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Influences of Population Dynamics on Agricultural Land Use in Rural Northeastern Thailand: A Case Study in Nang Rong District

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Population and Land Use

Matters of international concern in developing countries include unavoidable attention to deforestation and global warming (Entwisle, 1998; FAO, 1970). The concern has come to focus not only on forest exploitation and settlement, but also on population behavior and land use. Population growth plays a major role in land use cover change (Sermsri, 1989). Malthus (1798) implied that rapid population growth causes anxiety for demographers about death and famine. Population pressure impels extensive cultivation as far as the hills and the forests. Moreover, population growth is also forcing people to invent agricultural technologies such as fertilizers, rotation plants, genealogical developments, agricultural machines, insecticides, and herbicides (Boserup, 1965; Boserup, 1981; Caldwell, 1998; Davis, 1963; Walsh et al, 2003).

Humans are intimately acquainted with land use and utilization of land. Important aspects of land use are dramatic shifts, like population growth. Urbanization and society have changed from agricultural production for consumption in household to production for consumers in market (Mather, 1986; Davis, 1976). For example, people who live in a high population density would migrate to a lower one where there is arable land, for example, during the 17th century, which was a period that had free international migration. International migrations flowed from Europe and from Asia (only from China and India) to North America, South America, and Australia where there was low population density. The reasons for migration were demand for land and economic opportunities. The phenomena consisted not only of migration between

continents but also within continents. For example, in North America, where there was a migration flow from the east coast to the west coast during the 18th century. In the case of the Soviets, the eastern people moved to the western region. Those phenomena show that rapid population growth creates a big demand for land, available for production and for dwelling. High demand for land induces people to wipe out forests so that forest area steadily decreases (Bilsborrow and Geores, 1992; Fellmann et al, 1992)

Households occupy forest land, but as the number of population steadily increases it is difficult for latter households to find vacant land except to share land from heritage. Equal allotments of parental land is a popular norm to prevent quarrels among children and to ensure household harmony. Nowadays, new marriages can become somewhat of a dilemma due to lack of land for cultivation while heritable land is of little worth because of its small size. Limitation of cultivated land, increase in household size and experience in only paddy farming entrapped farmers (TDRI, 2000; NSO, 2004; Ramitanondh, 1989; Phongpaichit and Piriyarangsan, 1991; Lin and Esposito, 1976).

Agricultural households are related to population dynamics and land use change. Households are forced to change their behavior and their strategy to earn a living. Some households gave in to the problems by moving whole households out and migrating to find jobs in the city and even though the households owned some really small plots, these would be sold or given to their siblings or neighbors. Some households utilize their land and increase the size of agricultural land just sufficient for household consumption. Acquisition of agricultural land is normally by a sharecropper pattern. (Ramitanondh, 1989; Chanchai et al, 1993; Sawangdee, 1997; Sukwong, 1989; FAO, 1986).

Influences of population factors play a part in household shifts. Difference in family size is greatly responsible for the way of life in each household. Extended families usually have more population pressures than single families. For example, supply of labor force exceeds demand of occupants in household. The problem of

excess labor force in household is solved by creating jobs for those in the household by moving household members to jobs in town. The responses of household to family size affect household decision-making with regard to land management. Moreover, population dynamics such as birth, death, and migration, are closely related to family size and have an impact on land use as well. There have been a few researches that diagnose the population phenomena to land use in an agricultural society but most researches about population and land use emphasize only migration while none have conclusively proven the impact of population events on land use and none of the researches have been proven by experiments (Sawangdee, 1997; Girdwichai, 2001; Rattanawarang, 2002).

Nang Rong, a district in the northeastern region of Thailand, is a primitive agricultural area and has always been a prosperous settlement from the past to the present. Its size is about 1,300 Km^2, and it is located at the basin of 4 major streams, making it a plain with plenty of water in which to grow rice. Nang Rong is definitely one of the places, like any other rural area, that is being confronted with population change in quality and quantity, namely in lifestyle as well as in number of population. For most villages comprising mostly of children and the elderly, it is not surprising that there would be a lack of labor force. Agricultural households in Nang Rong have very few children due to the population policies and are faced with land fragments or small pieces of land which are worthless.

