Spatiotemporal Change for Agricultural Distribution from Local Administrative to Provincial Scales-based Spatial Clustering Analysis

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Abstract

Nowadays, agricultural diversities and productions in Thailand have high competition in all scales. Therefore, this paper would like to study spatiotemporal change for agricultural distribution of from local administrative to provincial scales-based spatial clustering analysis in case study of Nakhon Ratchasima (NK) province, Thailand. In this methodology, we presented a GIS-based spatiotemporal analysis with ArcGIS program that was used for spatiotemporal analysis in land use and spatial clustering models (using cluster and outlier and hot spots analysis) of agricultural distribution. This study used land use data between 2007 and 2015 from Land Development Department (LDD) through reference of land use classification system. As results, overall of land use between 2007 and 2015 in both municipal (298.21 km^2) and provincial (20,727.35 km^2) scale, was found that agricultural land was the highest number (> 50%), mostly paddy fields. Agricultural change in all municipal areas in NK decreased from 2007 to 2015 (1.62 km^2 or 0.54%) while overall NK province increased (46.23 km^2 or 0.22%). For spatial clustering analysis, cluster and outlier results showed the difference of municipal (two groups: HH clusters and HL outliers) and provincial areas (four groups: two clusters (HH and LL) and two outliers: (HL and LH). Interesting, high-density of agricultural lands (HH clusters) was found as active paddy fields in both local administrations and province were seen in more nearby locations in 2015, located in north, south-eastern and middle-west areas. In hot spots-based Gi* analysis, hot-spot areas in both municipal and provincial areas in 2015 were more increased than 2007 that indicated highly agricultural area density. Moreover, we found that such density of agricultural area included diversity of agricultural classification based on 3rd level of LDD classification system as same, i.e. ., sugarcane, corn, cassava, custard apple, pasture. Conversely, the decreased change of cold-spot areas in 2007 and 2015 was found that was paddy field, was happened in the south-eastern locations. Consequently, these obtained results will be able to support and contribute for national security policy 2015-2021, focuses on policy no. 12: strengthening energy and food security through adaptation or survival from climate change. Especially, in food security, it will response (1) to support the active participation of the private sector or social entrepreneurship organizations and (2) to contribute market access and agricultural value chains for smallholders.

Keywords: agricultural distribution, spatiotemporal analysis, spatial clustering analysis

1. Introduction

In era of Thailand 4.0, it is time to adjust the Thai technological changes, not even the Thai agricultural sector. Currently, agricultural diversities and productions in Thailand have high competition in all scales (from local to national areas). Thitiprassert et al. (2007) reported that Thailand occupies an area of 320.7 million (m) rai or 51 m ha (1 rai = 0.16 ha), was considered an agricultural country as approximately 130 m rai (41%), was engaged in agricultural land about 49, 21, and 21 %, was devoted to paddy rice, field crops and fruit trees, respectively. Furthermore, the world's population in 2050 will reach 9.1 billion, 34 percent higher than today, nearly all of this population will occur in developing countries, and about 70 percent of the world' s population will be urban (Alexandratos & Bruinsma, 2012). Consequently, there are increasing demand of agricultural areas and productions including food security and safety. In spatial analysis, Geographical Information System (GIS) is power tool for studying a spatially agricultural phenomenon, Peeters, et al. (2015) mentioned in which yield defining variables such as soil conditions, topography and microclimate vary in space, processes related to agricultural crops and environments should be modeled using spatial methods.

Therefore, this study would like to study spatiotemporal change (between 2007 and 2015) for agricultural distribution from municipal to provincial scales-based spatial clustering analysis in case study of Nakhon Ratchasima (NK) province, Thailand. The objectives focused on (1) to study spatiotemporal changes of land use in such two scales and (2) to analyze spatial clustering of agricultural distribution in such two scales using spatial clustering methods.

2. Literature review

2.2 Spatiotemporal analysis

Many papers that have 'spatio-temporal analysis' or 'space-time analysis' in the title or keywords (Fortin and Dale, 2005) but now some papers uses term of 'spatiotemporal analysis as example of Bil & Sedonik (2019); Barow et al. (2019); Jin et al. (2019). Generally, Spatiotemporal analysis allows spatial or time-series analyses and describes investigation (Alatorre & Begueria, 2010; monitoring (Mugiraneza et al., 2017; Haas et al., 2015); detection (Furberg & Ban, 2012) and evaluation (Haas & Ban, 2014) for the persistence of patterns over time that exists at a certain time and location (Jantakat et al., 2019). This study used spatiotemporal analysis-based GIS or 'a GIS-based spatiotemporal analysis' that Geographical Information System (GIS) is useful for modeling and detecting environmental change (Juntakut & Jantakat, 2019; Asadi et al., 2007).

2.3 Spatial clustering analysis

Spatial variability and agglomeration can be evaluated using spatial cluster analysis, which partitions data into homogenous and heterogeneous groups, considering the geographical location of features and their spatial relationships (Peeters, et al., 2015). Therefore, spatial clustering methods evaluate the degree of spatial autocorrelation between features and quantity the statistical significance of identified clusters (Peeters, et al., 2015; Neethu & Surendran, 2013; Han et al., 2001) and current spatial clustering techniques can be broadly classified into three categories; partitional, hierarchical and locally-based algorithms. (Varghese et al., 2013).

In this study, we require two spatial clustering methods: Cluster and outlier analysis based- Local Molan's I statistic and hot spot analysis based- Getis-Ord local statistic. Cluster and outlier analysis will help to explore diversified high and low group of agriculture types and areas and hot spot analysis identified the highest-and the lowest-specific sites and such two spatial clustering methods can be explained as below:

2.3.1 Cluster and outlier analysis

This study required the spending anomalies or something that deviates from what is standard, normal, or expected. Therefore, we should use cluster and outlier analysis to examine or inspect closely and thoroughly spending behaviors looking for outliers in space and time. Consequently, a sudden change in spending patterns or frequency could suggest suspicious activity (ESRI, 2018a). On the other words, the nature of spatial-temporal autocorrelation based on cluster and outlier analysis can be categorized into four groups: two categories of positive spatial correlation, or spatial clusters (high-high and low-low) and two categories of negative spatial correlation, or spatial outliers (high-low and low-high) (Dadhich et al., 2018) that now called, 'Local indicators of spatial association (LISA).'

