interviews of farmers' household in Yunfeng village Market sector interviews at Sanliting, Jianqiao and Wulinmen vegetable markets	Wenzhou
	September 20–26, 2003	Farmers' household interviews in the suburbs of Wenzhou	Wenzhou
	September 27–28, 2003	Farmers' household interviews in the villages of Wencheng County, Wenzhou City	Wenzhou
	September 28–30, 2003	Interviews with related institutions Interviews with related companies and markets	Wenzhou
	September 30– October 1, 2003	Back to Beijing	
Data processing and report writing	October 1– December 1, 2003	Processing the data and information collected during the field surveys	Beijing
	December 2, 2003– January 31, 2004	Preparation of the draft report	Beijing
	Feb– May 2004	Finalising the report	Beijing

A2. PEOPLE MET AND INTERVIEWED

Institution	Name	Position
Safety vegetable office of Zhejiang Province	Mr Feng Lizhong	Vice Director
General Plant Protection Station of Zhejiang Province	Mr Zheng Yongli	
PPS of Xiaoshan District, Hangzhou Province	Mr Lou Manqing	Director
Jianqiao vegetable wholesale market in Hangzhou	Mr Chen Xiangde	Manager
Wenzhou Guolan Agricultural Material Ltd	Mr Liu Huazhou	Manager
The food management office of Wenzhou	Mr Zhang Shiliang	Director
Agriculture and Social Development Department, Wenzhou Agricultural Bureau	Mr Lu	Section Chief
PPS of Wenzhou City	Mr Zhou Xuejie	Assistant Agronomist
Agricultural products inspection and testing center of Wenzhou City	Ms Zheng Tao	Analyst
Shuixin vegetable wholesale market in Wenzhou		

A3. SOCIOECONOMIC DATA FOR SURVEYED AREAS

A3.1 Vegetable production in Wenzhou

Year	1988	1989	1990	1991	1992	1993	1994
Vegetable production (ton)	818,479	902,568	843,585	817,607	574,441	692,605	665,889
GDP of Wenzhou (10,000 yuan RMB)	672,077	728,378	778,977	929,184	1,268,594	1,965,257	2,967,801
Agricultural GDP of Wenzhou (10,000 yuan RMB)	205,865	207,848	213,424	243,484	237,351	262,528	308,008
Vegetable production (ton)	758,207	798,801	854,789	1,019,736	993,801	1,142,744	1,538,847
GDP of Wenzhou (10,000 yuan RMB)	4,035,891	5,100,892	6,058,218	6,771,891	7,331,880	8,281,243	9,320,751
Agricultural GDP of Wenzhou (10,000 yuan RMB)	417,656	479,074	524,130	540,353	534,095	544,153	576,270

A3.2 The certified safety vegetable bases in Wenzhou:

Location	Name	Area (ha)
Taishun County	Luoyang township vegetable base	66.67
	Xuexi countryside vegetable base	18.67
	Baoyang countryside vegetable base	46.67
	Xinpu countryside vegetable base	53.33
	Xiaocun township vegetable base	74.67
	Sankui township high mountain vegetable base	35.33
Wencheng County	Eryuan countryside vegetable base	80
	Nantian township vegetable base	190.67
Yongjia County	Fenglin township vegetable base	133.33
Ouhai District	Li'ao vegetable base	200
Longwan District	Three Zhou's vegetable demonstration base	24.67

A4. HOUSEHOLD SURVEY QUESTIONNAIRES AND CHECKLISTS FOR SEMI-STRUCTURES INTERVIEWS

A4.1 Household investigation questionnaires

_____County/district_____ township/countryside_____village
number：

Name：_____Sex：_____Age：____Education:

Household type：（1）IPM projects area （2）non-IPM project area

1. Household general information：

（1）family number（ ）	Labor （ ）, vegetable labor（ ）
（2）land situation and cultivated structure	Total land area（ ）mu，vegetable land（ ）mu
（3）transportation vehicle	A．minibus B．auto tricycle C．Tricycle
（4）annual income	（ ）yuan

2. Income source：

Year	Agriculture income		Non-agriculture income			Total income	Major reasons for the changes
	Vegetables	Other products	Work outside	House renting	Others		
2003							
2002							
2001							
2000							

3. Farming cost:

Input	Amount	Price	Total cost（yuan）	If it has increased in recent years?
Seeds				
Fertilizers				
Pesticides				
The framework, coverings of the green house				
Irrigation				
Cost for transportation and selling				
Cost for hiring labors				
Others				
Other cost related to IPM（for example）				
Anti-pest net				
Sex attractant				
Total				

