
Incidence of Bangkok city development on peri-urban agricultural patterns and cropping systems evolution

Buntoon Chunnasit¹, Jacques Pagès², Onouma Duangngam³

Abstract: *The very rapid growth of Bangkok city over the last decades, which cannot be confined to Bangkok administrative boundaries, has many impacts on the neighbouring provinces, at diverse levels : population density, economic activity, industrialisation, transportation,...all of these process ending in a growing pressure upon natural resources : land, water, but eventually air and light.*

Agricultural activity is strongly relying on availability, both in terms of quality and quantity, of these resources and as such, Bangkok development has induced many changes in agricultural sector.

Combination of different methodologies (statistic data processing, in-depth on-farm enquiries together with rapid survey over a sample of more than hundred farms, markets follow-ups) unveiled the wide diversity of situations, cropping patterns and production results. Data analysis by mean of GIS tools led to perform a mapping of production areas, expressing a spatial distribution of crops. This zoning is the result of different farmers strategies, related to different cultural or historical background as well as the evolution of their physical environment.

In the framework of the elaboration and implementation of cities master plans, objectives of city policy makers and farmers behaviour can thus show discrepancies, resulting in possible conflicts. Methodologies able to describe the dynamic of urban and periurban agriculture as an answer to the fast evolution of its global environment must then be evolved in order to provide to both the policy makers and the periurban growers, negotiation tools for the sustainability of agricultural activity within urban space.

^{1,3} Faculty of Agriculture, DORAS Centre, Kasetsart University 10900 Bangkok

² CIRAD, DORAS Centre, Kasetsart University 10900 Bangkok

1 Introduction

Agriculture has always been at the core of Thailand development and if Thai rice is well known world-wide, a few other agricultural productions are giving to this country a predominant place above all, i.e. cassava, rubber, shrimps,

Supported by the income derived from its agriculture, Thailand engaged in industrialisation process and as a matter of fact, infrastructures and services sector developed rapidly over the last decades.

The fastest developing site of the country, the Central Plain, still the major area for rice cultivation due to its climate and the water resources from Chao Phraya and Mae Klong Rivers, allowing up to 3 or 4 cycles per year, is also the framework of an intense urbanisation phenomenon, centred on Bangkok (DORAS project, 1997). With a growth rate of about 40 % during the 1980s, Bangkok and its 10 million people conurbation are rapidly inducing deep and often irreversible changes in the Central Plain agricultural and socio-economic landscape (Eiumnoh A., Parkpian P., 1998).

Rice paddy fields are progressively and rapidly giving way to more intensive cropping systems based on vegetable, ornamentals, herbs, fruit trees, coconuts...

Between 1989 and 1995, in Thailand Central Plain vegetable areas increased by more than 35 % when fruit trees increased by about 20 %. At the same time, paddy land slightly decreased by 2.7 % and field crops (sugarcane) by 3.4 %.

At the fringe of estates development, fallow lands are often met, unveiling landowners speculative strategies.

Bangkok and related urban centres have thus induced many changes in their environment and the close agricultural sector.

Competition, as for natural resources use, but also complementarity, as in the chain production / consumption, are the two main trends which can characterise urban - agriculture relationships. This specificity has been used as the basic guideline to define Periurban agricultural sector (Mbaye A., Pagès J. and de Bon H., 1998 ; Ellis F. and Sumberg J., 1998).

The price of land has increased where plots can be used as an estate settlement, resulting in an overexploitation of the remaining agricultural plots, or in their abandon and the cultivation of less favourable areas.

Water has to be shared between irrigation, industrial usage and urban consumption. Pollution by city wastes must now be considered, resulting in a reduced availability for farming.

City expansion comes along with a correlative development of transportation infrastructures as well as traffic activity. Roads are criss-crossing the agricultural landscape, spreading out

of the city core the pollution linked to vehicles operation. Heavy metals deposits can then be found on plants, and in canals in the fields along the roads. In the most active areas, light can be shaded by fog and photosynthesis process reduced, inducing a lower potential productivity.