The Local Molan's I statistic of spatial association is given as (ESRI, 2018a):

$$I_i = \frac{x_i - \bar{X}}{S_i^2} \sum_{j=1, j\neq 1}^{n} w_{ij}(x_j - \overline{X}) \qquad \text{(Eq.1)}$$

where X_i is an attribute for feature i, $\bar{x}$ is the mean of the corresponding attribute, w_{ij} is the spatial weight between feature *i* and *j*, and

$$S_i^2 = \frac{\sum_{j=1,j\neq 1}^{n}(x_j - \overline{X})^2}{n-1} \quad \text{(Eq.2)}$$

With *n* equating to the total number of features.

The z_I iscore for the statistics are computed as:

$$Z_{Ii} = \frac{I_i - E[I_i]}{\sqrt{V[I_i]}} \quad \text{(Eq. 3)}$$

where:

$$E[I_i] = -\frac{\sum_{j=1,j\neq 1}^{n} w_{ij}}{n-1} \quad \text{(Eq.4)}$$

$$V[I_i] = E[I_i^2] - E[I_i]^2 \quad \text{(Eq.5)}$$

2.3.2 Hot spot analysis

Hot spot analysis is based on Getis-Ord local statistic that is recognized by hot-spots (clusters of high data values) and cold-spots (cluster of low data values) (Peeters et al., 2015). The Getis-Ord local statistic is given as (ESRI, 2018b):

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \bar{X}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{n\sum_{j=1}^{n} w_{i,j}^2 - (\sum_{j=1}^{n} w_{i,j})^2}{n-1}}} \quad \text{(Eq.6)}$$

Where x_j is the attribute value for feature *j*, $w_{i,j}$ is the spatial weight between feature *i* and *j*,*n* is equal to the total number of feature and:

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n} \quad \text{(Eq.7)}$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2} \quad \text{(Eq.8)}$$

3. Materials and methodology

3.1 Study area

This study requires comparison between municipal and provincial areas in NK for analysing spatiotemporal change and spatial clustering of agricultural distribution. Therefore such two study areas can be displayed in Figure 1. and are explained as follows:

3.1.1 Nakhon Ratchasima province

NK province or Korat established in the northeast part of Thailand from 14°58'14.38''N to 102º 6'7.06''E. NK is Thailand's biggest province where situated on sprawling northeast plateau. The whole NK provincial area consists of 20,727.35 km^2. Boundary of NK province is taken from Land Development Department (LDD) in form of GIS layer.

3.1.2 NK-local administrative areas

All municipal areas in NK province have 298.21 km^2, is under Department of Local Administration (DLA). In NK, there are 37 municipal administrations that were available in form of GIS layer from DLA. The 37-local administration consisted of 4 city municipalities (CM): Nakhon Ratchasima, Buayai, Mueangpak, and Sikhio, 16 subdistrict administration organizations (SAO): Jo Ho, Chorakhe Hin, Chae, Soeng Sang, Kut Bot, Khukhad, Tajan, Thephalai, Khlong Muang, Plubpla, Kratoke, Khun Thot, Kampang, Danchak, Buayai, and Thai Samakkhi, and 17 subdistrict municipalities (SM): Phoklang, Oraphim, Taladkae, Makha, kham Sakae Saeng, Nonghuafan, Prathay, Takhop, Phimai, Huai Thalaeng, Hindad, Kutchik, Sungnoen, Khamtalayso, Nondeang, Sanjaopor, and Khui.

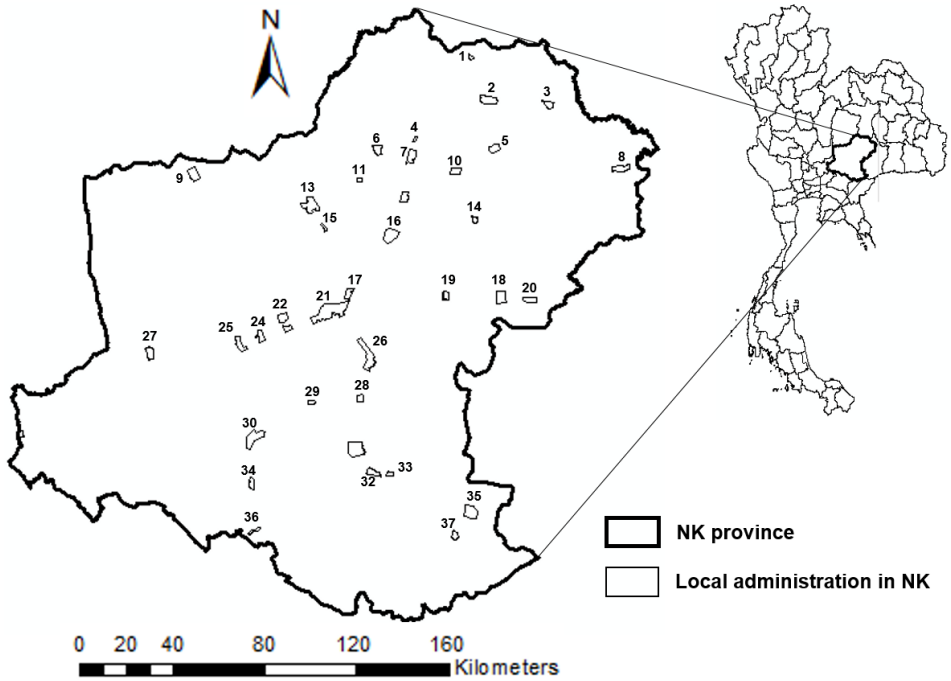
3.2 Data sources

This study used data from the related sources as follows:

1) Land Development Department (LDD) includes GIS layers of NK and municipal land use data between 2007 and 2015 and NK provincial boundary and analysis of agricultural and land use classification-based LDD-land use classification system.