4. Income* （Please indicated the units, such as mu, jin and so on）

Planting category	Area (mu)	Total products (jin)	Price (yuan)	Gross income	*Products cost**	Net income

5. Do you know what is IPM? A. yes B. no **If the answer is yes, please explain it briefly:**

6. If you have adopted the following IPM strategies?

	IPM strategies	**Adoption situation**	**Adoption time**	**Effective evaluation**
1	Soft and biological pesticide			
2	Anti-pest net			
3	Sex attractant			
4	Intercrop			
5	Pest attraction light			
6	Anti-pest board			
7	Manual sprayer			
8	Excellent breeds			
9	Reasonable rotation			
10	Manual catching pest			
11	Others (please indication)			

7. The reasons for adoption the IPM strategies （ ）

A.	Policy	With favorable policies such as reducing tax	
B.	Laws and regulations	The obvious forbidden for using the high toxicity and residues pesticides	
C.	Projects' improvement	There is an IPM project to improve the farmers to adopt this kind of technologies	
D.	Market demands	The vegetable produced by IPM strategies is more popular in the market	
E.	The improvement of extension institutions	The suggestion of extensional institutions and personnel, such as the experts from PPS	
F.	The improvement of related profit institutions	The suggestion of the pesticide sellers	
G.	The characteristics of the techniques themselves	Such as the techniques is very easy to use, and the effect is obvious	
H.	Gender reasons	Different genders have different attitudes to new techniques,	
I.	Income structure	The vegetable income is the main income of the family, and have to use new techniques to increase income	
J.	The social press	Others have adopted the IPM strategy, and you have to adopt it too.	
K.	Other reasons	Please state here _____.	

8. Why do not you like to learn IPM? （ ）

A. The techniques is too complicated and difficult to learn **B.** To learn a new techniques have to invest for it, and I won't invest **C.** No enough time to learn it

D. The new techniques have no very obvious effects on increasing the vegetable production

E. Needn't to input so much attention on learn IPM because the vegetable income is a small part of the total household income **F.** Lacking of labors

G. New technical have not obvious effect on increasing income **H.** Other reasons, please state here_____.

9. When you choose pesticides, what kind of information is useful for you :（ ）

A. Own experience B. pest information forecast of local PPS C. Neighbor or other experience persons D. Technical expert or technicians E. Pesticides sellers

F. others, please state here _____.

10. Have you got trainings for vegetable growing? （ ）**A. yes B. no**

If the answer is yes, please fill the following table:

Training times	Training content	Training place	Training time	Money input	Effective evaluation

11. If there are any training for the vegetable growing and pesticides management, do you like to learn the knowledge?（ ）

A. Yes →
- Can improve the growing techniques （ ）
- Can get the selling license （ ）
- Can increase the yield of the vegetables （ ）
- Can improve the quality of the vegetables （ ）
- Others, please state here _____ （ ）

B. No →
- You know how to deal with it and needn't to learn it anymore （ ）
- No time to learn it （ ）
- There is not obvious improvement for the quality or yield of the vegetables （ ）
- It need to pay money for learning it （ ）
- Others, please state here_____ （ ）

12. Is there any change related the vegetable growing? What is the reason?

		Reason	Ranking
1	Growing condition	Cultivated land changed, for example, the lands have been used by the government	
2	Income structure	For example, you found other work opportunities which can get more income	
3	Labor force	For example, the labor force reduced and can not growing vegetables anymore.	
4	Others affection	For example, neighbors have go to do other kinds of things	
5	Projects improvement	The input of the projects improved the vegetable growing	
6	Technical characteristics	The IPM strategy can promote the vegetable growing technical level	
7	Service institutions	The services from the extension departments, PPS, which can improve the interest of the farmers to growing vegetables	
8	Marketing condition	The requirement for the vegetables has been increased in the market	
9	Policy environment	The policies require the farmers have to grow security vegetables	
10	Others	Please state here _____.	

13. Most of your vegetables have been:( )

A. consumed yourselves B. wholesaled in the market C. Retailed in the market yourselves D. Given to the companies according to the orders E. Others, please state here _____.

14. How do you get the market information? ( )

A. Judgment yourself B. Listening to others suggestion C. Watching TV and reading newpapers D. Contract with the related companies E. Getting the information from the market F. others, please state here_____.

