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NATIONAL STATISTICS BUREAU
Towards Supporting Evidence-Based Decision Making



2021 Area under apple cultivation (2021 AuAC-GIS) through the use of GIS/RS Technology

About the 2021 AuAC-GIS

Recognizing the need to develop a systematic data collection, synthesis and documentation of crop area, production and productivity, the Agricultural Statistics Division, NSB in collaboration with the Department of Agriculture (DoA), Ministry of Agriculture and Forests proposed estimation of the 2021 area under apple cultivation through the use of GIS/Remote Sensing technology (2021 AuAC-GIS).

The objective of the above initiative was in the context of the need for precise crop area and production statistics for apple to enable strategic plan and development in the RNR sector. Agricultural Statistics Division (ASD), NSB in close collaboration with DoA initiated area estimation for major apple growing dzongkhags in Bhutan through RS/GIS and plans to gradually cover other major fruit crops like citrus, areca-nut and cardamom in the subsequent years.

Director's Note

National Statistics Bureau in its efforts towards strengthening the quality of statistics has been producing a number of thematic reports. The 2021 AuAC-GIS is one of many efforts in integrating the use of GIS and Remote Sensing techniques to complement and integrate with the conventional census and survey data.

I hope this brief report which is an example of how GIS and remote sensing could be used to supplement the traditional statistics will be useful to our readers.

(Chhime Tshering)

DIRECTOR

National Statistics Bureau

Acknowledgement

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INTRODUCTION

In the current RNR statistical system, crop area and production statistics are generated through annual agricultural survey based on farmers' recall method, and this is often criticized as unreliable and inaccurate.

The 2021 AuAC-GIS is one of many efforts of NSB to provide a sound methodology that will improve the quality and reliability of production statistics to guide policy analysis and informed decision making.

An In-depth Country Assessment of the National Statistical System for RNR Statistics in Bhutan (IdCA) has identified data gaps, inconsistencies and lack of reliable time series data for evidence-based decisions.

Given the strategic importance of the RNR sector in the country's socio-economic development, the sector planning and decision-making process has to be scientific and evidence-based. Therefore, the RNR statistics need to be robust meeting the requirement of relevant users, producing statistics of good quality through the application of modern technological tools.

The 2021 AuAC-GIS will complement and integrate the conventional agriculture survey with the use of latest GIS/RS technology to provide high quality and timely RNR statistics. The reliable, consistent and sound data are critical for assisting the planning and developmental activities in the RNR sector.

OBJECTIVES

The specific objectives of the 2021 AuAC-GIS were to:

- Estimate area under apple cultivation disaggregated by *gewog*, which will eventually enable in generating reliable apple production statistics in the country

- Establish a sound methodology for area estimation for major crops in the country through the use of GIS/RS technology to compliment the conventional statistical method for production, and gradually up-scale the activities in subsequent years for other signature and mandatory crops in Bhutan
- Validate the change in the area under apple cultivation to other land use types

METHODS

In terms of the technical methods, ASD employed second-stage approaches to estimate the 2021 AuAC-GIS. First, the major desk-top activity to digitize the area under the apple cultivation from Google-Earth images were carried out by GIS officials in ASD for months. In the second stage, like elsewhere around the world, where images of Google-Earth are not clear and are of not recent time, require intensive field validation or ground-truthing. However, for this current exercise the field validation was not conducted due to movement restrictions of the COVID-19 pandemic.

Identification of the *dzongkhags*

Apple is one of the most important cash crops in Bhutan. There is declining production observed over the years due to economic and social factors associated with the production of apples in Bhutan. For example, the change in the land use and fragmentations are common observable factors that have impacted the production. Some areas under apple production are also being lost to developmental activities.

The apple production which was recorded at 7,666 MT in 2012 has dropped more than half its production to 4,056 MT in 2020 (Figure 1). The production for six major apple growing *dzongkhags* were also observed to decrease over

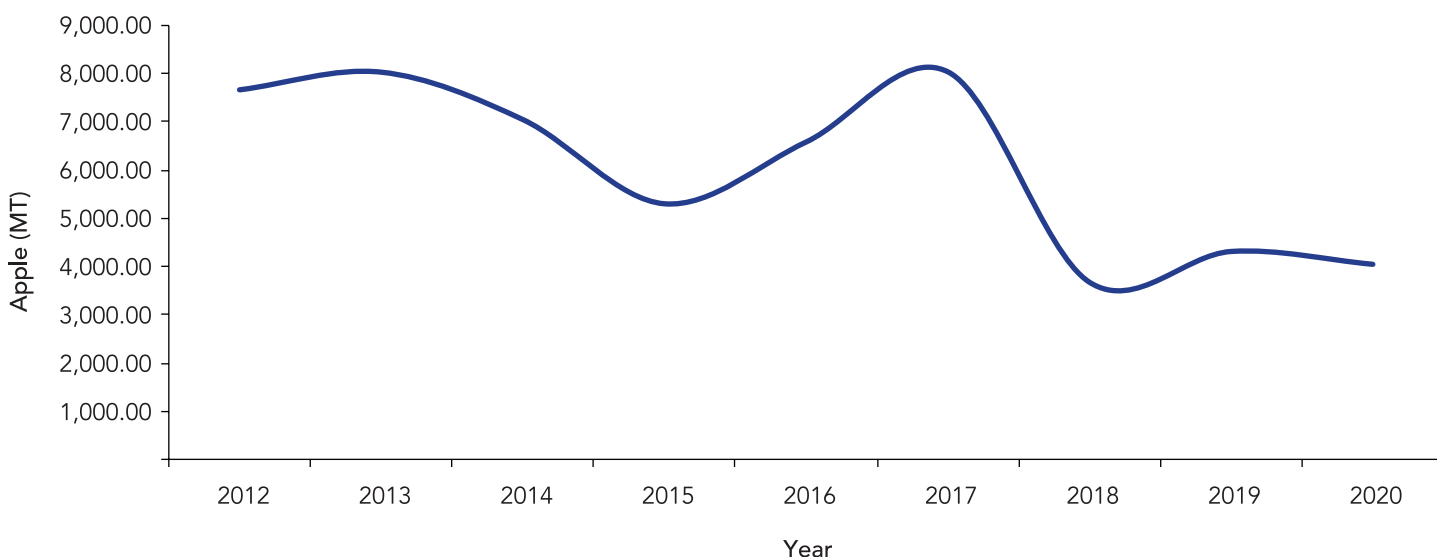


Figure 1 Total apple production in Bhutan from 2012 to 2020

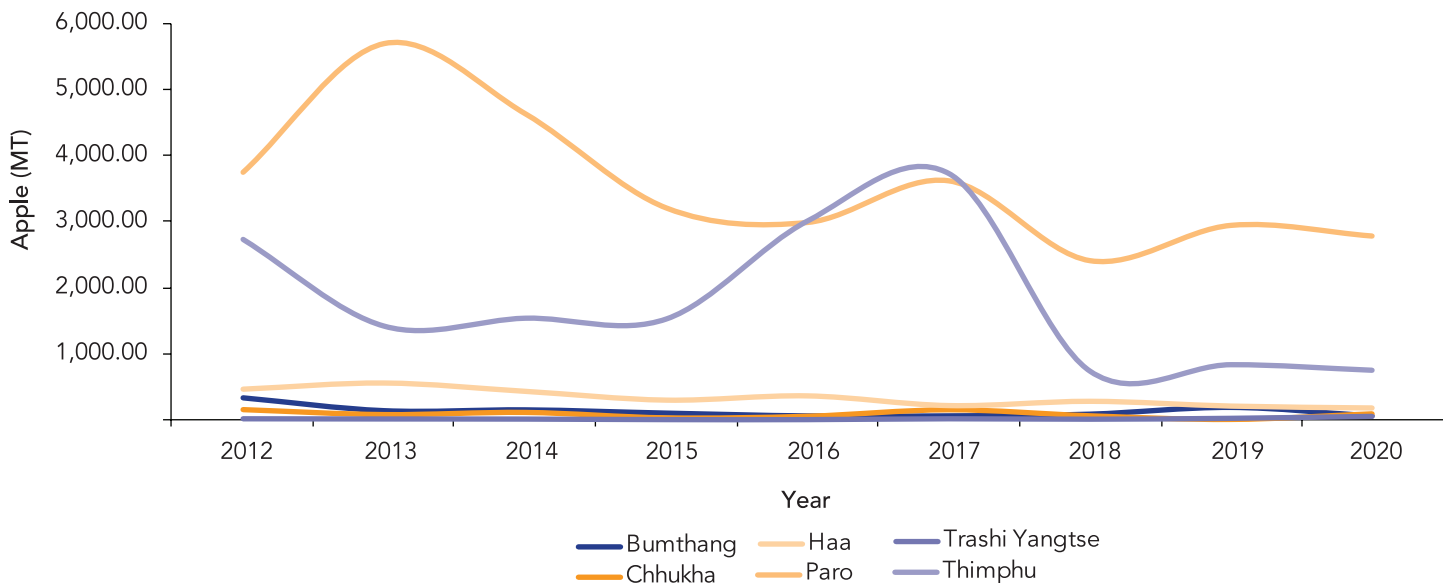


Figure 2 Trend in the apple production by major growing dzongkhags

the years (Figure 2). For the current study, based on the production size the identified dzongkhags were: Bumthang, Paro, Haa, Chhukha, Thimphu and Trashi Yangtse.