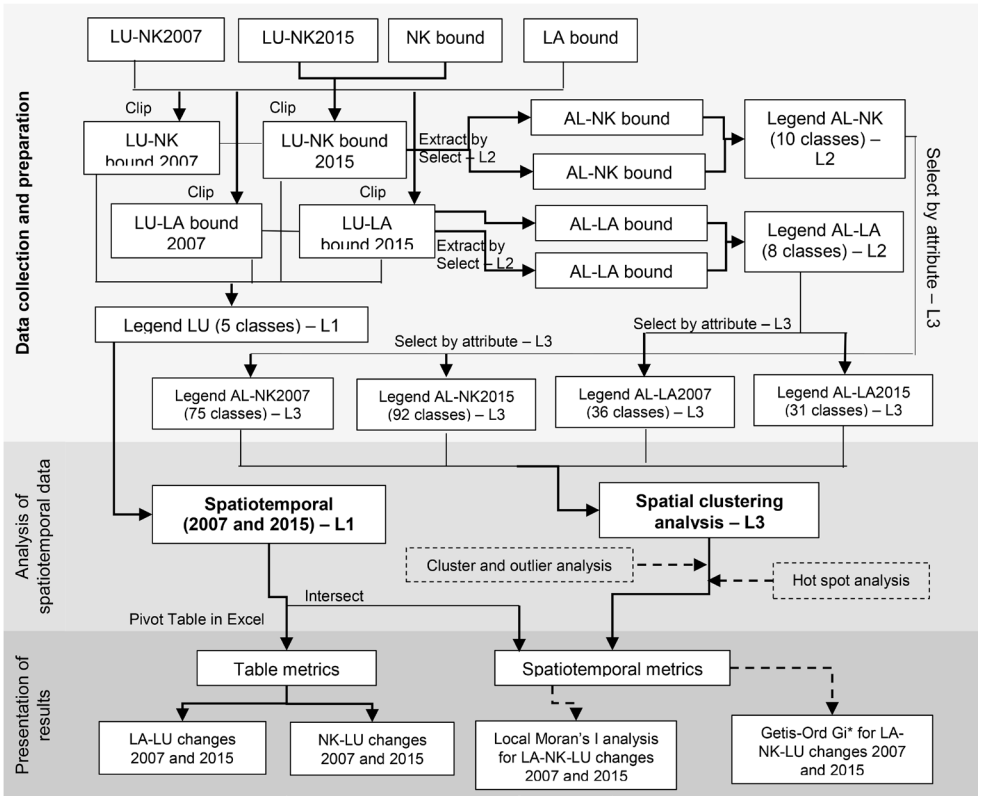
2) Department of Local Administration (DLA) comprises of GIS layers of municipal boundaries in NK province and the related data i.e. population.

3) Guideline of spatiotemporal land use and data for studying and analysis based on final report (2017), named 'Applied GeopInfomatics Teachnology to Urban Green Space Management on Role of Stormwater Runoff Reducing and Increasing of Subsurface Water in Nakhonratchasima City Municipality', article of Jantakat et al. (2018), named 'Applied Geo-Informatics Technology to Urban Green Space Management on Role of Stormwater Runoff Reducing and Increasing of Subsurface Water' and article of Jantakat et al., (2019) named 'Spatiotemporal change of urban agriculture using Google Earth Imagery: A Case of Municipality of Nakhonratchasima City, Thailand.'



Remark:
1-Buayai CM,
2-Buayai SAO,
3-Prathay SM,
4-Tapalai SM,
5-Nondeang SM,
6- Kham Sakae Saeng SM,
7- Mueang Khong SM,
8- Khui SM,
9- Dan Khon Thot SM,
10- Khukhad SM,
11- Nonghuafan SM,
12- Taladkae SM,
13- Khoksawai SM,
14- Pimai SM,
15- Nonthai SM,
16- Makha SM,
17- Nakhonratchasima PAO,
18- Huaithalaeng SM,
19-Jakkarat SM,
20-Hindad SM,
21- Nakhonratchasima CM,
22- Khamtalayso SM,
23-Nongpailom SM,
24-Kutchik SM,
25-Sung Noen SM,
26-Chockchai SM,
27-Sikhio CM,
28-Dankwian SM,
29-Takhob SM,
30-Mueanpak CM,
31-Chorakhehin SM,
32-Chae SM,
33-Saiyong-Chaiwan SM,
34-Sanjaopor SM,
35-Nonsombun SM,
36-Thai Samakkhi SAO

Figure 1. Areas of local administration in NK



Remark: LU is land use, NK is Nakhon Ratchasima province, LA is local administration, Al is agricultural land, L1, L2 and L3 are levels of land use classification from Land Development Department

Figure 2. Overall of a GIS-based spatiotemporal analysis for land use changes and spatial clustering models of agricultural distribution

3.3 Methodology

In methodology, we used a GIS-based spatiotemporal analysis in ArcGIS program that studied land use changes and spatial clustering models of agricultural distribution based on land use dataset between 2007 and 2015 from LDD (as shown Figure 2.). The method included three-main step as:

1) Data collection and preparation based on land use data between 2007 and 2015 from LDD, were checked, examined and update correctly based on available high resolution of satellite data in same periods.

2) Analysis of spatiotemporal data included land use change-based 1stand 2nd level of LDD classification system and spatial clustering analysis of agricultural distribution-based 3rd level of LDD classification system. This step used cluster and outlier analysis and hot spot analysis in ArcGIS program. Cluster and outlier analysis-based local Moran's I to explore the diversified high and low groups of agriculture types and areas. Hot spot analysis-based Getis-Ord Gi* to identify the highest-and lowest-specific sites in NK provincial and NK-municipal scales.

3) Presentation of results was displayed by the pattern of spatiotemporal and table metrics as follows:

3.1) Land use changes were presented by both spatiotemporal and table metrics.

3.2) spatial clustering models of agricultural distribution were presented by spatiotemporal metrics, were based on two spatial clustering methods: 1) Cluster and outlier analysis using local Moran's I statistic explored the diversified high and low group of agriculture types and areas and 2) hot spot analysis using Getis-Ord local statistic indicated the highest-and the lowest-specific sites. The first method will group the highly homogeneous and lowly heterogeneous areas while the second method specific the highest location in the highly homogeneous areas and the lowest site in the lowly heterogeneous areas from the first method.