The aim of this research is to follow population behavior in agricultural land use in rural villages in the Nang Rong district, which is located in the northeastern region of Thailand, in order to find out how population events have impact on household decision-making in the cultivation of land in rural areas. Predicted probability of land use observed by each population event and/or all population events is expected from this investigation. The first hypothesis is that changes in household population, such as migration, which has more impact on land use than mortality and fertility, affect land use. Another hypothesis is that population phenomena are more likely to affect agricultural land use. For example, emigration lessens the probability of agricultural land use, while birth event increases the probability of agricultural land use.

Data and Method

The Nang Rong Projects are pooled efforts of the Institute for Population and Social Research (IPSR), Mahidol University in Thailand and Carolina Population Center (CPC), University of North Carolina at Chapel Hill in USA. The aim of the projects is to follow population dynamics on social and environmental changes in Nang Rong district from 1984 onwards. The Nang Rong projects are longitudinal surveys, including mainly 3 major surveys in 1984, 1994, and 2000. Only the 1994 and 2000 surveys have been used for this study. The purposes of both surveys give emphasis to population and land use at household level, namely parcel level. Linkage of data on household characteristics and land use cover change is an outstanding feature of the Nang Rong projects. Compatible data of the social survey and geographical survey makes the role of Nang Rong projects a unique survey that brings out one's strong points.

We focused on demographic changes in households that affect land use of the agricultural society in rural areas. Household size, household structure, fertility, mortality, and migration are pointed out in the diagnosis. A dependent variable is land use for agriculture in the 1999-2000 growing season, coded 1 for households that used some lands for agriculture and 0 for households that did not use land for agriculture. The dependent variable that is among agricultural land seems to be a better dependent variable than the dichotomous dependent variable, but this study placed emphasis on seeking the probability of agricultural land use that would rank between 0 and 1. Independent variables include 14 variables from 3 parts, namely population dynamics, household factors, and village factors. Measurements of population dynamics are birth, death, and migration. If a household has those population events, it is coded 1; otherwise it is coded 0. Population structure in the household is presented by population size and labor in household, such as family size, number of labor in household, and mean age of labor. However, there may be other endogenous factors such as the influence of land use and land characteristics that affect population but they have not been included in this study.

Household factors comprise 7 variables of facility items that measured lifestyle. For example, households with more facility items have less agricultural land because for them agricultural work would seem to be a toilsome task. Facility items variable is calculated by in-house facilities, which indicate the behavior of household members. This variable does not represent economic indicators but represents the convenience of life. The more facility items, the more convenient the life. A highly convenient life is less likely to cultivate crops than a lower convenient life. Age of household head is measured by a generation of household head that is divided into 4 age groups: lowest to 39 years old, 40 to 49, 50 to 59, and 60 years old to highest. Measurements of dependency on agriculture sector are percentage of agricultural occupation, land owned, and percentage of agricultural machines. These variables are necessary capitals for the agricultural society. Number of sibling networks is represented by the ability of household to easily share resources such as land parcels, agricultural machines, and labor. Village factors are percentage of labor force in the village and the distance from the village to Nang Rong town. These village factors are measured by economic structure and urbanization or access to urbanization.

Although the lag time of this study is about 6-7 years, some researches proved that a lag time impact on 4 years or on 10 years gives the same results (Sawangdee, 1997; Rindfuss, 1991). Therefore this study expects to re-diagnose the influence of the variable on the dependency variable with a lag time of 6-7 years. Moreover, this study concentrates on out-migration events only because there has been a study that reports that out-migration plays a dominant role in the Nang Rong district. In-migration is rare and most of them since childhood (Piotrowski, 2006). Details of all variables and descriptive statistics of all variables are shown in the table below.

Table 1: All variables and measurements

Variables	Measurements
POPULATION DYNAMICS	
Family size	Number of members[a] in 1994
# of labor in household	Number of labor in household[a] in 1994
Mean age of labor	Mean age of labor in household[a] in 1994
Birth event	Have birth in household during 1994 Have birth = 1, Have no birth = 0
Death event	Have death in household during 1994-2000 Have death = 1, Have no death = 0
Out-migration event	Have migrant in household during 1993-1994 Have migrant = 1, Have no migrant = 0
HOUSEHOLD FACTORS	
# of facility items	Facility items in 1994 are electricity, water supply, gas and electricity for cooking, television, video player, and refrigerator.
Age of household head	Age of household head in 1994
% of agricultural occupation	= # of farmers[a] in household during 1994 * 100 # of labor[a] members in household during 1994
Owned land (Size)	Have owned land in 1994
# of Agricultural machines	Agricultural machines in 1994 are agricultural truck, light truck, tractor, plowing machine, electric generator, water pump, rice thresher, and rice mill
# of sibling networks	Number of sibling in village in 1994
VILLAGES FACTORS	
% of labor force in village	= # of labor[a] in village during 1994 * 100 # of population[a] in village during 1994
Distance from village-town	Distance in 1994 from village – Nang Rong town (Km.)
OUTCOME VARIABLE	
Land use	Use land for agricultural season 1999-2000 Use land for agriculture in 2000 = 1, Not use land for agriculture in 2000 = 0

