CHAPTER III

RESEARCH METHOD

This chapter presents the descriptions of study site and methodologies for data collection and analysis. It aims to determine the factors affecting Pb and Cd accumulation in vegetable production systems. The combination of qualitative and quantitative data analysis was applied. Primary data were collected through formal interview questionnaires and field survey. Secondary data were collected from documents and other published papers.

3.1 The study site

This study was conducted in Thai Nguyen city, an old industrial city in the northern part of Vietnam. It has a large population which includes many industrial parks, major universities and hospitals of the province. Moreover, it is an important traffic hub of the northern region of Vietnam. This is a good condition for the consumption of agricultural products.

The choice of this study site based on vegetable growing area where have the largest vegetable area grown by farmers in Thai Nguyen city - the center of Thai Nguyen province (Figure 3.1). Selected research area is Tuc Duyen ward in which having the largest production of vegetables of the city (accounting for 15.78 percent of total area, 17.67 percent of total production citywide) (Statistics Department of Thai Nguyen city,

2006). In Tuc Duyen ward, people live mainly on agricultural production (about 68%), in which agricultural production of Tuc Duyen ward focuses primarily on developing vegetable intensive production.

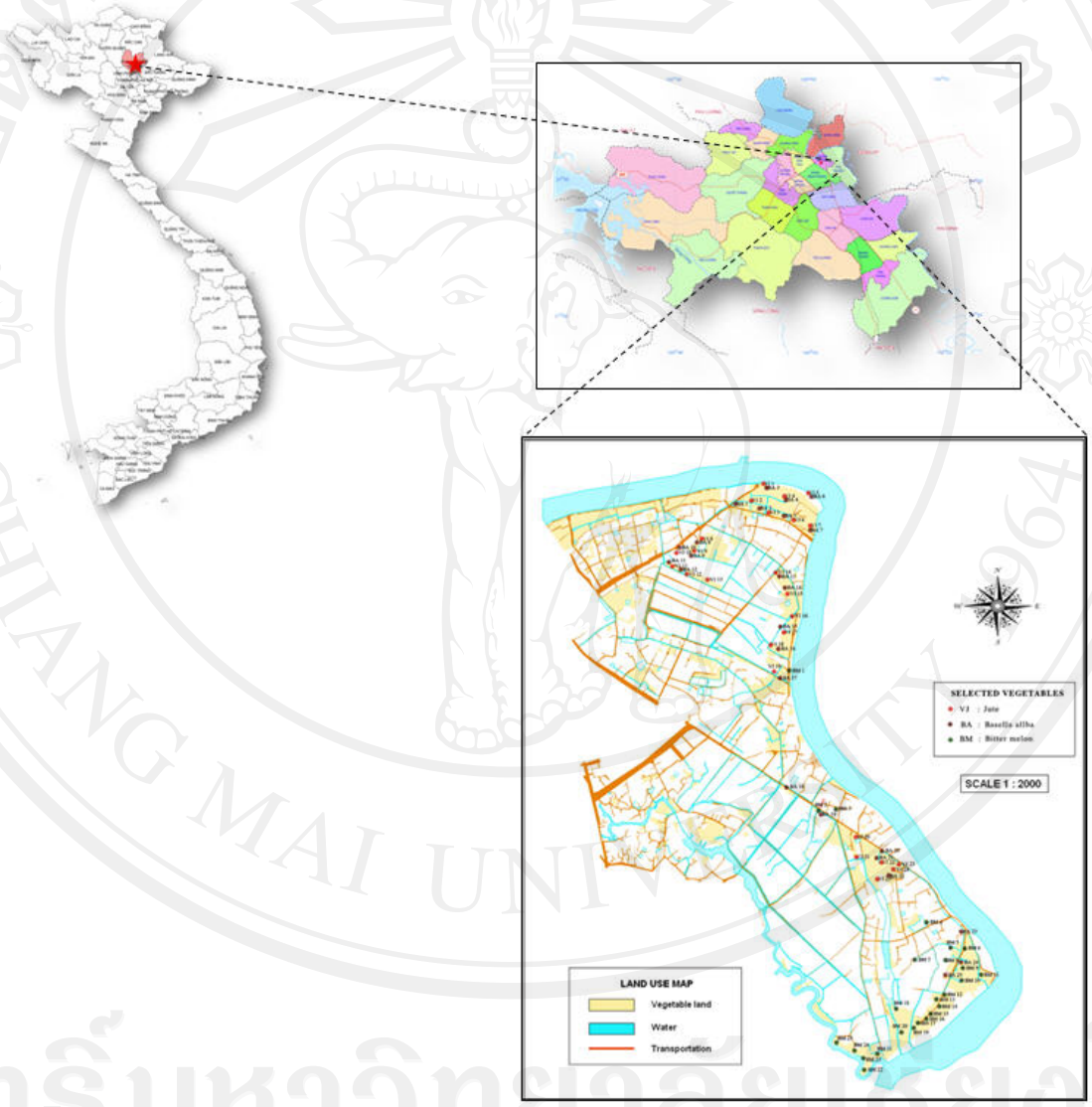

Figure 3.1 Location of study area, Tuc Duyen ward, Thai Nguyen city, Vietnam

3.2 Sampling technique

This study was conducted between April and June 2010. A simple random sampling method was used to select farm households who planting three kind of selected vegetables which are jute, basella allba and bitter melon. Totally, 75 farmers who planted three selected vegetables along Cau river at Tuc Duyen ward were randomly selected in the study. It was composed of 25 households growing jute, 25 households growing basella alba and 25 households growing bitter melon. 75 households were selected for interviewing with prepared questions. In particular, the interviews focused on the heads of households. Standard set of interview questions were used to understand the social-demographic information of growers, the status of farming and vegetable production in these areas. Along with field survey, location of the fields where planting selected vegetables were determined by GPS (Global Positioning System) for collecting vegetables, water and soil samples. Through the course of field survey and discussions with extension officers, each vegetable growing area was identified. Location of the fields and areas planting three research vegetable were identified on a map by using GPS satellite meter. After determining the number of fields, they were numbered and fields were determined by using simple random sampling method.