4. Results and Discussions

4.1 Change of land use and agricultural distribution and diversity

Land use changes of municipal and provincial area in NK between 2007 and 2015 based on 1st level of LDD land use classification, are shown in Figure 3 and Table 1 and Table 2. Scale of such two study areas over periods was almost covered by expansion of urban and built-up lands in area of all local administrations (4.04 sq.km^2 or +1.35%) and NK area (110.77 sq.km^2 or +0.35%). Importantly, changes of agricultural land in all local administrations were decreased by 1.62 sq.km^2 (-0.54%) while changes in the whole of NK province was increased by 46.23 sq.km^2 (0.22%). Actually, most of both scales in such periods was covered by agricultural lands, as paddy fields. In area of all local administrations, most agricultural lands were seen, except in the 3 municipal areas (Mueangpak, Thephalai, and Huai Thalaeng, were mostly seen as forest lands). Meanwhile, in overall of NK province, the northern and central part were occupied with agricultural land where distributed along route of main rivers (Mun, Chi, LamPlaimat, Lammunbun-Lamphraphloeng, Lamtakong, Lamchiangkai, and Lamsatad).

Moreover, this study was concentrated on changes of agricultural distribution and types' diversity in municipal areas and NK province from 2007 to 2015 based on 2nd level of LDD land use classification, are shown in Figure 4. and Table 3. The outputs were found that the highest agricultural area was paddy fields and the second-highest area was field crops. In changes of agricultural land between 2007 and 2015, the highest increased area was perennial crop that was changed from 3.45 sq.km. (1.94%) to 4.68 sq.km. (2.66%) with changes as 1.23 sq.km. (+0.72%) for all local administrations and changed from 445.26 sq.km. (3.11%) to 626.34 sq.km (4.37%) with changes as 181.08 sq.km. (+1.25%) for NK province. For the second-highest of agricultural land, field crops were increased for the whole local administrations that was changed from 27.37 sq.km. (15.43%) to 28.33 (16.12%) with changes as 0.96 sq.km. (+0.69%) and, in NK, changed from 6122.23 sq.km (42.82%) to 6266 sq.km. (43.68%) with changes as 143.82 sq.km. (+0.86%). In changes 2007-2015 of agricultural land, the highest decreased area was paddy field that was changed from 136.54 sq.km. (76.77%) to 133.51 sq.km. (75.96%) with negative changes 3.03 sq.km. (1.01%) for local administrations and, for NK, changed from 7009.20 sq.km. (49.20%) to 6793.94 sq.km. (47.36%) with changes as 215.26 sq.km. (-1.66%). The second highest decreased area for local administrations was horticulture that was changed from 2.81 sq.km (1.58%) to 2.36 sq.km. (1.34%) with change as 0.45 sq.km. (-0.24%) and, for NK, changed from 421.97 sq.km. (2.95%) to 331.29 sq.km. (2.31%) with change as 90.68 sq.km. (-0.64%).

For changes for diversity of agricultural classification based on 3rd Level of LDD in local administrations and NK province between 2007 and 2015 as shown Table 4. Overall changes of diversity in agricultural classification for 2007 and 2015 was compared ratio between municipal and provincial areas (0.48 and 0.34 respectively).

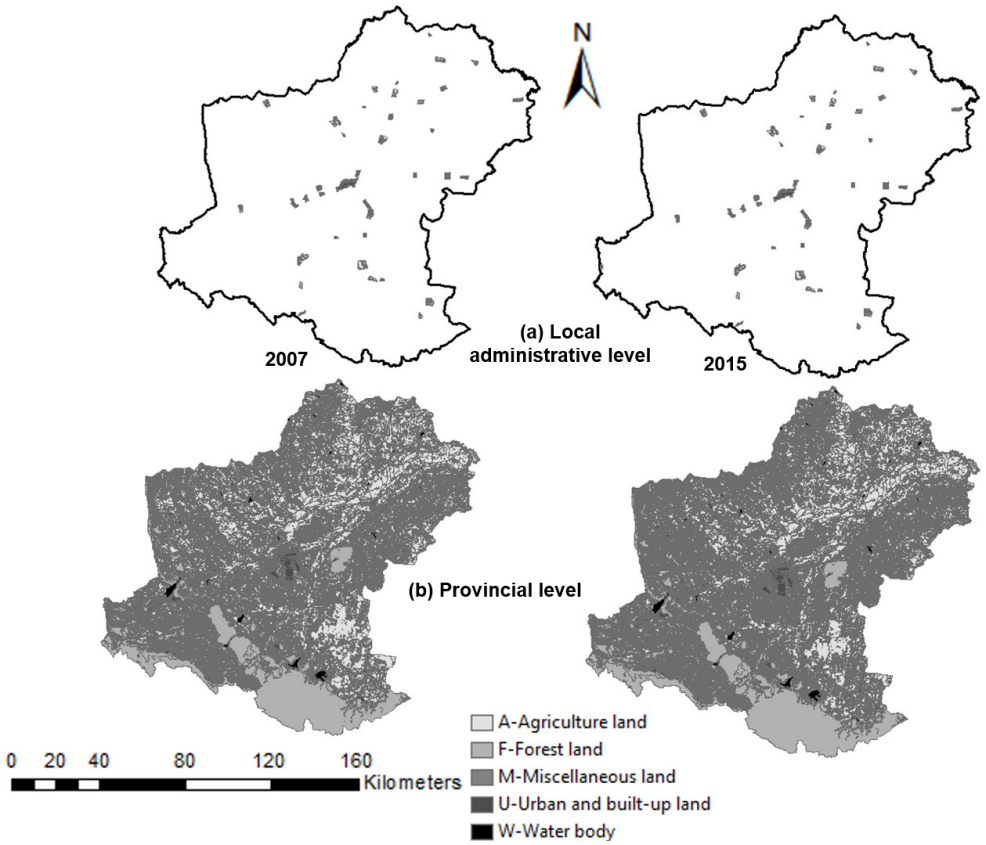


Figure 3. Changes of land use in local administrations in NK and NK province 2007-2015