City' vicinity also leads to changes in socio-economic conditions of production sector. Apart from the cost of land rental, inputs required to achieve high level productivity, labour force is becoming more expensive, the relatively high wages which can be fetched in the nearby industry and services upscaling the cost of living in the whole city area, periurban agriculture included. Production costs are then increased, and as the skill and knowledge, necessary to produce the high quality standards required by urban consumers arise, manpower is impacting heavily on agriculture sustainability.

In this very dynamic environment, agricultural producers must express a strong capacity for adaptation and evolution, both diversifying and intensifying their strategies and their practices as an answer to any change in their surroundings.⁴

New plants, new technologies are thus investing farmers' fields and the once rice cultivators are now growing a wide range of vegetable, some of them just being domesticated, or just introduced from remote places in the world. Cultivation techniques required to attain the best production, either in quantity or in quality are often barely known, and the incidence of these changes on environment is more than often not considered.

In the meantime, Governemental agencies, as well as private sector (production, post harvest technology, marketing) are aiming at a better quality for production and establish closer links with international organisations and European countries, in order to implement in Thailand normae regulations and production references guidelines.

Development agencies, training institutions and research organisation are part of the panoply that the Thai government is mobilising to assist producers and citizens for a better mutual understanding and living together.

As in many countries, in Thailand, research infrastructures are closely related to implementation and training services.

In the particular concern of periurban agriculture⁵, a research activity has been engaged in Kasetsart University, within the Development Oriented Research on Agricultural Systems (DORAS) Centre. Research programmes are carried out using system approach methodology, generally in close partnership with end-users of research products.

⁴ Apart from typical agricultural activity, aiming at producing food or plant material, there is a trend to develop other sources of income, based upon non-directly productive agricultural resource, such as water pond, land space, hosting facilities,...These increased roles of agricultural sector, not presented in this paper has been reported in other countries as well, and is usually designed as related to the multifunctionnality of agriculture (Losada H., Martinez H., Vieyra J., Pealing R., Zavala R. and Cortes J., 1998 ; Midmore D.J., 1998)

⁵ Which must be understood here in its broadest meaning, including urban agriculture

The field of research is "agriculture within urban space". It is based on the definition of Periurban Agriculture, generally agreed upon: the agriculture which competes with the city in the use of natural resources (land, water, energy, labour). Important sectors of this agriculture include horticulture (vegetable, fruits, mushrooms, roots and tubers), livestock, fodder and milk production, aquaculture and forestry.

Problems at stake have been identified as requiring mainly three types of actions :

- assistance to producers in order for them to achieve sufficient levels of good quality products, and particularly to meet urban requirement on food supply ;
- knowledge and practices pertaining to the sustainability of agriculture within urban environment, and particularly to the improved management of natural resources ; ultimately, this would give information leading to measure the degree of sustainability of this agriculture (Nugent R.A., 1999)
- deliverance of useful information on agriculture in urban environment, so that agriculture can be acknowledged by policy makers and urban planners.

This paper presents the first findings on this agriculture, assessing its diversity, its variability but also pointing out to some specific evolution either qualitative or geographic, with definite trend which must be taken into consideration in order to establish or implement cities master plans.

2 Methodology

The methodology applied is derived from system analysis, and combine many tools such as statistics, survey, GIS ... as it is commonly performed in this type of study (Banzo M., 1998) ;

Results gained so far are derived from statistical processing of data issued by the Ministry of Agriculture and Cooperatives and the Ministry of Interior (census year 1998, 1999). These data have also been considered with complementary information gathered through on-farm surveys (December 1998 till august 2000), enquiries and bibliography analysis. In order to get knowledge upon marketing sector, a survey is also being carried out at market place level (mainly Talat thai). The area which has been considered is composed of the 350 tambons of changwat Chachoengsao, Nakhon Pathom, Nonthaburi, Pathumthani, Samut Prakhon, Samut Sakhorn and Bangkok Metropolitan Authority. An assessment of economic value of periurban agriculture has also been prepared, though the high degree of variability of data collected may hamper heavily this type of attempt (Hormann D.M., 1999).

3 Results

3.1 Urbanisation and agricultural activities

Preliminary remark: due to the expertise of the team of researcher engaged in the programme, most of work carried out so far deal with plant production. Only a few data have been gathered regarding animal production, but this field indeed will have to be address in the forthcoming studies.