Note: [a] who have been living in household since 1994 or have moved out less than 2 months ago

Table 2: Descriptive statistics of variables to be examined on agricultural land

Variables	N	Min	Max	Mean	SD.
Family size	6,448	1	15	4.32	1.670
# of labor in household	6,448	0	9	2.44	1.229
Mean age of labor	6,448	.00	59.00	34.70	10.290
Birth event	6,448	0	1	.08	.270
Death event	6,448	0	1	.29	.456
Out-migration event	6,448	0	1	.15	.361
# of facility items	6,448	0	10	2.73	1.379
Age of household head	6,448	1	4	2.44	1.130
% of agricultural occupation	6,448	.00	100.00	53.59	37.430
Owned land (Size)	6,448	1	5	2.77	1.422
# of Agricultural machines	6,448	0	6	.37	.725
Total sibling networks	6,448	0	22	4.43	4.734
% of labor force in village	6,448	51.31	65.78	58.19	3.324
Distance from village-town	6,448	3	36	16.17	6.767
Agricultural land use	6,448	0	1	.78	.416

Rusults

Overall, our results show that population phenomena have a significant effect on land use, especially the death event and out-migration event, which have distinct impacts on agricultural land use. Households that have death or out-migration are less likely to have agricultural land than households that have no death or out-migration. On the other hand, households with large family size, large labor force, and old labor force are more likely to have agricultural land than households with small family size, small labor force, and young labor force. Moreover, the results indicate that the way of life is acceptably related to agricultural land use as well. Households that have a good many facility items are less likely to have agricultural land than households that have only a few facility items, the reason being that farm work is laborious and rarely do farmers expect their children to become farmers. They educate their children and hope that their

children would become government officers, which would keep them far away from the paddy fields. More details are shown in table 3.

Table 3: Logistic regression results, examined on agricultural land use

Variables	Model 1		Model 2		Model 3	
	Exp(B)	S.E.	Exp(B)	S.E.	Exp(B)	S.E.
Population Dynamics						
Family size	1.122***	.026	1.122***	.029	1.114***	.029
# of labor in household	1.386***	.038	1.232***	.047	1.247***	.047
Mean age of labor	1.009***	.003	1.007*	.003	1.007*	.003
Birth event	.915	.122	.919	.129	.915	.129
Death event	.732***	.066	.825**	.073	.827**	.073
Out-migration event	.641***	.082	.783**	.088	.778**	.088
Household Factors						
# of Facility items	-	-	.778***	.025	.780***	.025
Age of household head						
(Ref.) 15 - 39 years old						
40 - 49 years old	-	-	.879	.113	.882	.113
50 - 59 years old	-	-	.521***	.121	.518***	.121
60 years old+	-	-	.329***	.103	.328***	.104
% of agric-occupation	-	-	1.011***	.001	1.011***	.001
Owned land						
(Ref.) 0 - 2.5 rai						
2.5 - 12.5 rai	-	-	2.103***	.093	2.095***	.093
12.5 - 22.5 rai	-	-	2.613***	.101	2.599***	.101
22.5 - 32.5 rai	-	-	2.793***	.120	2.789***	.120
32.5 rai +	-	-	2.361***	.110	2.353***	.111
# of Agricultural machine	-	-	1.154**	.053	1.160**	.053
# of sibling networks	-	-	1.013	.009	1.014	.009
Village Factors						
% of labor force in village	-	-	-	-	.973*	.012
Distance from village-town	-	-	-	-	.995	.006
N	6,448		6,448		6,448	
-2 Log likelihood	6487.218		5912.824		5907.288	
Cox & Snell R Square	.053		.133		.134	