Desktop digitization of maps

The desktop digitization of area under apple cultivation took almost three months from July to September, 2021 to complete using the Google Earth Pro. It was conducted at zero cost in two teams by GIS officials in ASD, NSB. The area under apple cultivation was digitized dzongkhag-wise and

further zooming into the target areas by gewog to ensure complete digitization and no target areas were missed. The paths for areas under apple cultivation were created and saved in “KML” files. After saving all the created paths covering area under apple cultivation, the teams from ASD created a compressed (zipped) file containing the saved KML files by dzongkhag for field validation. A sample of how desktop digitization of the areas under apple cultivation for selected dzongkhag was conducted is provided in Figure 3.



Figure 3 Sample of how digitization is done for the 2021 AuAC-GIS

Table 2 Estimated area under apple cultivation by the past RNR surveys/census and 2021 AuAC-GIS

(Acre)

Year	Bumthang	Chhukha	Haa	Paro	Thimphu	Trashi Yangtse	TOTAL
2012*	75.28	72.88	230.03	1,587.95	438.12	62.50	2,466.76
2013*	64.58	32.49	253.87	1,662.53	470.37	110.71	2,594.55
2014*	67.54	43.27	177.53	1,328.22	543.34	81.10	2,241.00
2015*	64.18	15.64	168.02	1,142.15	488.20	76.33	1,954.52
2016*	29.41	23.42	144.69	878.49	810.25	89.55	1,975.81
2017*	33.15	41.47	187.81	1,412.56	826.46	57.54	2,558.99
2018**	37.36	44.80	177.98	1,554.30	490.56	61.20	2,366.20
2019*	58.25	18.22	111.26	1,371.05	512.92	70.22	2,141.92
2020*	52.86	47.85	128.70	1,507.93	373.31	58.68	2,169.33
2021***	18.70	14.64	107.97	1,154.18	813.03	39.12	2,147.64

Note: *Agriculture survey; **RNR Census; ***2021AuAC-GIS

Figure 4 shows the trend in the area under apple cultivation over the years by six major apple producing *dzongkhags*. The areas under apple cultivation in the past years were estimated from the total number of apple trees reported in the annual agriculture surveys and the RNR census. The downward trend in the area under apple cultivation is observed for many *dzongkhags* like Bumthang, Chhukha, Haa, Paro and Trashi Yangtse.

For Bumthang *dzongkhag*, about 18.70 acres were estimated which is a down of about 57 acres from 2012. Of the total 18.70 acres estimated based on the google earth observation data, 83 percent (about 16 acres) are in Chhumig gewog (Map 1).

Chhukha *dzongkhag* was estimated with only about 15 acres of area under apple cultivation, of which, majority are in Chapchha gewog with close to 13 acres (Map 2).

Haa, the third apple producing *dzongkhag* was estimated with 108 acres of area under apple cultivation in 2021 from 230 acres in 2012 (Map 3).

Paro and Thimphu are the two major *dzongkhags* with highest area under apple cultivation respectively estimated with 1,154 acres (Map 4) and 813 acres (Map 5) in 2021. Paro *dzongkhag* had about 1,588 acres of area under apple cultivation in 2012 while Thimphu had about 438 acres. Trashi Yangtse *dzongkhag* was estimated a little more than 39 acres (Map 6) of area under apple cultivation in 2021 compared to 63 acres in 2012.

Table 2 provides the estimated areas under apple cultivation by the past agriculture surveys, RNR census and the current study-2021 AuAC-GIS. The difference in the estimated areas under apple cultivation for *dzongkhag* like Thimphu

was observed high due to the fact that the 2021 AuAC-GIS covers both the areas under apple cultivation in rural and urban locations while the annual agriculture survey covers majority of agricultural holders in rural areas.

LIMITATIONS

Like any other studies, the 2021 AuAC-GIS has the following limitations:

- Sporadic apple trees planted in and around the apple holders and a few areas under apple cultivation may have missed as the satellite images are observed to be old and not clear.
- Some areas under apple cultivation in *dzongkhags* may have overestimated or underestimated due to the fact that we were not able to clearly differentiate among different fruit trees through google images.
- Field validations are normally recommended to address all these issues and ascertain the accuracy of the estimates relative to the ground reality in the field. The ground truthing for the study was not conducted due to the current pandemic.
- The results of the 2021 AuAC may not be directly comparable with the past area statistics estimated due to the following reasons:
 - In the past RNR surveys and census, area statistics were not collected and only number of apple bearing and total trees were collected. Thus, there is no basis to compare the change in the area under apple cultivation between the time periods.

- The RNR surveys cover apple holders in rural areas while the 2021 AuAC covers both the areas.

RECOMMENDATIONS

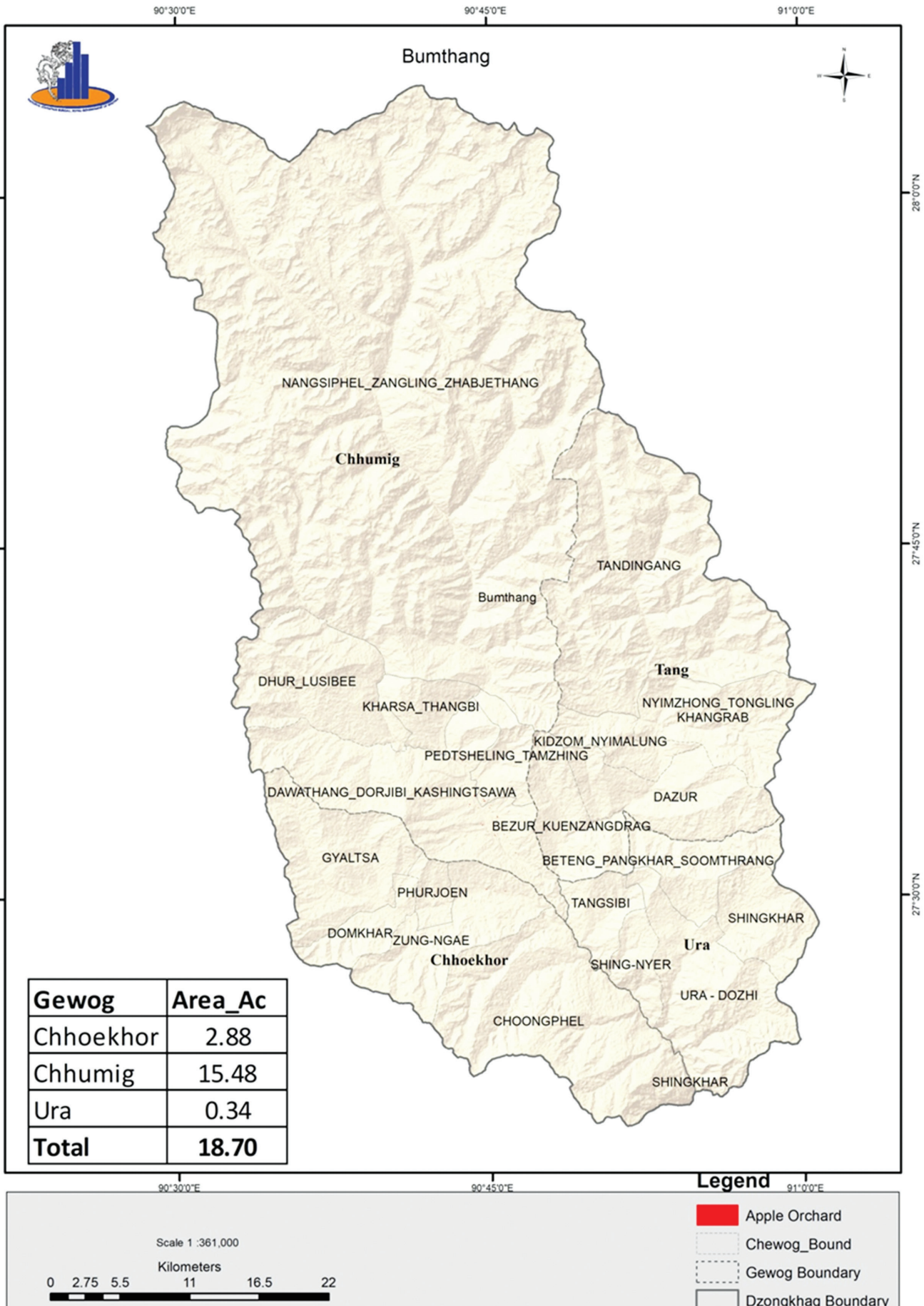
The 2021 AuAC-GIS proposes the following recommendations to improve and strengthen area statistics for apple in future.