The incidence of urbanisation process can be assessed through the change in the general landscape of city suburbs. Agricultural land are quickly evolving towards human settlement and all the related infrastructures. Study of the seven changwats unveil different ratio of agricultural land use compared to their acreage. These ratio can be related to population density, which gives an indication of urban pressure upon natural resources and particularly land use (table 3 hereafter as shown in the table 2 and 3 below, as well as graph 1. 2, as well as population density).

TABLE 1 : AGRICULTURAL LAND USE

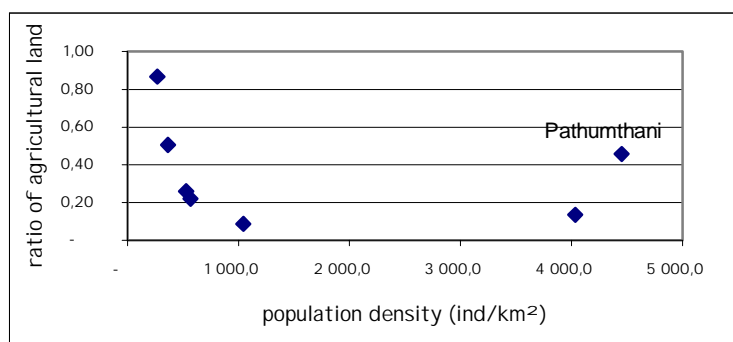
Changwat	total area (ha)	agricultural area (ha)	Ratio Ag/total
Chachoengsao	237 042	205 352	0,87
Nakhom Pathom	221 009	111 864	0,51
Nonthaburi	142 715	31 384	0,22
Pathumthani	150 224	68 884	0,46
Bangkok	156 609	21 276	0,14
Samut Prakhan	97 042	8 614	0,09
Samut Sakhorn	86 355	22 500	0,26

Source: Statistic Ministry of Agriculture and Cooperative, 1998

TABLE 2 : POPULATION DENSITY (REF. NATIONAL CENSUS 2000)

Changwat	total area (ha)	population	density ind/km ²
Chachoengsao	237 042	632 533	266,8
Nakhom Pathom	221 009	809 062	366,1
Nonthaburi	142 715	810 254	567,7
Pathumthani	150 224	6 690 402	4 453,6
Bangkok	156 609	6 320 174	4 035,6
Samut Prakhan	97 042	1 014 449	1 045,4
Samut Sakhorn	86 355	457 078	529,3

GRAPH 1 : RELATIONSHIP POPULATION DENSITY AND AGRICULTURAL USAGE OF LAND



The **graph n°1** shows the incidence of an increase population density on the use of land for agriculture.

Anyway, the particular case of Pathumthani changwat already stresses the fact that, in spite of a high population pressure upon land, even higher than encountered in BMA, it is still possible de maintenir an agricultural land use similar to less densely changwat, such as Nakhon Pathom.

In the case of Pathumthani, we will see that this rather high ratio of agricultural land use is due for the most to a sole cropping system : orchard of orange trees.

Though located in a very similar physical environment (climate, soil and water), cropping patterns evolved by farmers present many distinct characteristics, in terms of type of crops, land and water management, economic importance.

The following table (table 3) shows difference between cropping systems and the relative importance of cropped areas at changwat level and tambon level.

TABLE 3 : COMPARATIVE CROPS AREA IMPORTANCE AT CHANGWAT LEVEL (1998)

%area	Rice	Vegetable	fruits	perennial	ornamentals
Chachoengsao	38	7	31	54	1
NakhonPathom	24	51	23	11	39
Nonthaburi	8	11	7	2	19
Pathumthani	19	12	19	1	1
SamutPrakhan	2	12	7	17	-
SamutSakhorn	1	3	9	13	15
Bangkok	8	4	3	1	25
total area (ha)	480 307	20 401	96 115	39 119	5 014

At a first glance, the two changwats of Chachoengsao and Nakhon Pathom appear to be more concerned by agricultural production than the five other ones. Ranking either first or