3.3 Data collection

3.3.1 Primary data

Primary data was collected from household survey (farmer's interviews, group discussion and field observation) by using a formal questionnaire and through field

survey by collecting vegetables samples, cultivated soil samples and irrigation water samples at 75 selected fields and measure the samples in the laboratory. The collected data in formal questionnaires included farmer's socio-economic characteristics, vegetables production situation and farmer's practices in farming in the research area. Data were entered in spreadsheets and applied using SPSS 16 and LIMDEP for data analysis.

Soil, irrigation water, and vegetable samples took from vegetable growing fields of 75 selected vegetable households.

All samples were analyzed for Cd and Pb in the Central laboratory, Life Science Institute, Thai Nguyen University of Agriculture and Forestry, Thai Nguyen city, Vietnam. To determine the heavy metals (Cd and Pb), chemical interaction (break samples) method was used by interaction using a mixture of HNO_3 + $HClO_4$ and measure sample by F-AAS (Flame Atomic Absorption Spectrometry).

- **Soil samples**

Soil samples were taken from the same location with vegetables sampling by a diagonal sampling method of cultivation soil layer (20 cm), taking 5 points/field, then mix them together and take a sample about 500 gram for laboratory analysis.

- **Irrigated water samples**

Samples of irrigated water for vegetables were taken from the ditches (intake water from Cau river) from 10-20 cm depth with a 0.5 liter plastic PE bottle. Water sample was taken at the same time with vegetable and soil samples.

- **Vegetable samples**

Vegetable samples were taken on the same day as the water sampling date and soil sampling date. With per field of households, three kinds of vegetables will be taken sampling. Each kind of vegetable sample took randomly from 5 points in the field and then mix together. After that take per sample is about 500 gram for laboratory analysis. Sampling the edible part of vegetables: stem (basella alba), stalk (jute), fruit (bitter melon).

3.3.2 Secondary data

In order to get the most understanding of existing situation of production in the target area, secondary data were gathered from published and unpublished information about heavy metal (Pb and Cd) in soil and vegetables in particular and at the study area in general. This information was collected from documents, statistic data related research area and studied field from management organizations, specialized agencies in Thai Nguyen city such as Tuc Duyen ward's Agricultural department, Thai Nguyen city's Agricultural department, Statistics Department of Thai Nguyen city.