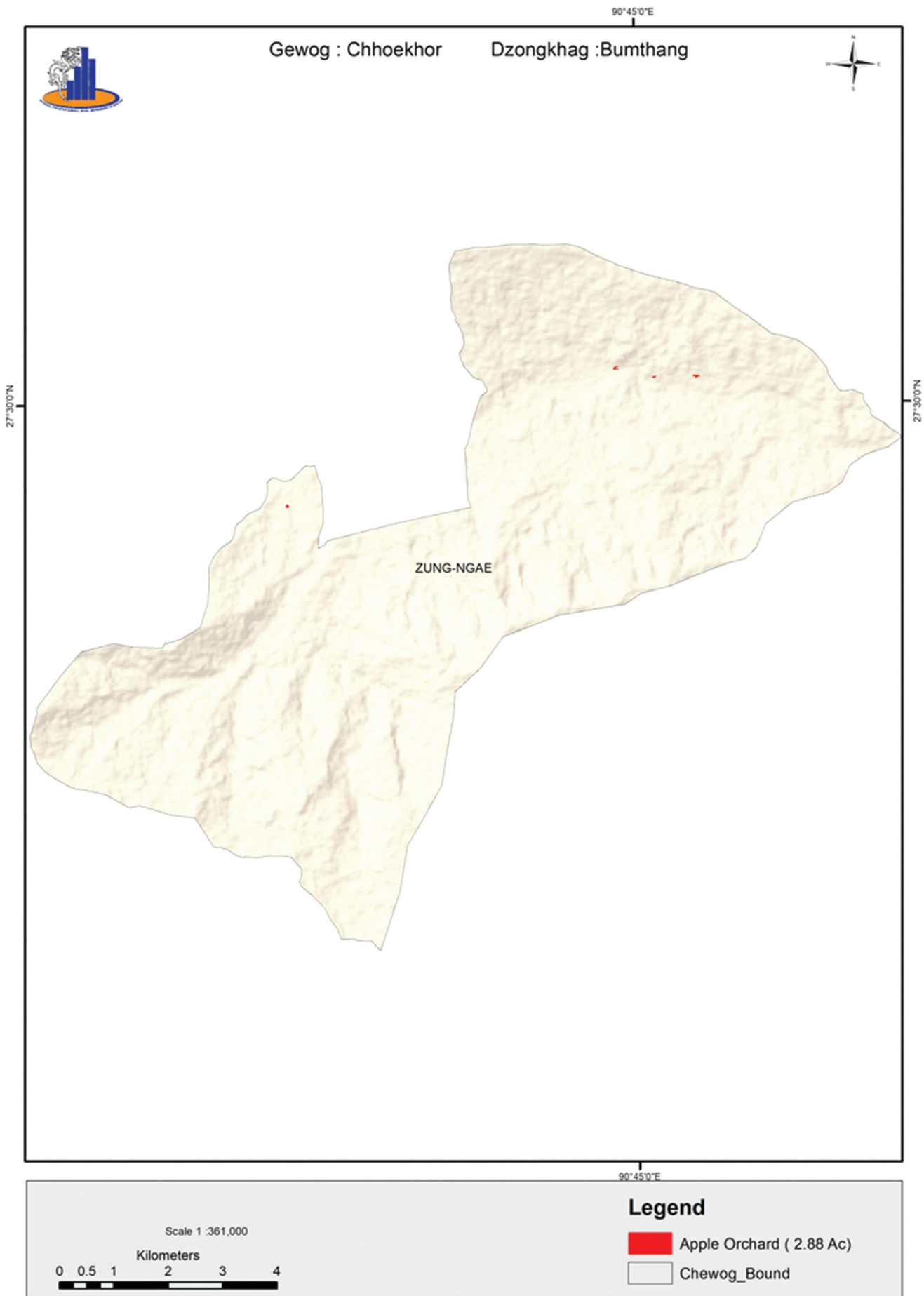
- a. Similar time period study is recommended to determine the actual change in the area under apple cultivation.
- Since there was no prior baseline study conducted to estimate the area under apple cultivation, the area estimated based on the 2021 AuAC-GIS

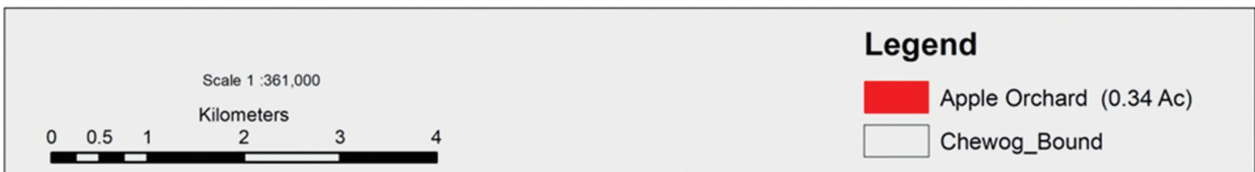
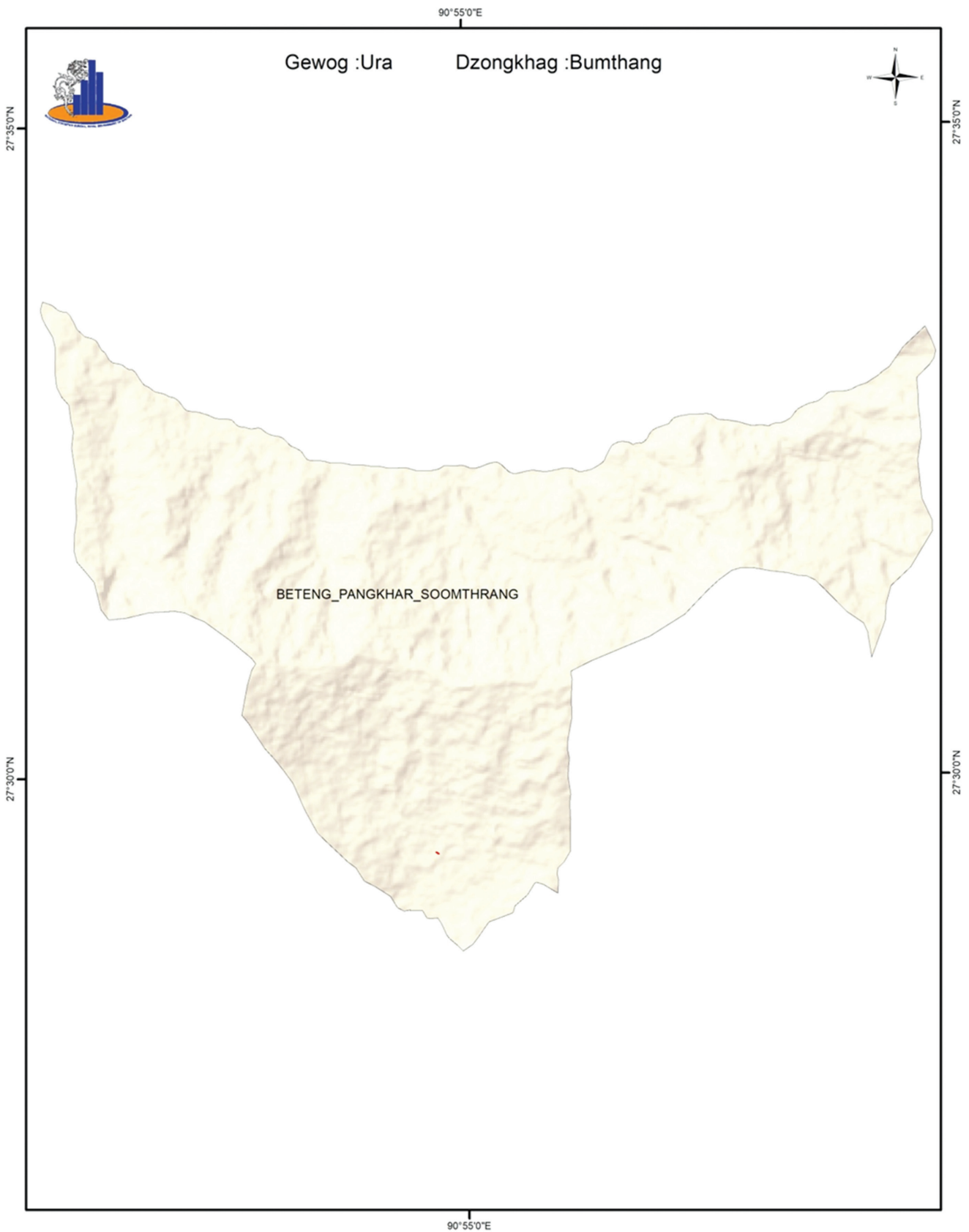
could be used as the baseline study to understand the change in the area under apple cultivation in Bhutan.