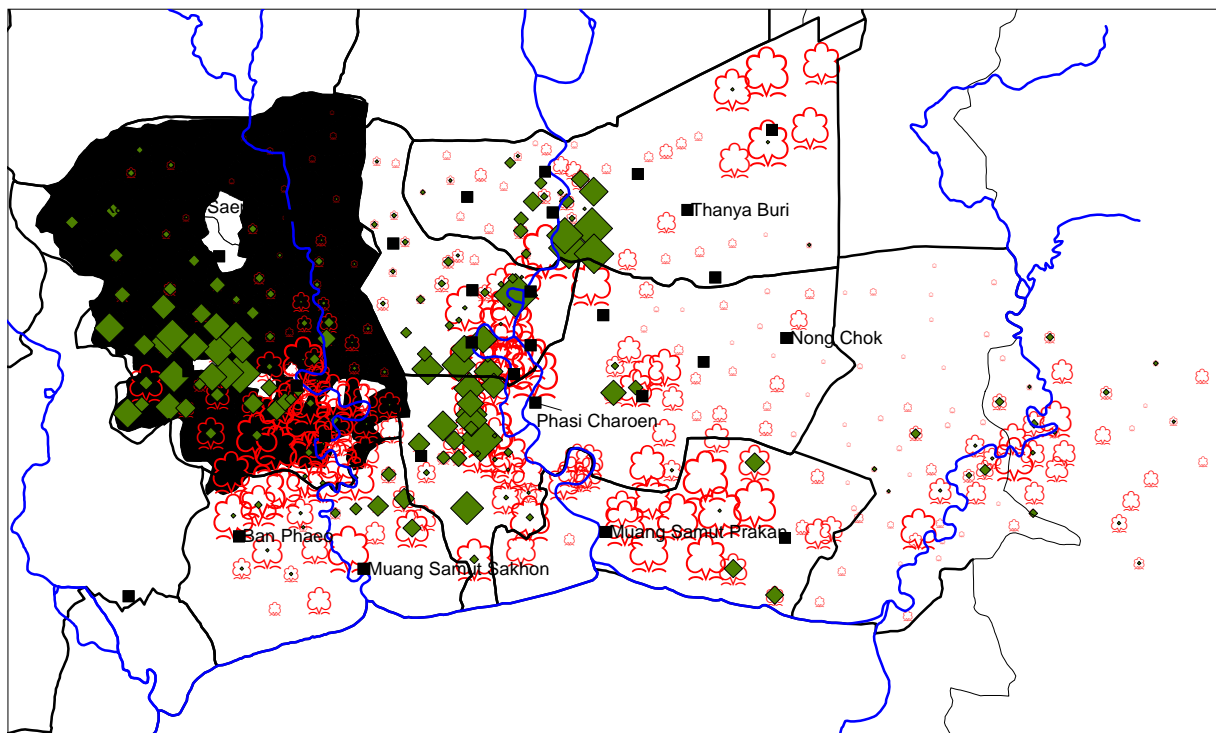
second for rice paddy fields, orchards and cassava, Nakhon Pathom moreover holds the first place for area under vegetable or ornamental cultivation.

The two coastal changwats of Samut Prakan and Samut Sakorn, on the other hand, have devoted most of their agricultural land to perennial crop or vegetable, and the rice paddy fields are occupying a relatively small area compared to the other changwats.

Bangkok eventually allocated most of its 21.300 ha of agricultural area to ornamental plants, a more relevant system whenever space is limited.

Another indication given by this table is the fact that, relative importance given to the different type of crop are unequal between changwats. This suggests a certain geographic specialisation of the cropping patterns.

This characteristic is better expressed in the map 1, hereafter. For a better reading, only vegetable and fruit areas have been represented.



Map 1 : Spatial distribution of cropped area

*Tree symbol refer to relative importance of orchard area,
Square symbol refer to vegetable area.*

Apart from stressing the specialisation mentioned before, this map also points out to the fact that tambon level analysis is a more relevant study level, unveiling the heterogeneity of any changwat. In Changwat Nakhon Pathom (lined area on the map) for example, most of fruit production is located in the southern tambon, while vegetable area is more central, close to Kamphaengsaen city, and very few of these crops in the northern zone.