3.4 Data analysis

Descriptive statistic, factor analysis and multiple regression were used to meet the first, second and third objectives respectively. Statistical Package for Social Science (SPSS) and Microsoft Excel software were used for descriptive statistic. LIMDEP version 8 was used to run multiple regressions.

3.4.1 Descriptive statistic

Descriptive statistics were used to describe the situation of vegetable production from the secondary data (collected from management organizations, specialized agencies in Thai Nguyen city) and primary data (households' survey and field survey).

The data from formal survey and interview were analyzed using descriptive statistic. The socio-demographic data of the study area and respondent, and their practices were expressed in terms of charts, graphs, percent, means and standard deviation in order to overcome the first objective.

The data from measure samples (soil, irrigation water, vegetables) in the laboratory were analyzed using descriptive statistics as percent, mean, standard deviation values and expressed in terms of charts, graphs in order to determine the accumulation of heavy metals (Cd, Pb) in soil and in the selected vegetables to overcome the second objective.

3.4.2 Factor analysis

In order to determine factors affecting accumulation of heavy metals (Cd, Pb) in vegetables and cultivated soil, factor analysis was applied in the first step.

Factor analysis used to calculate factor scores of the main components. Principal component analysis (PCA) used to extract the main components which have high multicollinearity from all varieties of independent variables. The variables which have highest loading were selected and named the components according to the commonness of variables. Explanatory variables (X_i) including in factor analysis are presented in Table 3.1.

Table 3.1 Explanatory variables affecting lead (Pb) and cadmium (Cd) accumulation in cultivated soil and selected vegetables

Variables	Description	Measurements
AGE	X1= Age of the vegetables grower	years
EDU	X2= Schooling years	years
FARM_SIZE	X3= Family size	number of member
TOTAL_AREA	X4= Total area of cultivated	m^2
AREA_FIELD	X5= Area of vegetable field	m^2
EXP	X6= Vegetable growing experiences	number of years
N_SOURCE	X7= Number of irrigation water sources	number
USE_POND	X8= Farmer using irrigation water from public pond	Yes=1, No= 0
AMOUNT_WATER	X9= Average amount of irrigation water/day	liter/ m^2
TIME_WATER	X10= Time of watering	times/ day
F_SAFE_P	X11= Farmer plant and produce vegetables following safe vegetable production process	Yes=1, No= 0
UNDERSTAND_HM	X12= Farmer know about accumulation of heavy metals in vegetable	Yes=1, No= 0
PB_IN_SOIL / CD_IN_SOIL	X13= Accumulation of lead (Pb) or cadmium (Cd) in cultivated soil	mg/kg *

Table 3.1 Continued

PB_IN_WATER / CD_IN_WATER	X14= Accumulation of lead (Pb) or cadmium (Cd) in irrigation water **	mg/l **
	Dependent variables	
PB_IN_VEG	Y1= Accumulation of lead (Pb) in vegetables	mg/kg
PB_IN_SOIL	Y2= Accumulation of lead (Pb) in cultivated soil	mg/kg
CD_IN_VEG	Y3= Accumulation of cadmium (Cd) in vegetables	mg/kg
CD_IN_SOIL	Y4= Accumulation of cadmium (Cd) in cultivated soil	mg/kg

*, ** Corresponding for Y1 and Y3

** Corresponding for Y2 and Y4

The above variables can affect Pb and Cd accumulation in cultivated soil and in vegetables, and the hypotheses for the study are as follows;

- **Age of the vegetables grower (AGE)**

It was hypothesized that social-demographic characteristics of farmers such as the age of the household head has affected on accumulation of heavy metals (Cd and Pb) in cultivated soil and vegetables.

- **Schooling years (EDU)**

Schooling years indicate education level of the household head. It was considered as an indicator of information that shapes management skills or simply human capital. It was hypothesized that with the amount of formal education, it increases farmer's ability to access information about accumulation of heavy metal (Pb and Cd) in cultivated soil and vegetables and thereby to improve his/her knowledge on understanding about heavy metals.

- **Family size (FARM_SIZE)**

It was hypothesized that social-economic characteristics of farmers such as size of family has effect to practices in vegetables production thereby to effect accumulation of heavy metals (Cd and Pb) in cultivated soil and vegetables.