Types	Local administration in NK, km² (%)		NK, km² (%)		Change 2007-2015, km² (%)	
	2007	2015	2007	2015	M	NK
Urban and built-up land	80.72 (27.07)	84.76 (28.42)	1,263.40 (6.10)	1,374.17 (6.63)	+4.04 (+1.35)	110.77 (0.53)
Agricultural land	177.39 (59.48)	175.77 (58.94)	14,298.11 (68.98)	14,344.34 (69.20)	-1.62 (-0.54)	46.23 (0.22)
Forest land	15.09 (5.06)	14.16 (4.75)	3,752.70 (18.11)	3,667.49 (17.69)	-0.93 (-0.31)	-85.21 (-0.41)
Water body	7.89 (2.65)	8.16 (2.74)	471.95 (2.28)	491.31 (2.37)	+0.27 (+0.09)	19.36 (0.09)
Miscellaneous land	17.12 (5.74)	15.36 (5.15)	941.19 (4.54)	850.04 (4.10)	-1.76 (-0.59)	-91.15 (-0.44)
Total	298.21 (100.00)	298.21 (100.00)	20,727.35 (100.00)	20,727.35 (100.00)	+4.31 (+1.62) and -4.31 (-1.44)	+176.36 (+0.75) and -176.36 (-0.85)

Remark: NK is Nakhon Ratchasima province, + is increasing areas and – is decreasing areas

Table 1. Land use changes in local administrations in NK and NK province 2007-2015

Table 2. Land use changes matrix for Local administration in NK and NK province 2007-2015

Types	Urban and built-up land		Agricultural land		Forest land		Water body		Miscellaneous land		Total	
Local administration	**km²**	**%**	**km²**	**%**	**km²**	**%**	**km²**	**%**	**km²**	**%**	**km²**	**%**
Urban and built-up land	80.72	100.0	1.62	0.91	0.93	6.16	0.00	0.00	1.49	8.70	84.76	28.42
Agricultural land	0.0	0.0	175.77	99.09	0.00	0.00	0.00	0.00	0.00	0.00	175.77	58.94
Forest land	0.0	0.0	0.00	0.00	14.16	93.84	0.00	0.00	0.00	0.00	14.16	4.75
Water body	0.0	0.0	0.00	0.00	0.00	0.00	7.89	100.00	0.27	1.58	8.16	2.74
Miscellaneous land	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	15.36	89.72	15.36	5.15
Total	80.72	100.0	177.39	100.0	15.09	100.0	7.89	0.0	17.12	100.0	298.21	100.0
NK province												
Urban and built-up land	1,168.81	92.51	46.01	0.32	69.00	1.84	19.36	4.10	70.99	7.54	1374.17	6.63
Agricultural land	45.96	3.64	14252.10	99.68	23.11	0.62	0.00	0.00	23.17	2.46	14,344.34	69.20
Forest land	38.72	3.06	0.00	0.00	3,628.77	96.70	0.00	0.00	0.00	0.00	3,667. 49	17.69
Water body	6.90	0.55	0.00	0.00	31.82	0.85	452.59	95.90	0.00	0.00	491.31	2.37
Miscellaneous land	3.01	0.24	0.00	0.00	0.00	0.00	0.00	0.00	847.03	90.00	850.04	4.10
Total	1,263.40	100.0	14,298.11	100.0	3,752.70	100.0	471.95	100.0	941.19	100.0	20,727.35	100.0

Table 3. Changes of agricultural area in local administrations in NK and NK province 2007-2015

Types	Local administration in NK, km² (%)		NK, km² (%)		Change 2007-2017, km² (%)	
	2007	**2015**	**2007**	**2015**	**M**	**NK**
Integrated farm/Diversified farm	0.14 (0.08)	0.15 (0.09)	12.52 (0.09)	15.22 (0.11)	+0.01 (+0.01)	+2.70 (+0.02)
Paddy field	136.54 (76.97)	133.51 (75.96)	7009.20 (49.02)	6793.94 (47.36)	-3.03 (-1.01)	-215.26 (-1.66)
Field crop	27.37 (15.43)	28.33 (16.12)	6122.23 (42.82)	6266.05 (43.68)	+0.96 (+0.69)	+143.82 (+0.86)
Perennial crop	3.45 (1.94)	4.68 (2.66)	445.26 (3.11)	626.34 (4.37)	+1.23 (+0.72)	+181.08 (+1.25)
Orchard	3.28 (1.85)	3.17 (1.80)	421.97 (2.95)	331.29 (2.31)	-0.11 (-0.05)	-90.68 (-0.64)
Horticulture	2.81 (1.58)	2.36 (1.34)	39.93 (0.28)	45.78 (0.32)	-0.45 (-0.24)	+5.85 (+0.04)
Shifting cultivation	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Pasture and farm house	3.26 (1.84)	3.05 (1.74)	229.60 (1.61)	245.34 (1.71)	-0.21 (-0.10)	+15.74 (+0.10)
Aquatic plant	0.00 (0.00)	‘0.00 (0.00)	0.10 (0.001)	0.11 (0.001)	0.00 (0.00)	+0.01 (+0.0001)
Aquacultural land	0.54 (0.30)	0.52 (0.30)	17.3 (0.12)	20.28 (0.14)	-0.02 (-0.01)	+2.98 (+0.02)
Total	177.39 (100.00)	175.77 (100.00)	14298.11 (100.00)	14344.35 (100.00)	+2.2 (+1.69) and -3.82 (-1.41)	+352.17 (+2.29) and -305.94 (-2.3)

Remark: NK is Nakhon Ratchasima province, + is increasing areas and – is decreasing areas