Observations carried out so far give two types of valuable information :

in the process of **implementing quality labels**, production areas are key knowledge, which eventually will open way to geographic indicators.

in order to evolve **local master plans**, taking into account both agriculture and city dweller needs, the many different roles that agriculture could play are to be considered. Landscape is one of these roles, and knowledge of production areas spatial distribution is determining. Landscape could then be designed, whether is derives from plants themselves and their specific architectures (grass shape, bushy shape, forest shape) or by land (open field, greenhouse, raised bed) or water management (irrigated flooded, rainfed system) (Forster T.E., 1997).

3.2 Periurban agriculture and city feeding

While in the preceding chapter, landscape role of agriculture has been mentioned, one of the main objective of agricultural activity, food supply must also be considered (Mougeot L., 1999).

Surveys performed at market levels showed that most of the vegetable and fruit production, performed in changwats considered here, is devoted to local cities supply. These productions however are far from being sufficient to fulfil the requirement of city dwellers, both in terms of quantity⁶ and diversity. Other Thailand region, i.e. Chiang Mai or Rayong areas, are thus contributing to the overall supply, and import from foreign countries are also observed.

Table 4 hereafter shows the different contributions of the seven changwats, to Central Plain food supply.

TABLE 4 : COMPARATIVE PRODUCTION AT CHANGWAT LEVEL (1998)

Changwat	Rice	Vegetable	Fruits	Perennial
Chachoengsao (T)	710448	15173	45140	107920
%	33	6	8	19
Nakhon Pathom (T)	569985	120411	145643	41807
%	26	45	25	7
Nonthaburi (T)	190280	41029	17160	3623
%	9	15	3	1
Pathumthani (T)	449477	43600	141519	3467
%	21	16	24	1
SamutPrakhan (T)	58198	8004	4580	13549
%	3	3	-	2
SamutSakhorn (T)	15610	13975	206660	388421
%	1	5	35	69
Bangkok (T)	179256	24930	29445	12122
%	8	9	5	2
total prod (T)	2173254	267122	585567	565956

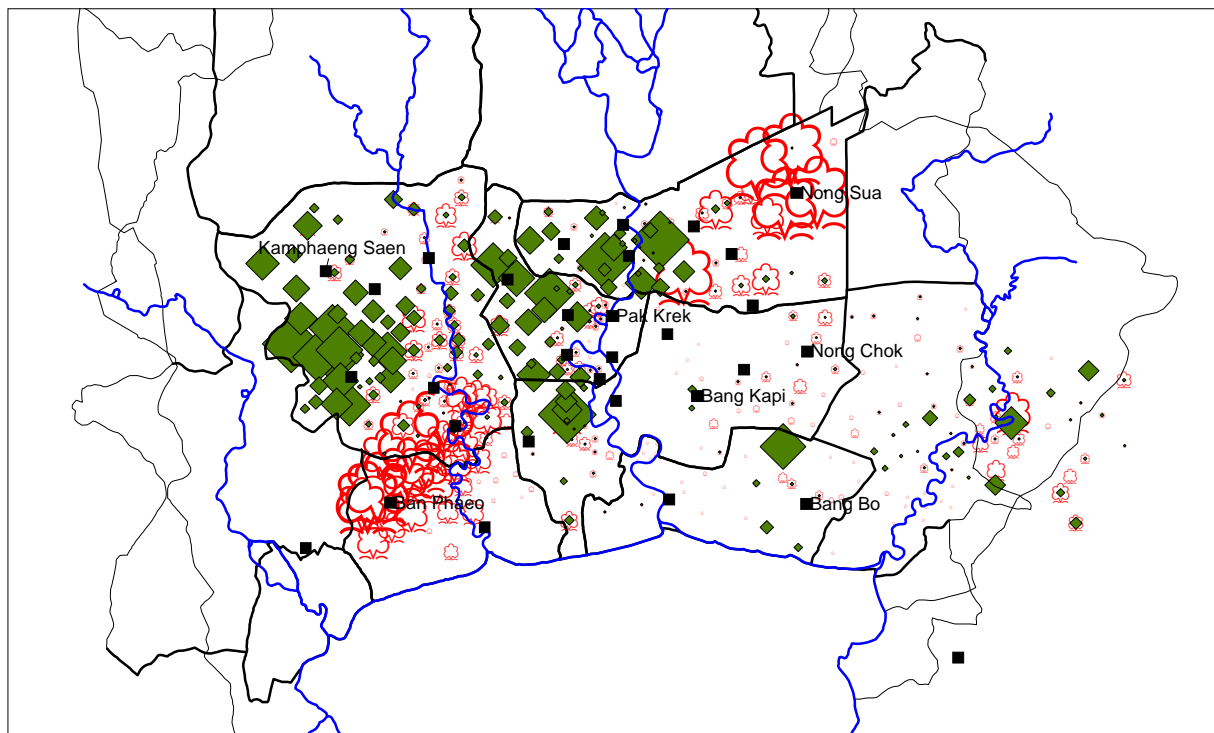
⁶ on a base of 200 g of vegetable per day and per capita (UNDP norm), the requirement of the 7 changwats is about 1.2 millions tons of vegetable per year, i.e. the local production covers 25 % of these needs.