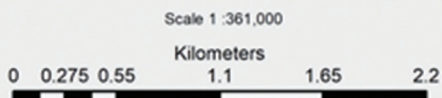
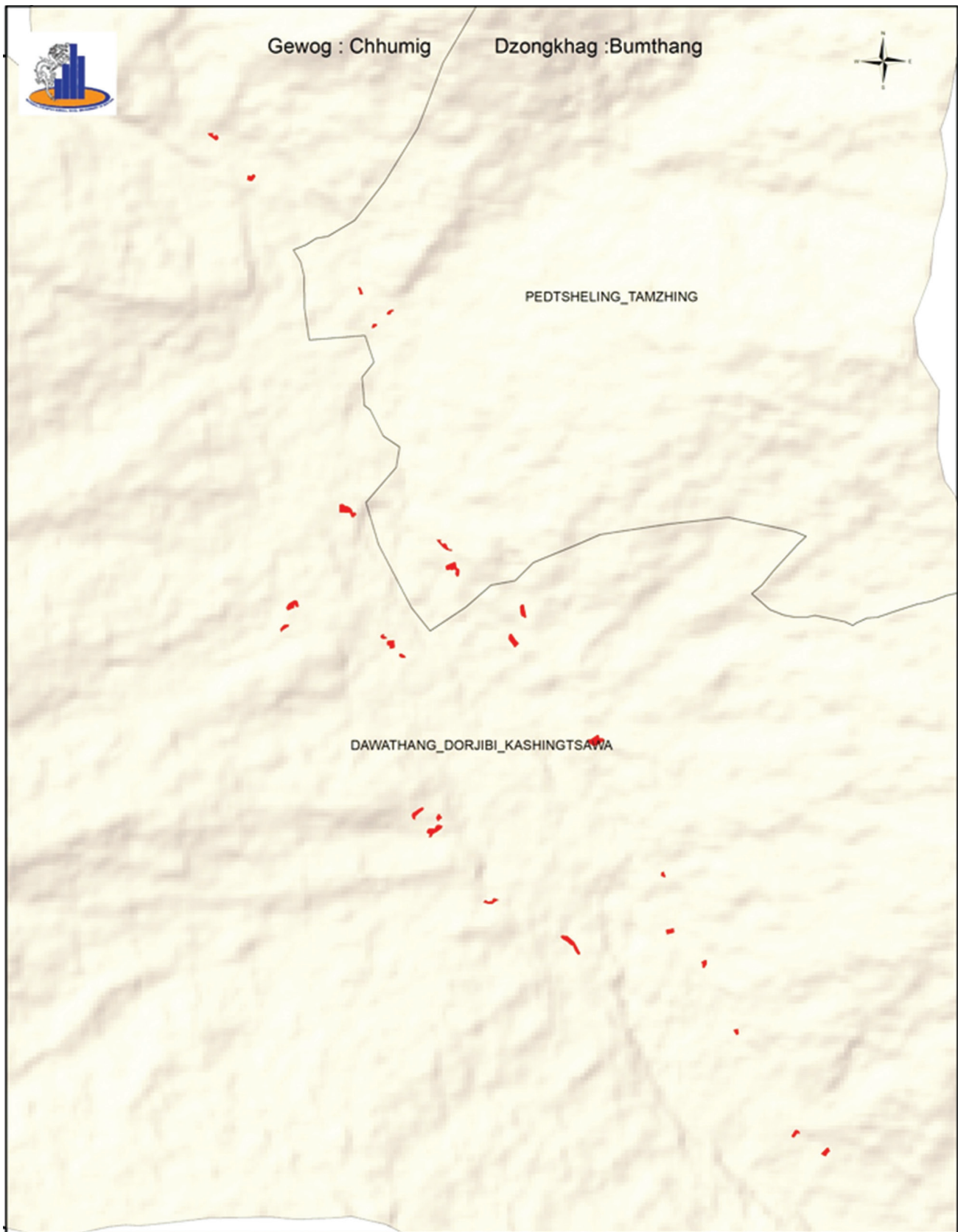
- Future in-depth study is recommended to estimate and validate the production data for apple.
- b. To improve the precision of the estimates of the current study, ground truthing is recommended based on the availability of the financial resources in future. The area estimated based on the google earth observation data will depend on the availability of the recent google images and may slightly vary from ground reality if ground truthing exercise is conducted.