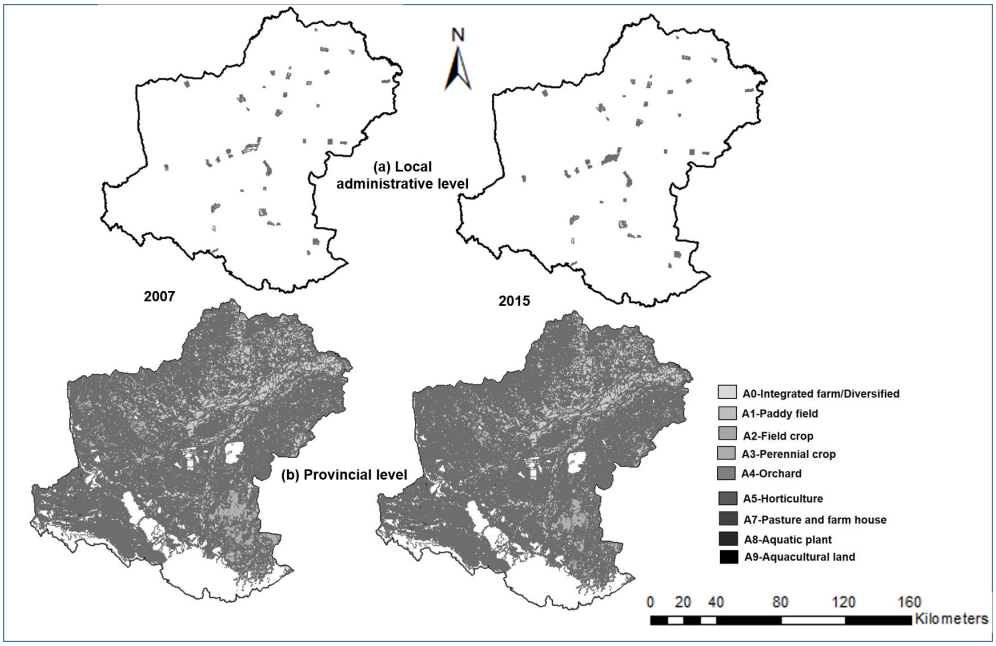


Figure 4. Changes of agricultural distribution and diversity in local administrations in NK and NK province 2007-2015

Table 4. Changes for diversity of agricultural classification based on 3rd Level of LDD in local administrations and NK province between 2007 and 2015

Types	M		NK		Diversity of agricultural classification based on 3rd Level of LDD classification system
	2007	2015	2007	2015	
Paddy field	2	2	2	2	M and NK: abandon paddy field, active paddy field
Field crop	5	5	14	16	M: mixed field crop, corn, sugarcane, cassava, chili NK: Abandoned field crop, Mixed field crop, Corn, Sugarcane, Cassava, Cotton, Peanut, Castor bean, Sweet potato, Watermelon, Tomato, Chili, *Ginger, Aloe vera, Pineapple, Mungbean, Soybean, Sesame*
Perennial crop	8	7	18	19	M: Mixed perennial, Para rubber, Eucalyptus, Teak, Magosa, Mulberry, Betel palm, Eagle wood *Bamboo, Oil palm*, NK: Mixed perennial, Para rubber, Oil palm, Eucalyptus, Teak, Magosa, Casuarina, Acacia, Padauk, Coffee, Mulberry, Bamboo, Kapok, Betel palm, Rain tree, White cheesewood, Eagle wood, *Indian mahogany, Broad leaf mahogany*, Bur-flower tree, *Abandoned perennial*
Orchard	13	13	26	29	M: Mixed orchard, Coconut, Litchi, Mango, Custard apple, Banana, Banana, Longan, Jack fruit, Langsat, *Rose apple, Lime, Pomelo, Abandoned orchard, Papaya, Sapodilla* NK: Mixed orchard, Orange, Durian, Rambutan, Coconut, Litchi, Mango, Cashew, Jujube, Custard apple, Banana, Tamarind, Longan, Guava, Jack fruit,Santol, Rose apple Papaya, Langsat, Lime, Dragon fruit, Pomelo, Sapodilla, Plummango, Burmese grape *Abandoned orchard, Sub-tropical fruit, Manila tamarind, Pomegranate*
Horticulture	2	2	4	14	M: Truck crop and Floricultural/Ornamental plant NK: Truck crop, Floricultural/Ornamental plant, Grapevine, Grass plantation Abandoned horticulture, Mixed horticulture, Pepper, Strawberry, Passion fruit, Raspberry, Herbs, Okra, Asparagus, Mushroom
Shifting cultivation	0	0	0	0	-
Pasture and farm house	5	5	5	5	M and NK: Abandoned farm house, Pasture, Cattle farm house, Poultry farm house, Swine farm house
Aquatic plant	0	0	2	2	M: None NK: Reed and Lotus
Aquacultural land	1	1	3	4	M: Fish farm Nk: Abandoned aquacultural land, Fish farm, Crocodile farm *Shrimp farm*
Total	36	31	75	92	

Remark: - Integrated farm/Diversified farm was not reported about species in LDD attribute data
- Italic shows the added species' change
- Italic and underline shows species that were lost in 2015

Table 5. Comparison of population, area and other relate rates between 2007 and 2015 in local administration in NK and NK province

Item	Year 2007		Year 2015		Rate of LA and NK in year 2007-2015	
	LA	NK	LA	NK	2007	2015
Population (No. of people)	801,244.00	2,552,894.00	868695.00	2628818.00	0.31	0.33
Total areas (km^2)	298.21	20727.35	298.21	20727.35	0.01	0.01
Density of population and total areas (people/km^2)	2686.83	8560.73	2913.03	8815.32	0.31	0.33
Agricultural areas (km^2)	177.39	14298.11	175.77	14344.35	0.01	0.01
Density of population and agricultural areas (people/km^2)	4516.85	178.55	4942.23	183.27	25.30	26.97
Rate between agricultural areas and total areas	59.48	68.98	58.94	69.20		

Remark: LA is local Administration in NK and NK is Nakhon Ratchasima province

Surprisingly, this study found that horticultural types had the highest change of classed diversity in NK level from 4 subtypes in 2007 to 14 subtypes in 2015. Moreover, in these 14-subtype, there were the 8-added species of horticultural types comprised of pepper, strawberry, passion fruit, raspberry, herbs, okra, asparagus, mushroom. In the present time, such added species are so interesting for health fruit.