Note: 1. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

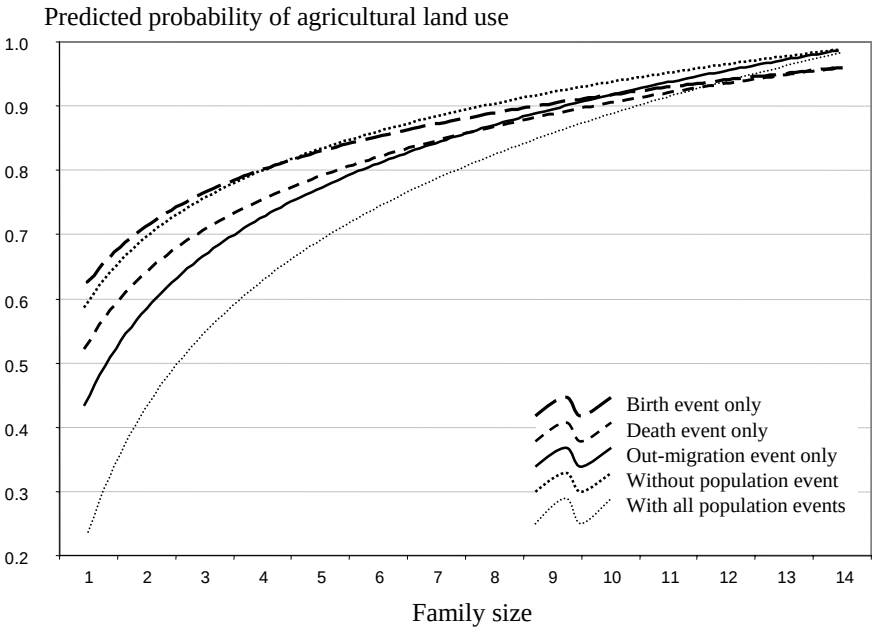
2. 1 rai = 1,600 M^2

3. Ref. = Reference Category

The results from model 3 show that only the birth event in the demographic phenomena is not significant in relationship with agricultural land use. However, the results represent all variables in model 3 used to predict the dependent variable, while only the significant variables and the remiss insignificant variables have not been represented. Thus by simulation of all population events, including birth event which is insignificant, it is possible to explain the population event and agricultural land use. From the above reasons, we can get predict the probability of agricultural land use by family size. Comparisons between population events are shown in figure 1. Differential family size and population events differ in the probability of agricultural land use. However, the probability lines of all population swing in a specific zone have the none population event on the upper line and have the all population events on the lower line. Both lines are divided equally by the migration event line. The migration event has more effect on land use for agriculture when compared with the death event, while the death event has more effect on agricultural land use than the birth event. Moreover, households that have all population events, namely birth, death, and out-migration, have a probability of having less agricultural land than those households that do not have any population event. Although population events have influence on agricultural land use, the gap will narrow when the number of household members increases. Besides, we found that the death line is in parallel with the none population event line in all family sizes, even though the mortality event reduces the probability of agricultural land use but it looks as though it decreases at the same rate as the none population event.

Figure 1

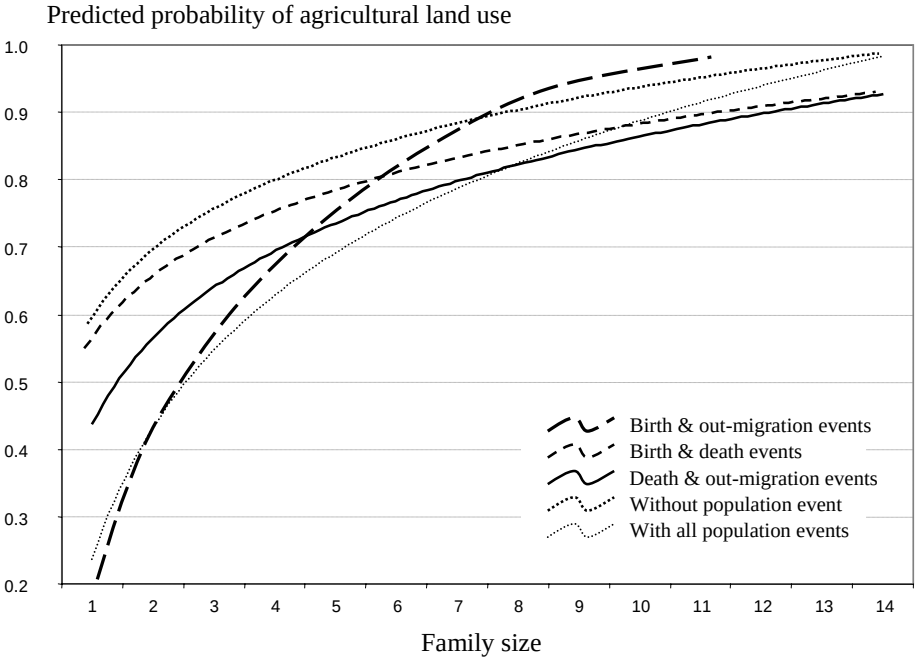
Predicted probability of agricultural land use when looking at family size and single population event