Map 1 Estimated area under apple cultivation in Bumthang dzongkhag






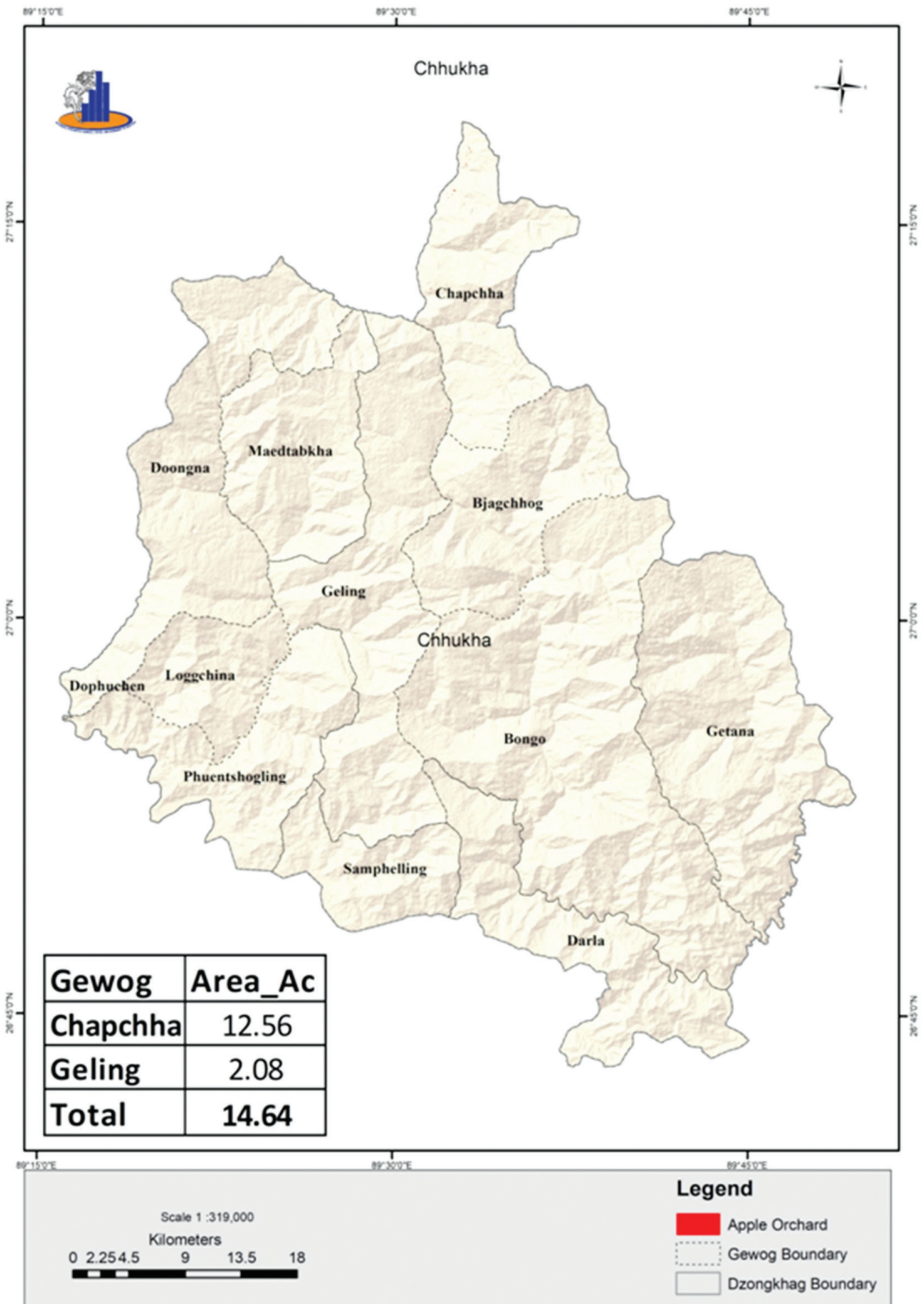


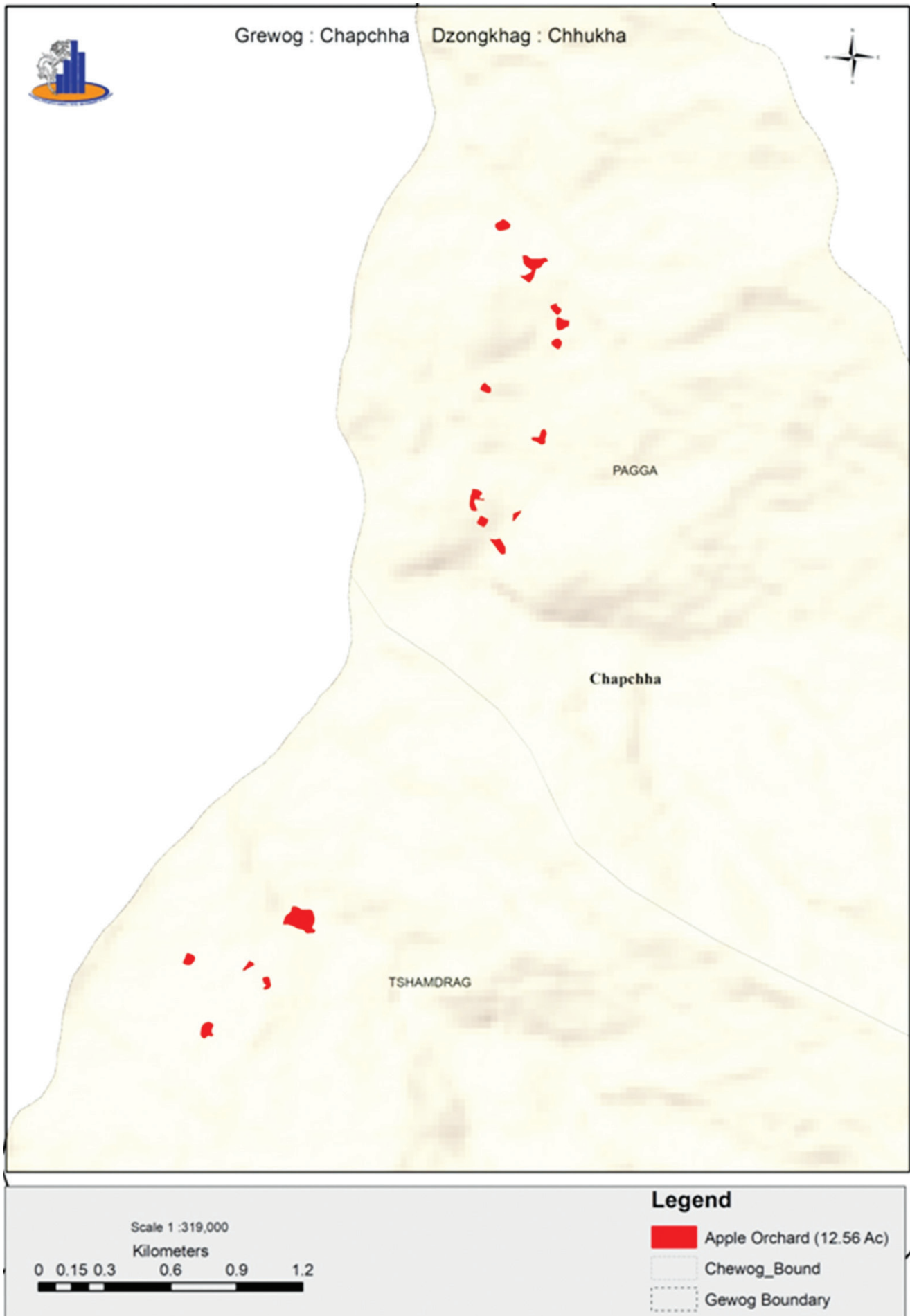


Legend

-  Apple Orchard (15.48 Ac)
-  Chewog_Bound

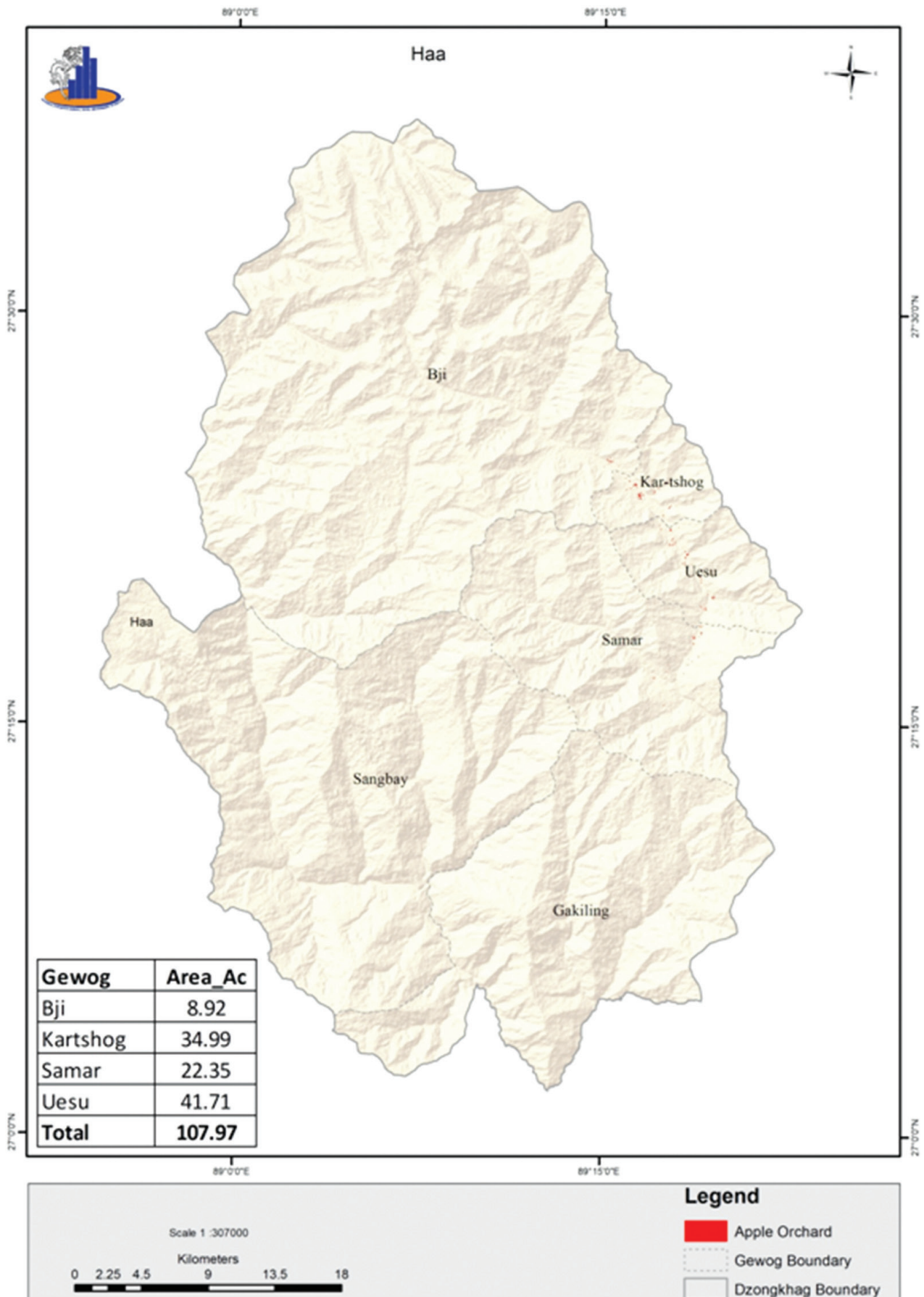
Map 2 Estimated area under apple cultivation in Chhukha dzongkhag