Comparison between table 3 and 4, underlines the fact that changwats with the most important acreage in a given crop are not necessarily the most productive ones.

If Chachoengsao appears definitively as the rice producer amongst the pool of changwats concerned, Samut Sakhorn is well ahead of it in fruit production activity, assuring by itself more than 35 % of the whole production.

These observation are confirmed in a spatial distribution comparison between production and cultivated area. In the map 2. hereafter, vegetable and fruit production are reported.

MAP 2 : PRODUCTION SPATIAL DISTRIBUTION FOR VEGETABLE AND FRUIT



Tree symbol : fruit production

Square symbol : vegetable production

Though there are significant areas of orchard in Bangkok and Chachoengsao sectors, these two changwats do not appear as fruit producers. Production in Chachoengsao sector is mainly performed in the close vicinity of Chachoengsao city, and is devoted to this specific market.

A more detailed analysis of these data will point out that there is a wide range of crops which are listed under the name “vegetable” or “fruit”. And it is necessary to carry out an in-depth study in order to better assume difference between location. As an example, Pathum Thani fruit production is widely composed of Java apples, when Chachoengsao one’s consists mainly of mangoes.

Another example of this diversity, referring to vegetable production, is given in the table 5, hereafter.

TABLE 5 : COMPARATIVE IMPORTANCE OF SOME SPECIFIC VEGETABLE PRODUCTS BETWEEN CHANGWATS

Product (T)	Chachengsao	Nakhon Pathom	Nonthaburi	Pathum Thani	Samut Prakan	Samut Sakon	Bangkok
Whole production	15 173	120 411	41 029	43 600	8 004	13 975	24 930
Range of products	Up to 26	Up to 37	Up to 38	Up to 15	Up to 3	Up to 11	Up to 12
Chinese keys		13 510					
Galangal	1 523						
Baby corn		10 461					
Chinese kale	3 262	13 936	13 905	14 413		6 566	4 855
Acacia insauvis		11 356					
Cucumber	1 292						
Yard long bean		5 403					
Sacred basil							3 577
Sweet basil							6 271
Water mimosa					6 843		
Pakchoi		7 188		7 793		3 056	
Water convolvulus			2 537	4 676			3 217
Green wax gurd	2 620						
Eggplant		5 954					
Chilli		6 351					
Lettuce			2 759	7 647			
Chinese radish			3 135				

This table shows that changwat differ by the range of vegetable grown, as well as the importance given to some specific crop. Range varies between 3, in the case of Samut Prakan, to 37 and 38 for Nakhon Pathom and Nonthaburi.

There does not seem to be any correlation, as one could have expected, between the diversity of the offer from the production sector, and the pressure of the demand, which might have been assessed through population density (see table 2). There is also no relationship between the importance of the production and this range.

In any case, more than half of the total production is achieved with 1 to 7 products.

Amongst these products, some of them are grown in significant only in one or two changwat. A closer look to data, will also show that even within each the changwat, some tambon are really specialised and provide most of the production of the changwat for some crop (for example, 90 % of water mimosa grown in Samut Prakan, is produced in tambon Sri Sa Chorake Noi).