Population events can occur with more than one event in each household. Cross population events are interesting because population in household has movement and it also has impact on agricultural land use. Figure 2 shows that fertility and migration have distinct influences on agricultural land use when both events are combined. In other words, households that have birth event and out-migration event will have a predicted probability of a more rapid agricultural land change than other households with controlled family size. Phenomena of death and out-migration events appears parallel to the no population event line. For example, when households have death event and out-migration event occurring, the probability of agricultural land use is lower than the probability of agricultural land use from households that have none population event though family size increases.

Figure 2

Predicted probability of agricultural land use when looking at family size and population events cross population events

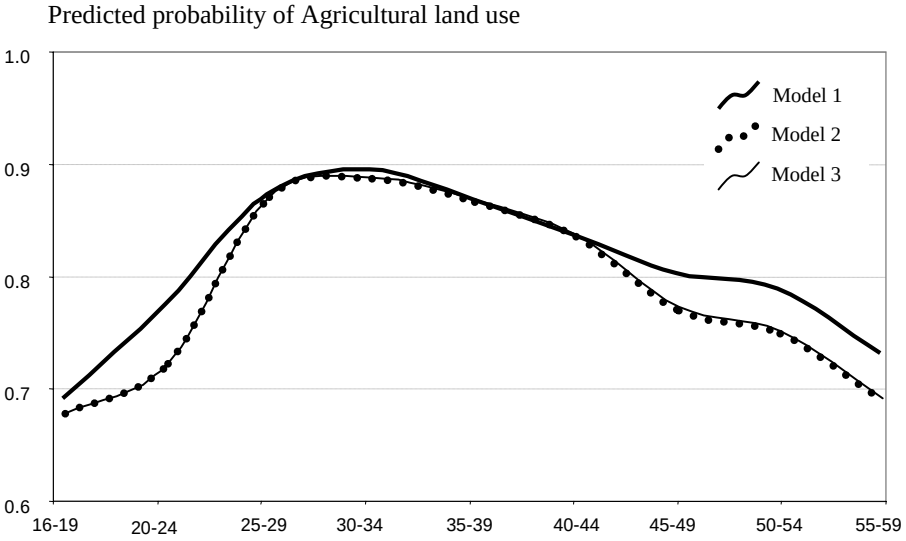


Although family size demonstrates some results, it is not the real household structure. The difference in age of members possibly affects agricultural land use as well, especially the mean age of labor because when age increases, strength diminishes. Figure 3 shows that the predicted probabilities of agricultural land use have an inverse U shape. The probability increases rapidly in young labor. It peaks during the 25-39 years old and then decreases continuously when age increases. The rapid growth of probability in early ages implies that the newer generation does not like agricultural tasks and most farmers expect their children to have more education and a better occupation. Also, when the children have a high education they do not want to do agricultural tasks, and work in hopeless occupations especially farming because farmers in the equator zone have to face heat from the sun, unreliable rain, sterile soil, and products which are almost worthless.

With regard to the senior groups, they did not have the opportunity of an education because when they were young Thai education was in the developmental phase and there were few schools in the rural areas. Most schools were only in the town or in the provinces. The other problem was their skills. Almost all the household members in rural areas were farmers and have lived in farms from generation to generation so the majority of this group is still farming. Farm skill continues from generation to generation in the primitive style, although nowadays technology has been developed. Although Thai farmers now have plowing machines instead of water buffaloes, farming is still a tedious job and task for the younger generation. It is also tedious for the older generation and they may lose their strength as they grow old. As the graph of probability descends, the older generation loses their incentive and their ability to plant.