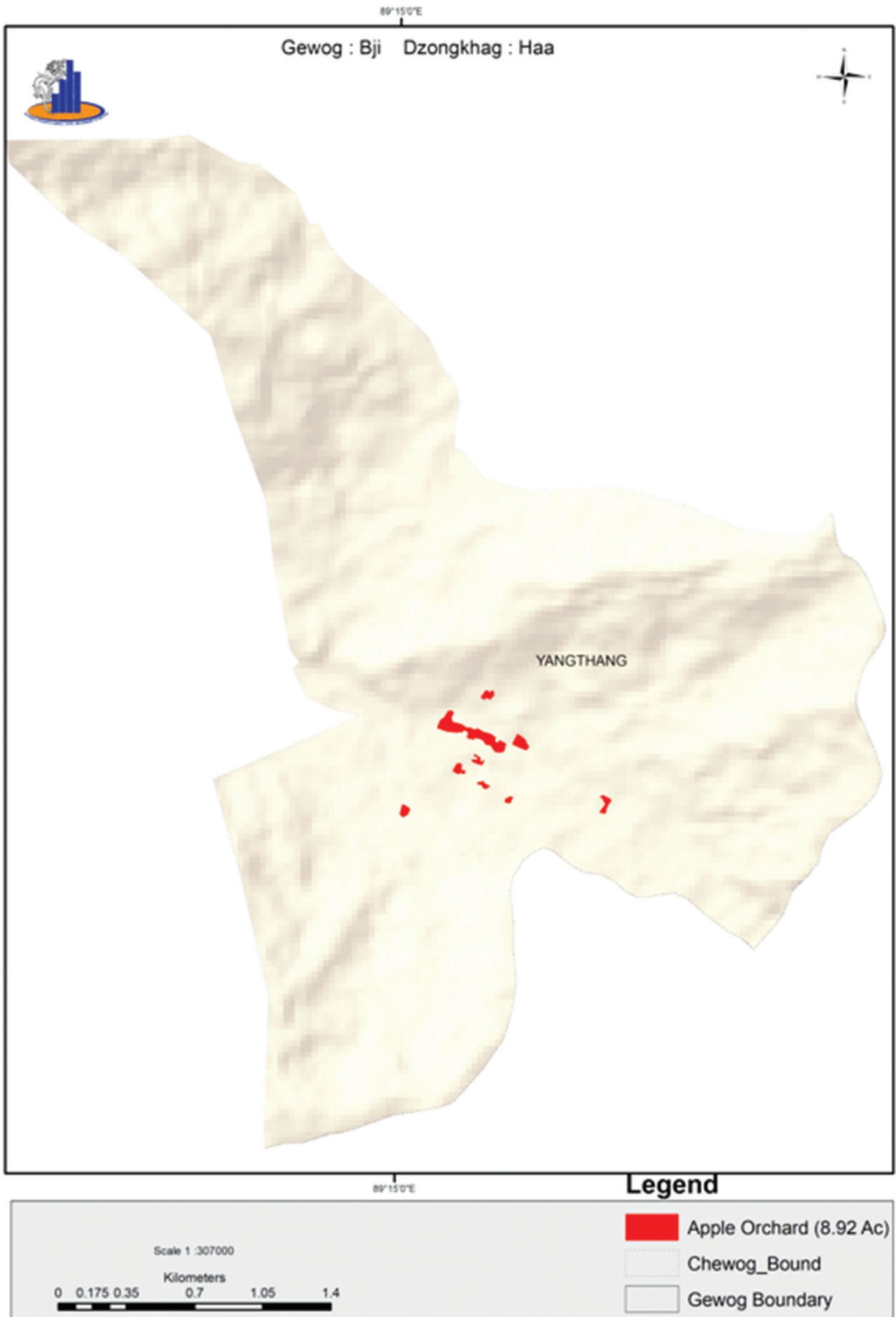


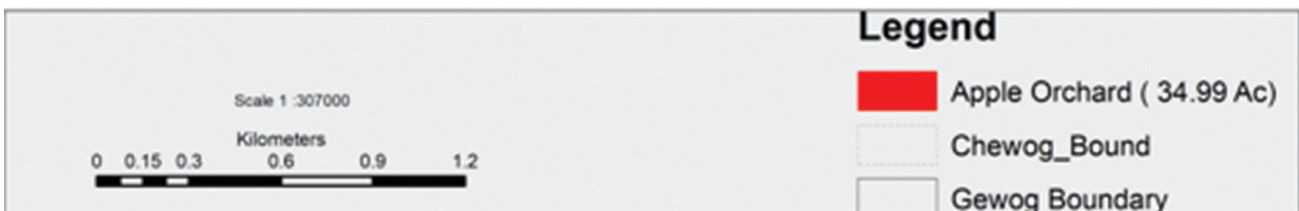
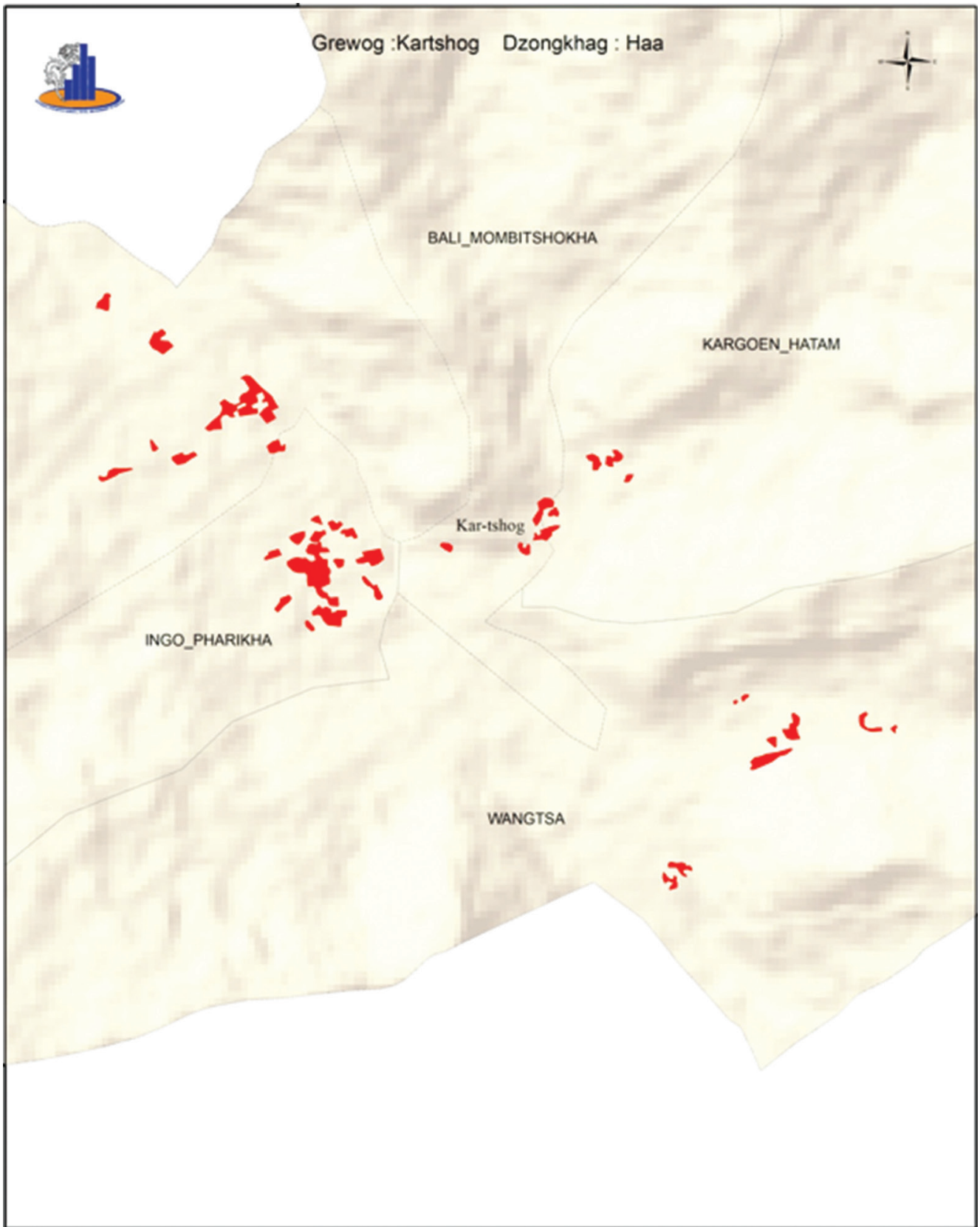