- **Total area of cultivated (TOTAL_AREA)**

It is a social-economic factor has effect to farming area of farmers thereby to effect accumulation of heavy metals (Cd and Pb) in cultivated soil and vegetables.

- **Area of vegetable field (AREA_FIELD)**

It is a social-economic factor has effect to farming area of farmers thereby to effect accumulation of heavy metals (Cd and Pb) in cultivated soil and vegetables.

- **Vegetable growing experiences (EXP)**

The number years of vegetable growing experiences was one of the social factors affecting tillage/cultivation practices of farmers in their fields. Therefore, it was also a factor relating to the accumulation of heavy metals (Cd and Pb) in cultivated soil and vegetables.

- **Number of irrigation water sources (N_SOURCE)**

Number of water sources is related to irrigation water sources. Different water sources have different water quality so it affected to the accumulation of heavy metals (Cd and Pb) in cultivated soil and vegetables.

- **Farmer using irrigation water from public pond (USE_POND)**

Using public water holes is a practical measure/cultivation practice of farmers for irrigation. Due to irrigation water sources were taken from public water holes, therefore, vegetable fields around these fields were also affected by accumulation of heavy metals from the same water in the public water holes.

- **Average amount of irrigation water/day (AMOUNT_WATER)**

This is considered as an information indicator in describing water sources which farmers irrigated vegetables daily. This indicator reflects the current status of vegetable production in the research areas.

- **Time of watering (TIME_WATER)**

This indicates the number of watering of farmers every day. It, along with the factor describing average amount of irrigation water in a day, reflects total number of watering times farmers spend daily on their vegetable plot.

- **Farmer plant and produce vegetables following safe vegetable production process (F_SAFE_P)**

This shows that whether farmers grew vegetables in accordance with clean and safe vegetable production process or not. This is one of factors affecting the accumulation of heavy metals in cultivated soil and vegetables. It was hypothesized that these fields

had not been grown vegetables in accordance with clean and safe vegetable production process, the risk of heavy metal accumulation in soils and vegetables in these fields would be higher.

- **Farmer know heavy metals accumulation in vegetables (UNDERSTAND_HM)**

This reflects the understanding of farmers about the accumulation of heavy metals in vegetables. Understanding of farmers about the accumulation of heavy metals in vegetables together with heavy metals' threat to the quality of vegetables had influence to tillage of farmers on their vegetable fields. This contributed to affect the accumulation of heavy metals (Cd and Pb) in cultivated soil and vegetables.

- **Accumulation of lead (Pb), cadmium (Cd) in cultivated soil (PB_IN_SOIL / CD_IN_SOIL)**

Accumulation of lead (Pb), cadmium (Cd) in cultivated soil are correlated with the accumulation of lead (Pb), cadmium (Cd) in irrigation water due to soil was supplemented substances from water sources. Substances which were added to the soil also included heavy metal. This was a contributing factor to affect the accumulation of heavy metals in soil.

- **Accumulation of lead (Pb), cadmium (Cd) in irrigation water (PB_IN_WATER / CD_IN_WATER)**

Accumulation of lead (Pb), cadmium (Cd) in irrigation water is very variable depending on the time of sampling, sampling location and discharge sources. The accumulation of heavy metals in soil and vegetables in general was affected by the accumulation of heavy metals in water.

- **Accumulation of lead (Pb), cadmium (Cd) in vegetables (PB_IN_VEG/ CD_IN_VEG)**

Accumulation of lead (Pb) in vegetables was affected by many factors such as cultivated environment and tillage of farmers. In which, the accumulation of heavy metals (Cd and Pb) in vegetables depended heavily on cultivated environment, especially cultivated soil environment.

3.4.3 Multiple regression

The factor scores of the main components from the factor analysis were used as independent variables in multiple regression analysis to find the relationship among accumulation of heavy metals (Cd, Pb) in vegetables and cultivated soil (dependent variables) with the main components (independent variables).

$$\mathbf{Y_i = \beta_0 + \beta_1 F_1 + \beta_2 F_2 + \beta_3 F_3 + \ldots + \beta_n F_n}$$

Where,

Y_i = Accumulation of heavy metals (Cd, Pb) in vegetables and cultivated soil (mg/kg)

β_0 = Constant

β_i = Coefficient for $F_1,\ldots, F_n$

F_i = Factor score i=1,…,n