Figure 3

Predicted probability of agricultural land use with mean age of labor

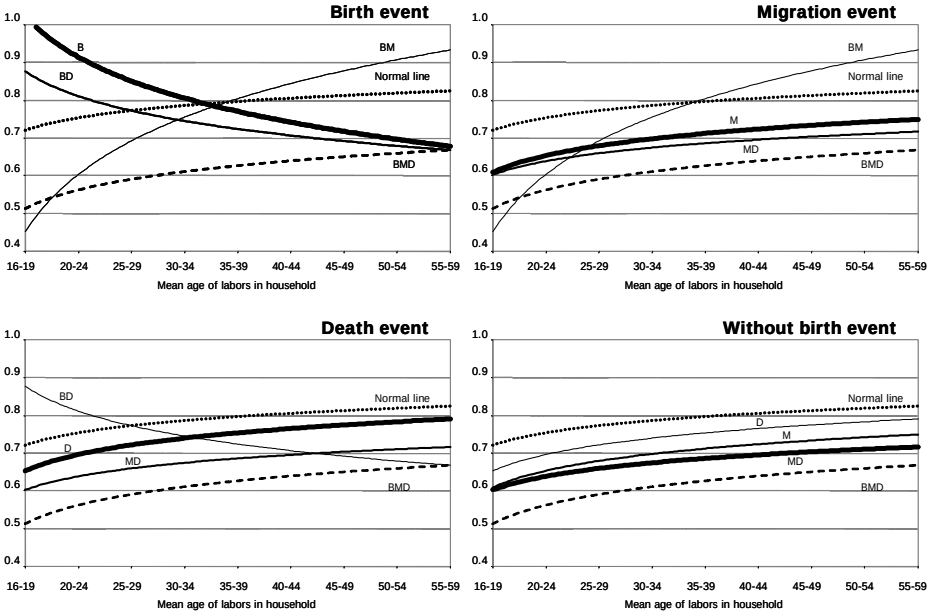


When concentrated on population dynamics and agricultural land use in the rural area, from model 3, we predicted the probability of agricultural land use in each

population event. Figure 4 shows that most population events have positive probability with mean age of labor. When mean age of labor increases, probability of agricultural land use increases as well. Probability of none population event is still higher than that of all population events; what is more, its probability is also higher than the death event, out-migration event, and death and out-migration events. Moreover, there are some look-alike parallel lines as well. Some probability lines are different from those patterns as probability of birth and out-migration events have more slope when the mean age of labors is controlled. In addition, the probabilities that have birth events are dissimilar from the pattern above; in fact, it made those patterns inverted. For example, when the probability of birth event declines, the mean age increases as well.

Figure 4

Predicted probability of agricultural land use with mean age of labor



Note: B = Birth event only; M = Out-migration event only; D = Death event only;
BM = Birth and out-migration events; BD = Birth and death events;
MD = Out-migration and death events; BMD = Birth, out-migration, and death events;
Normal line = Without all population events

Summary and Conclusion

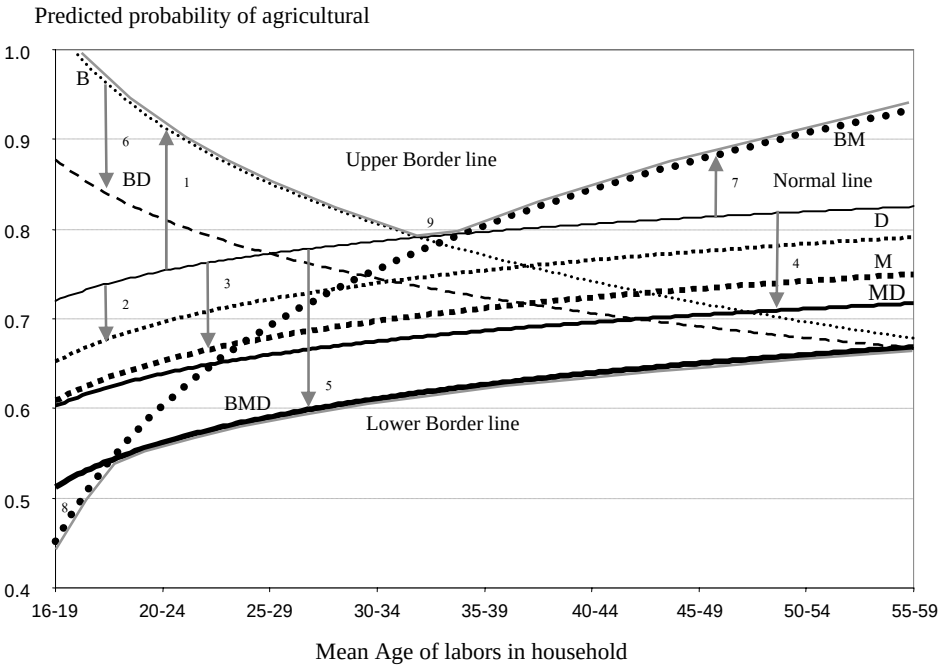
From the results above, we found that population dynamics have an influence on agricultural land use in rural areas. We call the probability of a household that is without population event a normal line because it is not at all influenced by population dynamics. When population events occur, the probability line shifts. For example, when a household member gives birth, the normal line rises up as per 1st arrow in figure 5. When the mean age exceeds 34.70 years old the probability of agricultural land use of household with a birth event is depressed under the normal line. On the other hand, when the age of labor in the household is very young and birth is given, it meant they were married and had a baby too early, implying a low education. They are more likely to do paddy field or become farmers. When the mean age increases the relationship between a baby and household members changes from that of children to grandchildren. When the mean age of labor gets close to old age, then the baby is the grandchild whose parents have left and who has been left in care of grandparents before 1993. As the labors get older, they slowly lose their strength to plant, and that is why the probability of agricultural land use declines between 34.70 years old or the 9th point. However, the probability line falls to the lowest point, but is still above the BMD line or the probability line that has all the population events that occur in the household.