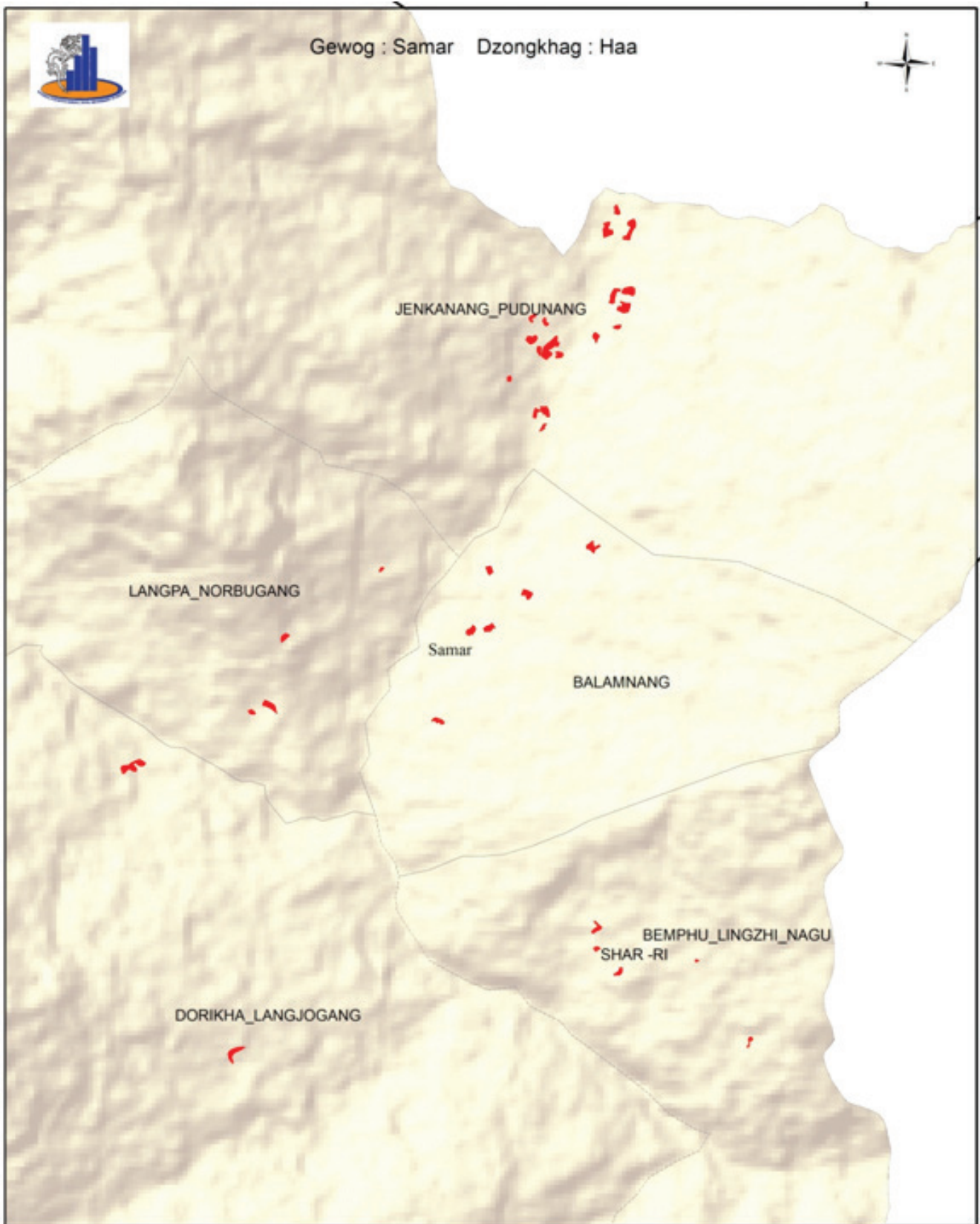


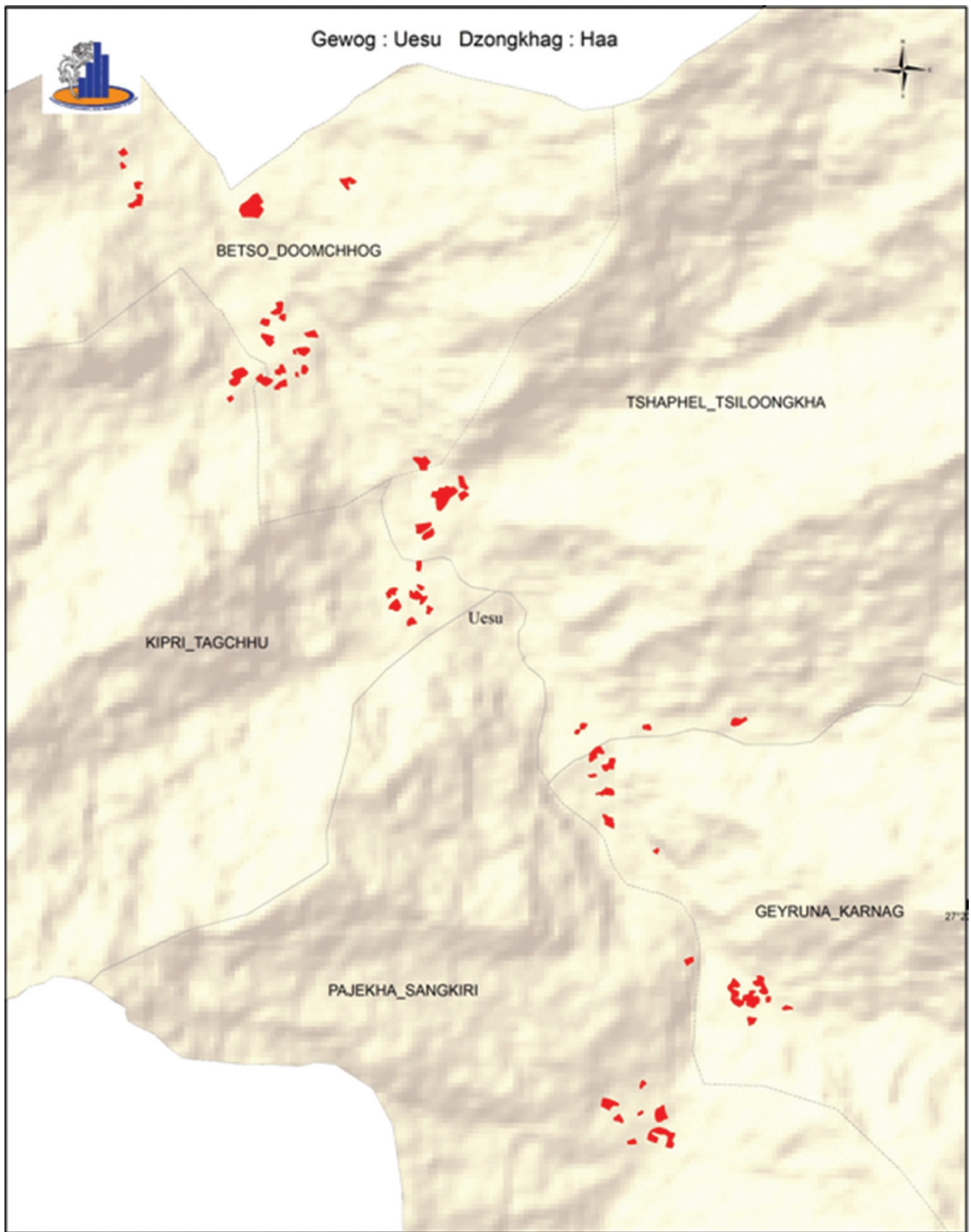
Map 3 Estimated area under apple cultivation in Haa dzongkhag