Furthermore, this study considered population, area and the related rates between 2007 and 2015 in overall local administrations and NK province which were compared each other (as shown Table 5). We observed that the density of population and agricultural land in local administrations from 2007 to 2015 were very higher than the density of NK provincial level about 25.30 times in 2007 and 26.97 times in 2015 of NK.

4.2 Results of spatial clustering analysis

4.2.1 Spatial-cluster and outlier analyses

Both Local administrative and provincial in NK between 2007 and 2015 include most paddy fields (all municipal areas including 76.97% in 2007 and 75.96% in 2015 and overall NK provincial areas including 49.02% in 2007 and 47.36% in 2015) that are divided into 2 types (abandon paddy field and active paddy field) based-3rd level of LDD classification system. Interesting, the highest area of paddy field were happened in NK province but the second-highest area was field crops about 42.82% in 2007 and 43.68% in 2015 that were nearly percent of paddy field. Then agricultural areas-based 3rd level of LDD classification system in both municipal and overall NK scales was been provided and then analysed by cluster and outlier analysis in ArcGIS program as shown Figure 5. The data presented in Figure 5, agricultural areas-based Local Moran's I analysis in all Local administrations in NK and the whole NK province between 2007 and 2015. Such results can divide area of over local administrative areas in to two groups (High-High or HH cluster and Low-High or LH outlier) while the whole NK province into four groups (two clusters as HH (high-high) and LL (low-low) and two outliers as HL (high-Low) and LH (Low-High) corresponding to the clusters and outliers with 95 percent confidence level and p-value smaller than 0.05 are considered statistically significant. In area of all municipal areas between 2007 and 2015, the outputs were appeared by 2 categories: HH and HL. HH clusters in 2007 were seen by 11 local administrations (Buayai, Kham Sakae Saeng, Mueang Khong, Khui , Dan Khon Thot, Khukhad, Khokhad, Nonthai, Makha, Chockchai, and Chorakhehin) but were still almost seen in 2015 except in Khukhad. At the same time, HL outliers were seen by 7 local

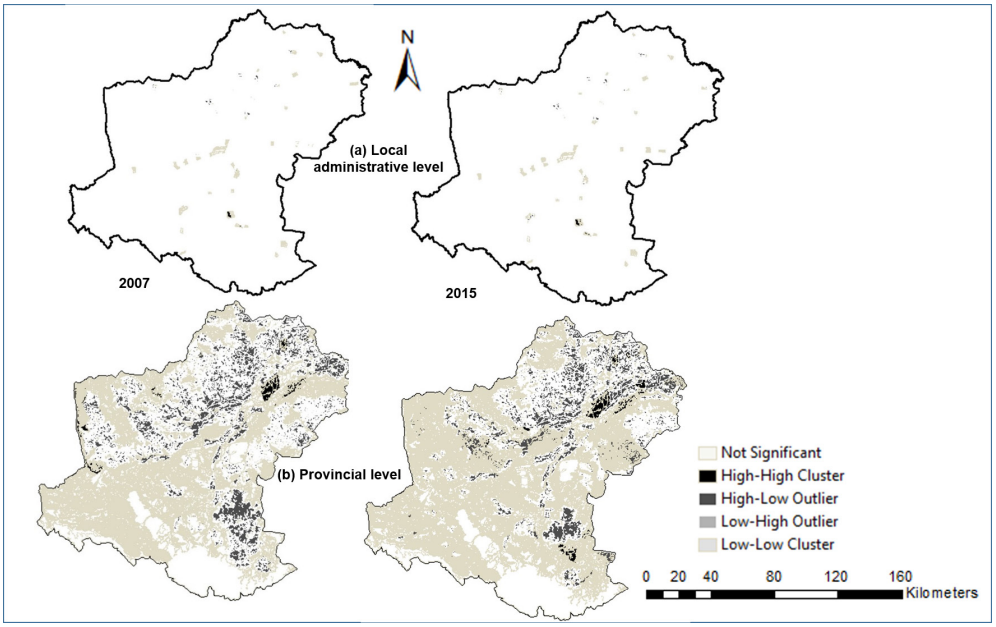


Figure 5. Analysis of Anselin Local Moran's I between 2007 and 2015 in local administrations in NK and NK province

administrations (Buayai, Mueang Khong, Khoksawai, Nonthai, Makha, Chockchai, and Chorakhehin) in 2007 but, in 2015, there were one additional area of local administrative site that was Mueanpak. In local administrative scale, most agricultural types and areas based-HH clustering were found that were active paddy field while most LL clustering was horticulture.

In area of the whole NK province between 2007 and 2015, the outputs were occurred by 4 categories: HH, HL, LH and LL. In area clusters and outliers, HH in NK province were found by higher than LL while HL outliers were more spatially statistical displayed than LH. Interesting, HH clusters in 2015 have increased in south-eastern areas and middle-west areas that are most field crops (group of sugarcane, corn, cassava and pasture). Most LL clusters in 2015 were horticulture.

4.2.2 Hot spot Analyses

Results of hot spot analysis with Getis-Ord Gi* or Gi* found out the highest-and the lowest-specifically agricultural sites in all local administrative areas and NK provincial area from 2007 to 2015 as shown Figure 6.

In local administrative areas, there were obviously difference between two years. In 2007, we saw hot-spots (clusters of highly agricultural area density) in 6 local administrations (Mueang Khong, Khukhad, Khoksawai, Makha, Mueanpak, Chorakhehin), while, in 2015, there were 11 local administrations (Buayai, Mueang Khong, Makha, Khoksawai, Khukhad, Mueanpak, Chorakhehin, Sanjaopr, Chae, and Saiyoung-Chaiwan). The left others were classed as cold-spots (clusters of lowly agricultural area density). Interesting, agricultural types and areas based-hot spots in 2015 were found that were the highest area as active paddy field and the lowest was integrated farm/diversified farm.