The above explanation gives some ideas about birth event on agricultural land use. For mortality, a death event in the household reduces the probability of agricultural land use as is shown by the 2nd arrow. Besides, an out-migration event also has the same effect as is shown by the 3rd arrow. When both events are combined they are powerful enough to make the probability line decline as is shown by the 4th arrow. Moreover, when the three events are merged the force is great enough to lower the probability line as is shown by the 5th arrow. Out-migration, death, and combined events have the same patterns, which increase the probability when the age of labor increases. It means that the young age group is less likely to have agricultural land use. Social expectation is one of the reasons why households have to support their children to get an education and make the family proud. Although some households are poor and cannot lend support to their children for their education, they would get them to go

to Bangkok and peripheral. Usually industrial jobs in factories are popular for the young generation because there is a lot of money from overtime; they have comfortable jobs, plenty of employment and there is also the kind civilization of Bangkok. However, the factory jobs spoilt them and they would avoid paddy field tasks. It is not surprising why the probability line improves when the age of labor increases.

Figure 5

Population dynamics on agricultural land use



Note: B = Birth event only; M = Out-migration event only; D = Death event only;
BM = Birth and out-migration events; BD = Birth and death events;
MD = Out-migration and death events; BMD = Birth, out-migration, and death events;
Normal line = Without all population events

Besides some households which have a birth event also have a death event that reduces the probability of agricultural land use as is shown by the 6th arrow. The death is possibly due to old age in the early part of the BD line. The gap between B and the BD line narrows continuously when the age of labor increases. Said death is reasoned to be the death of non-agricultural labor force and that is why it has a petty effect on the probability line. On the other hand, households that have both birth and out-migration events would improve the probability of agricultural land use from the normal line if the labor age is higher than 34.70 years old as is shown by the 7th arrow. Migrants of this situation are the children and a birth event is normally that of a grandchild. The parent of a baby moves after giving birth and leaves the baby with the grandparents, and that is why nowadays only the elderly and children are living in villages. On the other side of the BM line, labors in household are very young, and migrants are usually the parents, and the parents' new-born are their siblings. They would leave the baby with their brother or sister and the baby would also be looked after by neighbors who are close cousins, or siblings as well. In another case, the reason why the BM line drops under the normal line in the first part is because the husband has migrated and the wife is left to take care the baby in the village, and it is too difficult to grow rice when a woman has just given birth and is living alone with a baby.

The Nong Rong area, where agriculture dominates, has the probability of agricultural land use of over 70%, but when we consider population dynamics, it will swing under the upper border line in figure 5 and over the lower border line which is the BMD line minus 8th area. The above exposition elucidates the force of population events on agricultural land use. Some population events such as mortality and out-migration can reduce the probability of agricultural land use because both events are negative relationships and it reduces the total number of household members. Only the birth event can improve the probability of agricultural land use, but this is not absolute because we have to be concerned about labor age. This is not only an isolated birth event but it combines birth with other events as well. The result of this research can predict land use with population concern. If we can understand population behavior well we will be able to better project the land use change. The end result is that we would be able to create programs to prevent the negative effects that are by-products of the global change.

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