From the point of view of production it is thus possible to underline some key features :

the relationship between cropped area and production achieved does not appear to be a linear one. This could mean that all the **producers** engaged in agricultural activity **are not always looking for productivity**. This could also mean that in spite of the fact that farmers are willing to produce a given crop in some location, conditions (environmental or socio-economic) are not suitable for this crop.

some tambon are contributing to overall food supply with relatively high amounts of agricultural products. This indicates a **certain specialisation** as well as an intensification of production, i.e; a good environment and skilled producers.

3.3 Economic importance of periurban agriculture

Amongst others, preceding results pointed out the fact that there are many differences between tambons in a same changwat, in terms of amount of production achieved, and that it is necessary to work at tambon level to better apprehend the diversity of periurban agriculture.

Another of its not so well-known characteristic is the part it plays in the overall economic of urbanised area.

An attempt to evaluate the economic generation derived from this specific agriculture has been carried out. At this stage of the work it must nevertheless be pointed out that the economic value of every crop taken for calculation is an average value. Data are derived from surveys at market level, performed during years 1999 et 2000. This same survey showed that the selling price of vegetable is highly variable, depending on the season, some particular event, and the quality of production.

The table 5 hereafter gives data related to the major vegetable crops, as figured in the previous table. Map 3 is an attempt to give a spatial representation of economic value at tambon level, based upon production result and estimated price.

Still keeping in mind that this representation is based upon estimation and average values, it seems nevertheless that the highest economic value is derived from the farthest location from urban areas. There are some particular case, like tambon Bang Porm in BMA, rather close from Bangkok centre and with a high return, averaging 75 millions B. Flower and ornamentals, as well as vegetable and fruits produced in this area, are at the base of this result.

TABLE 5 : PRICES RANGE OF MAJOR VEGETABLE AT TALAT THAI MARKET

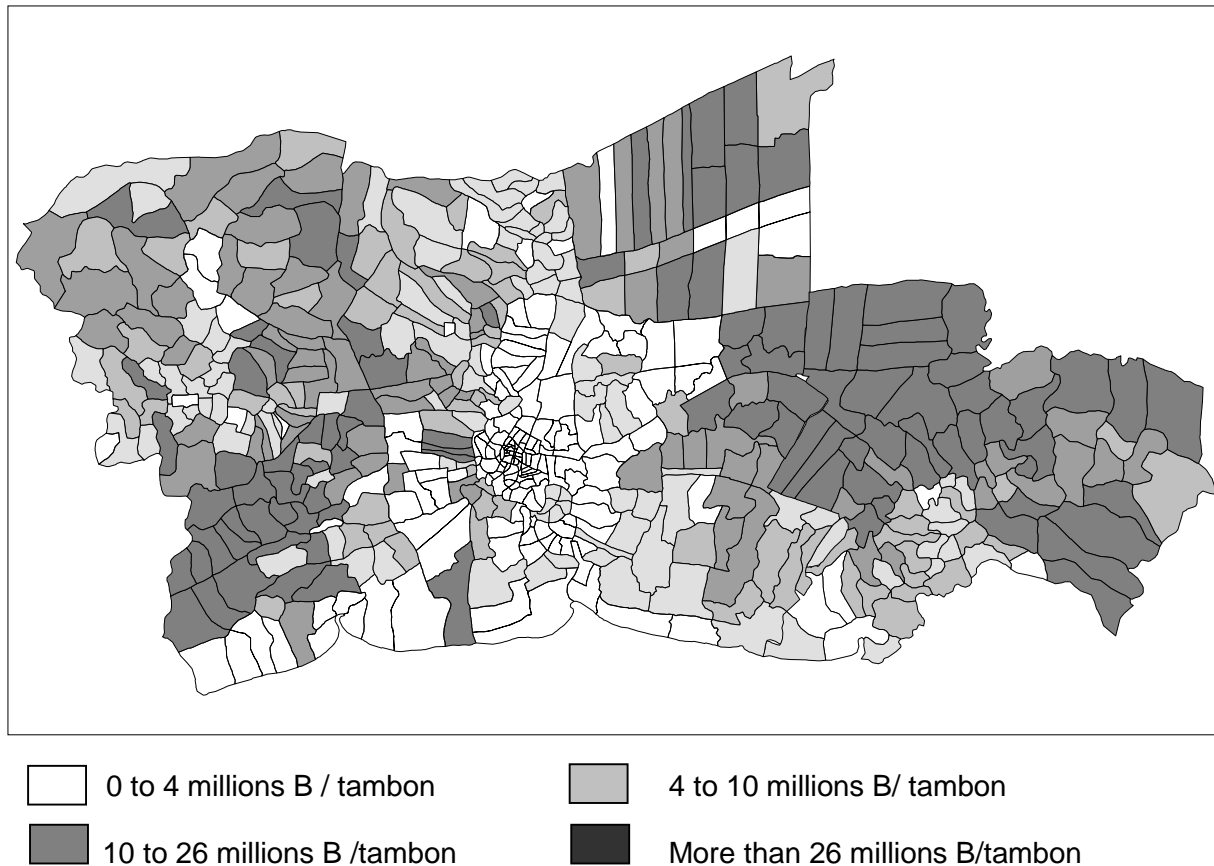
B/kg	Min price	Max price	Average
Chinese keys	10	28	15.2
Galangal	3	16	7
Baby corn	10	48	19.5
Chinese kale	2	30	10.4
Acacia insauvis	2	12	5
Cucumber	2	19	6
Yard long bean	3	50	17
Sacred basil	4	30	9.4
Sweet basil	4	30	9.7
Water mimosa	3.4	20.6	7.3
Pakchoï	2	18	7.3
Water convolvulus	4	30	10.3
Green wax gurd	2	12	5.7
Eggplant	1.7	21	7.1
Chilli	9	70	25
Lettuce	4	50	15.5
Chinese radish	2	15	7