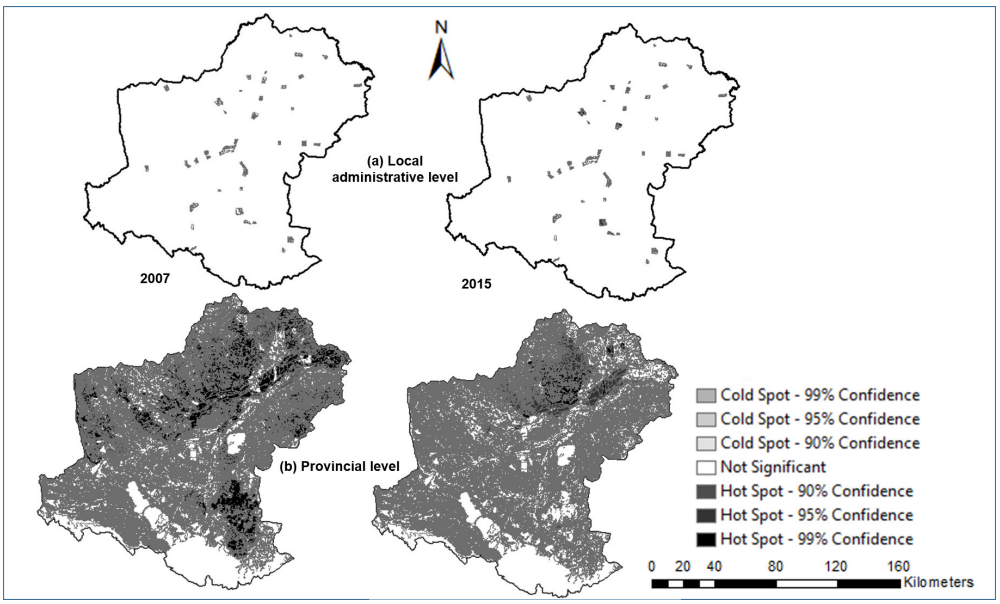


Figure 6. Analysis of Getis-Ord Gi* between 2007 and 2015 in in local administrations in NK and NK province

In NK areas from 2007 to 2015, hot-spot areas in 2015 were more changed with statistical significance than in 2007 that were mostly appeared on the northern and the middle sites. Consequently, cold-spot areas in 2015 had to be less changed with statistical significance than in 2007. Interesting, the increased change of hot-spot areas in 2015 was found that the highest area was sugarcane and the lowest was aquatic plant. Conversely, the decreased change of cold-spot areas in 2015 was found that was paddy field, was happened in the south-eastern locations.

From the above information, local administrations in NK was analysed by cluster and outlier analysis using local Moran's I statistic, was found that the high cluster was paddy field in the southern east (such as Buayai, Kham Sakae Saeng, Mueang Khong, Khui , Dan Khon Thot, Khukhad, Khokhad, Nonthai, Makha, Chockchai, and Chorakhehin SM) and then was analysed by hot spot analysis using Getis-Ord local statistic, was found that the highest paddy field same but it is seen in the area of Chorakhehin SM. NK province was analysed by cluster and outlier analysis using local Moran's I statistic, was found that the high cluster was field crop in south-eastern areas and middle-west areas of NK and then was analysed by hot spot analysis using Getis-Ord local statistic, was found that the highest field crop was sugarcane in south-eastern areas of NK.

5. Conclusions

In land use changes of local administrative and NK provincial areas between 2007 and 2015 was based on 1st level of LDD land use classification. The outputs were shown that agricultural land in all local administrations were decreased by 1.62 sq.km^2 (-0.54%) while changes in the whole of NK was increased by 46.23 sq.km^2 (0.22%). In area of local administrations, most agricultural lands were seen, except in the 3 municipal areas (Mueangpak, Thephalai, and Huai Thalaeng were mostly seen as forest lands). Meanwhile, in overall of NK province, the northern and central part were occupied with agricultural land where distributed along route of main rivers (Mun, Chi, LamPlaimat, Lammunbun-Lamphraphloeng, Lamtakong, Lamchiangkai, and Lamsatad).

Changes of agricultural distribution and diversity in all municipal areas and NK province from 2007 to 2015 was based on 2nd level of LDD land use classification. The outputs were found that the highest agricultural area was paddy fields and the second-highest area was field crops. In changes of agricultural land between 2007 and 2015, the highest increased area was perennial crop that was changed from 3.45 sq.km. (1.94%) to 4.68 sq.km. (2.66%) with changes as 1.23 sq.km. (+0.72%) for local administrations and changed from 445.26 sq.km. (3.11%) to 626.34 sq.km (4.37%) with changes as 181.08 sq.km. (+1.25%) for NK province.

For spatial clustering analysis-based 3rd level of LDD classification system in both local administrations and overall NK province was been analysed by cluster and outlier and hot spots analysis in ArcGIS program. In cluster and outlier-based Local Moran's I analysis, the outputs were differ from municipal and NK provincial areas. Municipal areas in NK were divided into two groups (HH cluster and HL outlier) while NK province was divided into four groups (two clusters as HH and LL and two outliers as HL and LH). Interesting, high-density of agricultural lands (HH clusters) was found as active paddy fields in both local administrations and province were seen in more nearby locations in 2015 where located in north, south-eastern and middle-west areas.

In hot spots-based Gi* analysis, hot-spot areas in both study areas in 2015 were more increased than 2007 that indicated highly agricultural area density. Moreover, we found that such agricultural area density included diversity of agricultural classification based on 3rd level of LDD classification system as same, i.e. ., sugarcane, corn, cassava, custard apple, pasture. Conversely, the decreased change of cold-spot areas in 2007 and 2015 was found that was paddy field, was happened in the south-eastern locations. For further study, defining distance of neighborhoods around in spatial-cluster and outlier and hot spot analysis should be concerned and you should specify how distance changes or how distance is affected.

Importantly, these obtained results will be able to support and contribute for national security policy 2015-2021, focuses on policy no. 12: strengthening energy and food security through adaptation or survival from climate change. Especially, in food security, it will response (1) to support the active participation of the private sector or social entrepreneurship organizations and (2) to contribute market access and agricultural value chains for smallholders.

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