15. Is vegetable selling license necessary for selling the vegetables in the market? ( )

A. yes B. no If "yes" then :

Vegetable selling license	Which departments give the license for you?	How much do you pay for it?	What kind of quality requirement for your vegetables?	What kind of advantage can you get after getting the license?

15. How can you recognize the plant disease and insect pests, and deal with it? ( )

A. Learn it yourselves such as reading books, magazines B. Consulting from the neighbors or other vegetable growers with good experiences C. Consulting from the technicians D. Consulting from the pesticides sellers E. Consulting the related departments, such as PPS F. Others, please state here _____.

17*. Do you believe the IPM can improve the income?

A. yes B. no **If the answer is B, then what the reasons?**

A. It need additional investment（such as buy anti-pest net） B. The yield of the vegetables has not obvious increase. C. The consumption of pesticides has no obvious reduction D. The consumption of fertilizers has no obvious reduction E. The labor force input has been increased F. The proportion of the income from vegetables is rather low in the total household income G. Others, please state here

18. Can your vegetables be sold in the market according to the price of the green food, environmental sound food?

19. Have you joined the IPM projects, and what's your thinking about it.

20. *Are there any changes in your vegetable producing, life and your thinking after adopting the IPM?

21. What do you need mostly currently, and what's your want in the future?

22. What is your estimated for the future development of the vegetable growing?

A4.2 The outline of institutional investigation

Number

Institution name	Interviewee	Duty	Telephone

1. The position structure and staff arrangement in your institution
2. The main function of your institution, and what functions are related to the IPM strategy.
3. The major role and function of this institution in the extension and implementation of IPM.
4. If there are any special persons who take charge of the work related to IPM?
5. What are the daily works of the special staff, such as technical services, providing information, policy extension?
6. The contact ways and frequency with the farmers of the special staff.
7. When did the IPM begin here? If there is any change of the governmental supporting for the vegetable growing? Is the supporting increased or decreased? What is the major cause for the change?
8. The implementation situation of IPM strategy this year. If there is any change compared with 3 years ago? If there is any change compared with the beginning of 1990s? What are the main causes?
9. What is your thinking about the farmers' attitudes for the IPM?
10. Which institutions does your institution often contact or cooperate with for IPM?
11. The main contact or cooperation content, frequency, methods and the effect evaluation.
12. What is the future development orientation of your institution?
13. Your suggestion for the future development of IPM.

A4.3 The outline of market investigation

9. The storing situation, the average storing time for the vegetables, the storing place and storing methods, and if the quality of the vegetables can be guaranteed?
10. How to deal with the problems related to the vegetable quality?
11. Market management, and how much will the farmers pay for vegetable trading fees?
12. Compared with other same markets, how the competition of the environmental sound vegetable is and what are the advantage and disadvantage of this market?
13. If the repute of the market is helpful for increasing the prices of the local vegetables and providing more selling chances?
14. How to spread the information of the market demands to the farmers?
15. How does the market drive the farmer households to adopt the IPM strategy?
16. If the market cooperates with other institutions, such as the governmental departments, the extension institution, the pesticide manufacturer and so on?
17. The development future of the market and the probably impact for the farmer households.
18. Please forecast the development future of he vegetable growing, the probably problems and the solving ways.

Market name	Interviewee	Duty	Telephone

1. The scale, location and transportation condition of the market
2. The proportion of the vegetable commodity in the market, and the main categories of the vegetable commodity.
3. Vegetable trading

The daily vegetable trading amount	The daily total trading income	The average trading amount of the vegetables per year	The total trading income per year

4.The vegetable sources and going place in this market: the origin place and selling place(the country nearby, the farther country, the radius of vegetable source-the nearest distance, the farthest distance, the mass distance, the average distance and so on)

	The nearest place	The farthest place	Major place	Average distance
The source place of the vegetables				
The going place of the vegetables				

4. The quality of the vegetables, and if there is obvious dividing of the vegetables for green food, environmental sound products and so on.
5. The proportion of the environmental sound vegetable.
6. Is there any identification for the farmers to sell their vegetables in this market? Are there any preferential policies for them? How to check the identification? How to deal with them if they have not this kind of identification?
7. Are there any preferential policies for selling the green vegetables, such as decrease the market management fee?
8. The prices of the environmental sound vegetables and the price of the general vegetables, and if the price of the environmental sound vegetables are higher, and the range of the higher.