MAP 3 : SPATIAL DISTRIBUTION OF ESTIMATED ECONOMIC VALUE DERIVED FROM PERIURBAN AGRICULTURE (FRESH PLANT PRODUCT DEVOTED TO LOCAL MARKET)

Considering the numerous constraints faced by agricultural activity within urban space, this preceding observation could lead to the conclusion that from an economic point of view, periurban agriculture is not an income generating activity, and this sole economic aspect cannot insure its sustainability.

But a given fact, supported by on-farm surveys, is that farmers are still going on with agriculture. This is confirmed by the discrepancy between cropped areas and production areas.

One must assume that other input, apart from economic ones, are heavily contributing to the sustainability of periurban agriculture. These input must be defined and assessed, in order to apprehend the incidence of city development projects on this agriculture.



4 Conclusion

Periurban agriculture encountered in the surroundings of Bangkok conurbation is very composite. Type of crops, production results, economic importance, all of these criteria point out the diversity of situations and the lack of homogeneity of this specific sector of activity.

Difference at tambon level have been observed, making it difficult to apprehend periurban agriculture by mean of limited surveys and extrapolation. Knowledge must be gained at tambon level, through in-depth enquiries, completed by market survey and agricultural census data processing. The lack of clear correlation between cropped area and production achieved, leads to the conclusion that the sole agricultural production is not always the goal aimed at by farmers.

There is still need for study particularly in the field of production environment, so as to understand origin of local low productivity area. Physical parameter, i.e. natural resources quality and availability, but also socio-economic one must be considered and their incidence on farmers behaviour and production results will have to be defined. Another study aiming at supporting city development project has already stressed the importance of ethnic origin and farmers' history in cropping system adoption.

The methodology applied in this work and results already at hand are part of a more comprehensive set of data and tools, still to be implemented in order to provide policy

makers and producers with information supporting the elaboration of city master plan and quality standards related to specific agro-environment.

Agricultural activity in the close vicinity of big cities must then be considered through the numerous roles, economic, but also food quality, jobs opportunity, heritage and culture preservation,... which it plays, so as to better understand the mechanisms which are supporting farmers' strategies and behaviour. This will suppose multidisciplinary team of scientists, in close partnership with concerned stakeholders : city policy makers, but also city dwellers and periurban farmers.

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