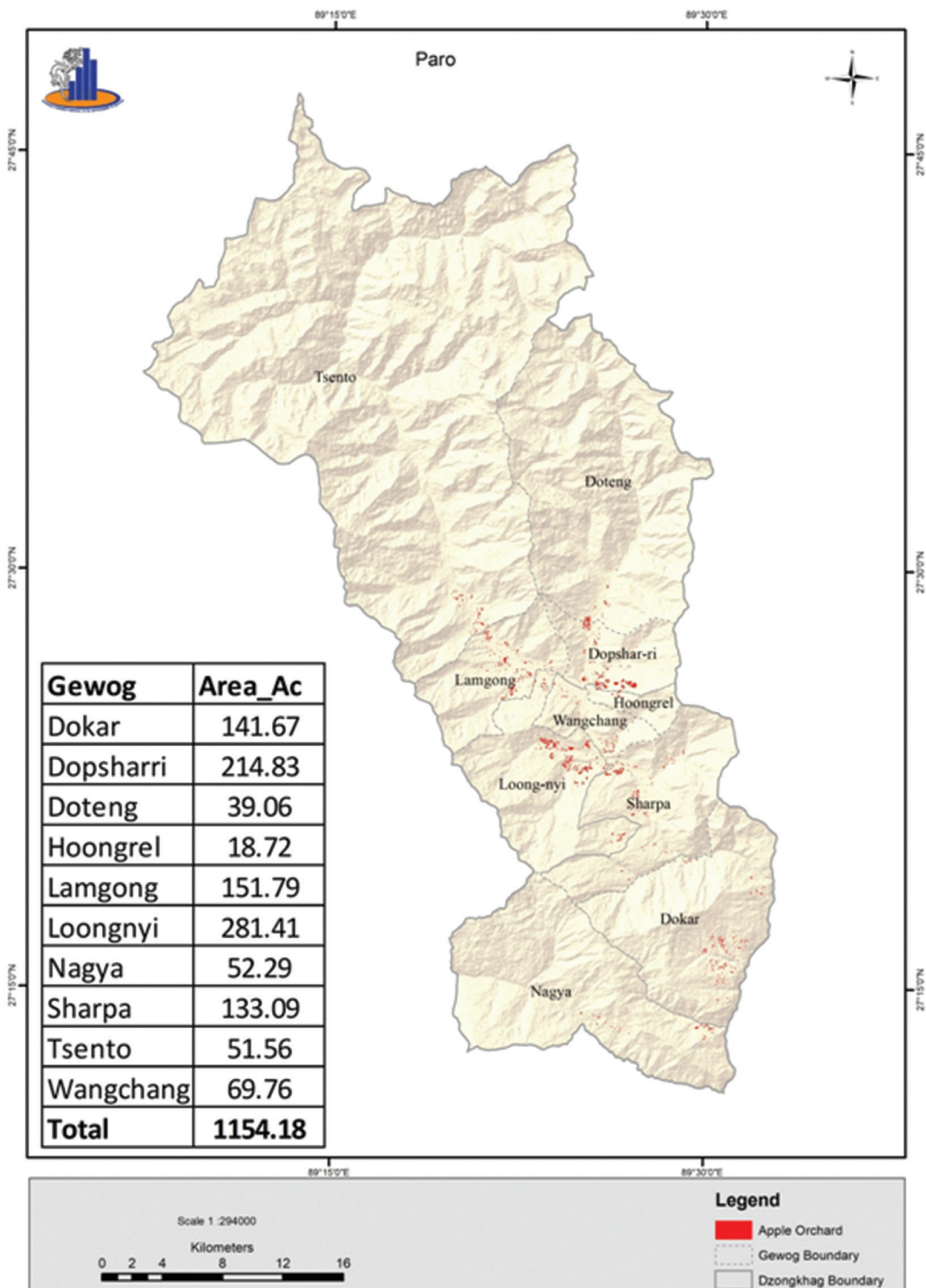


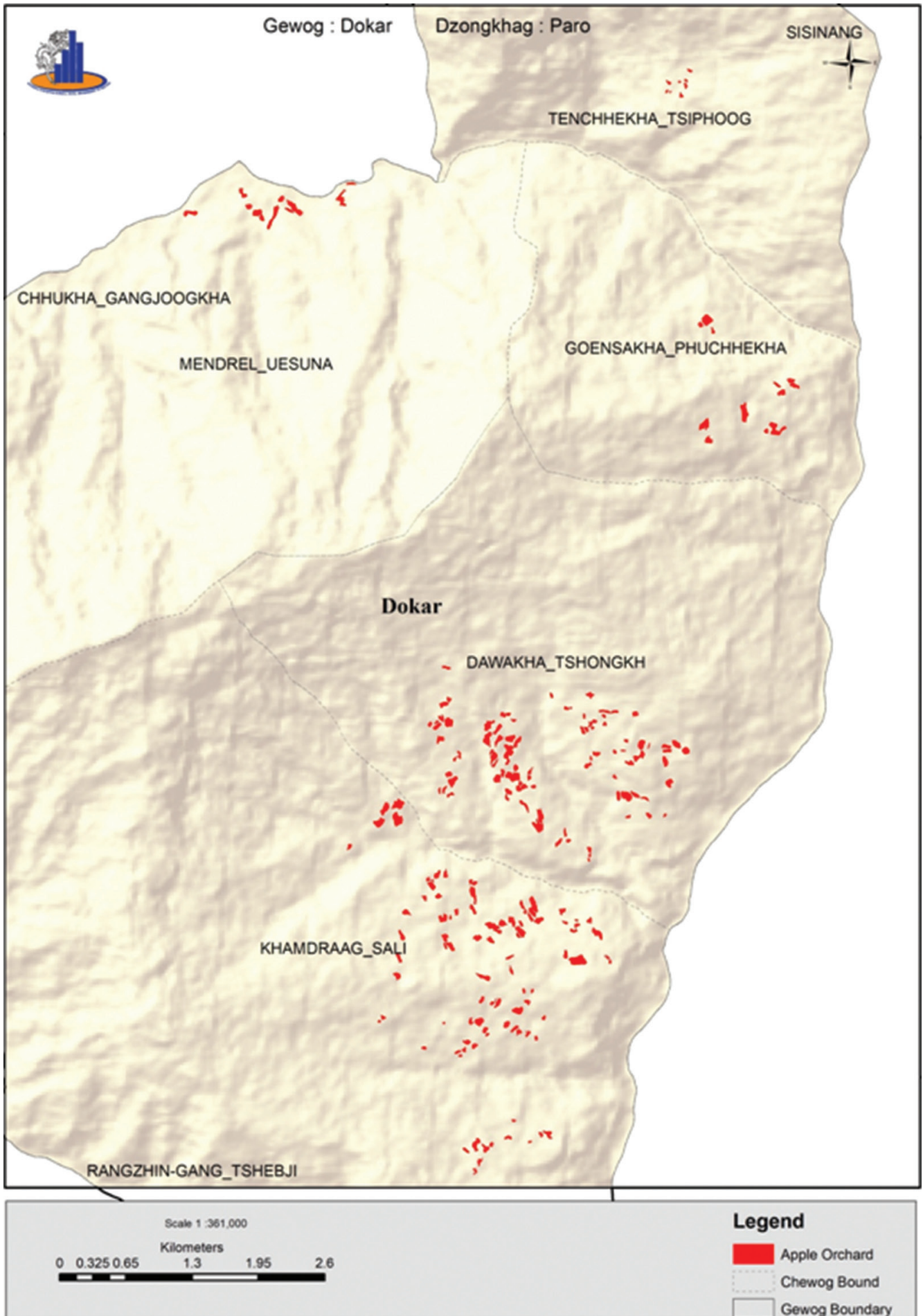


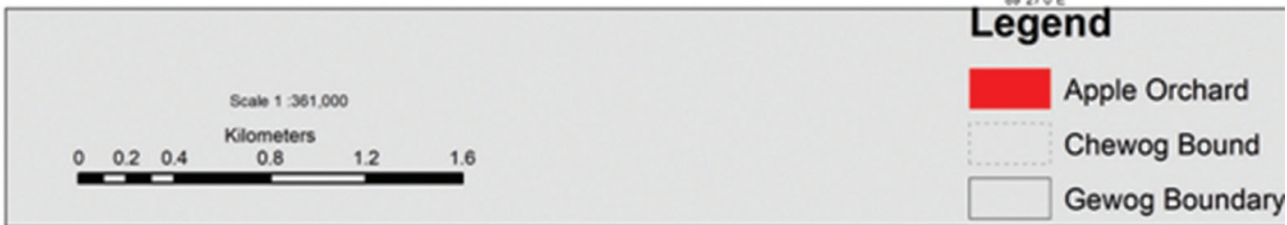
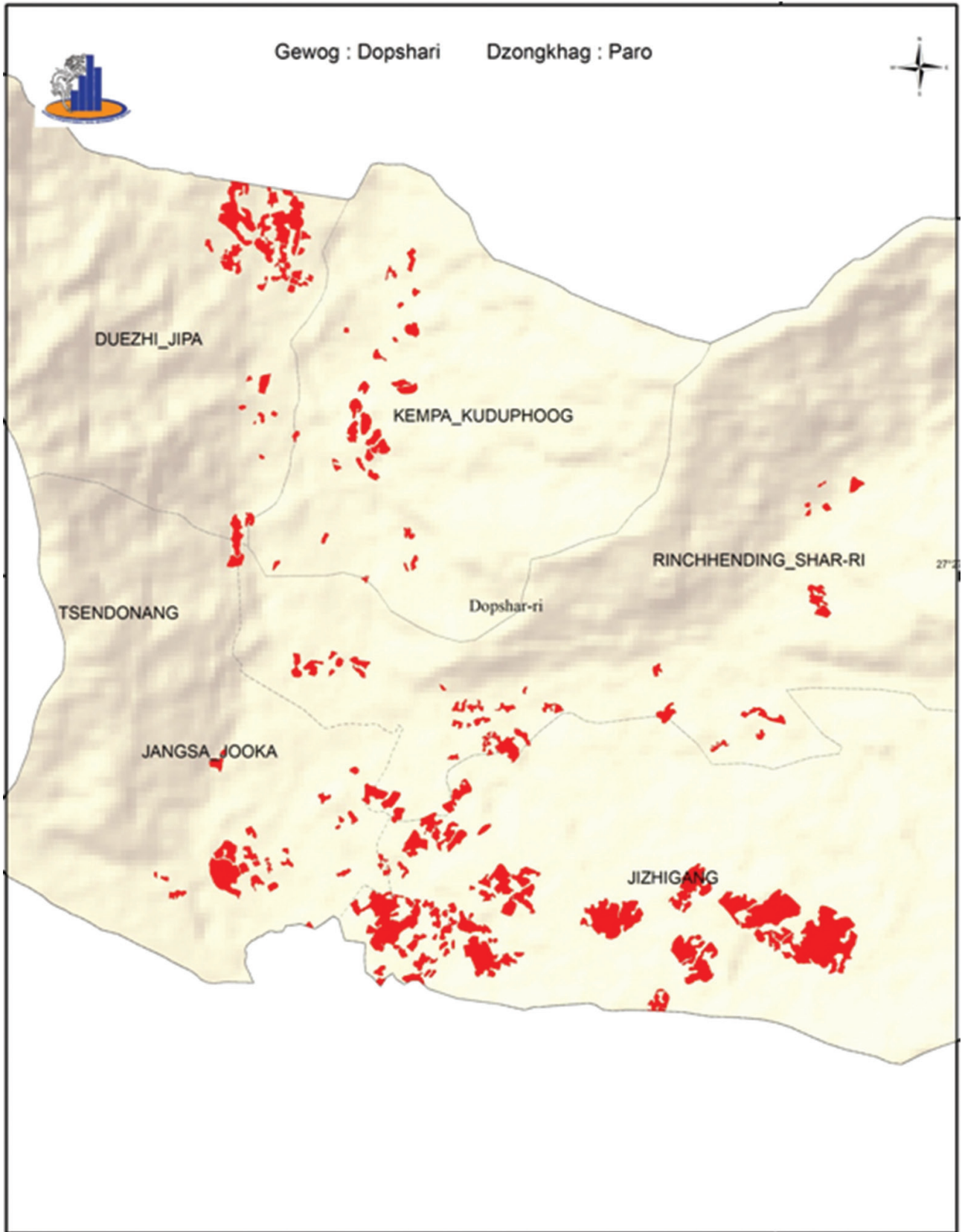


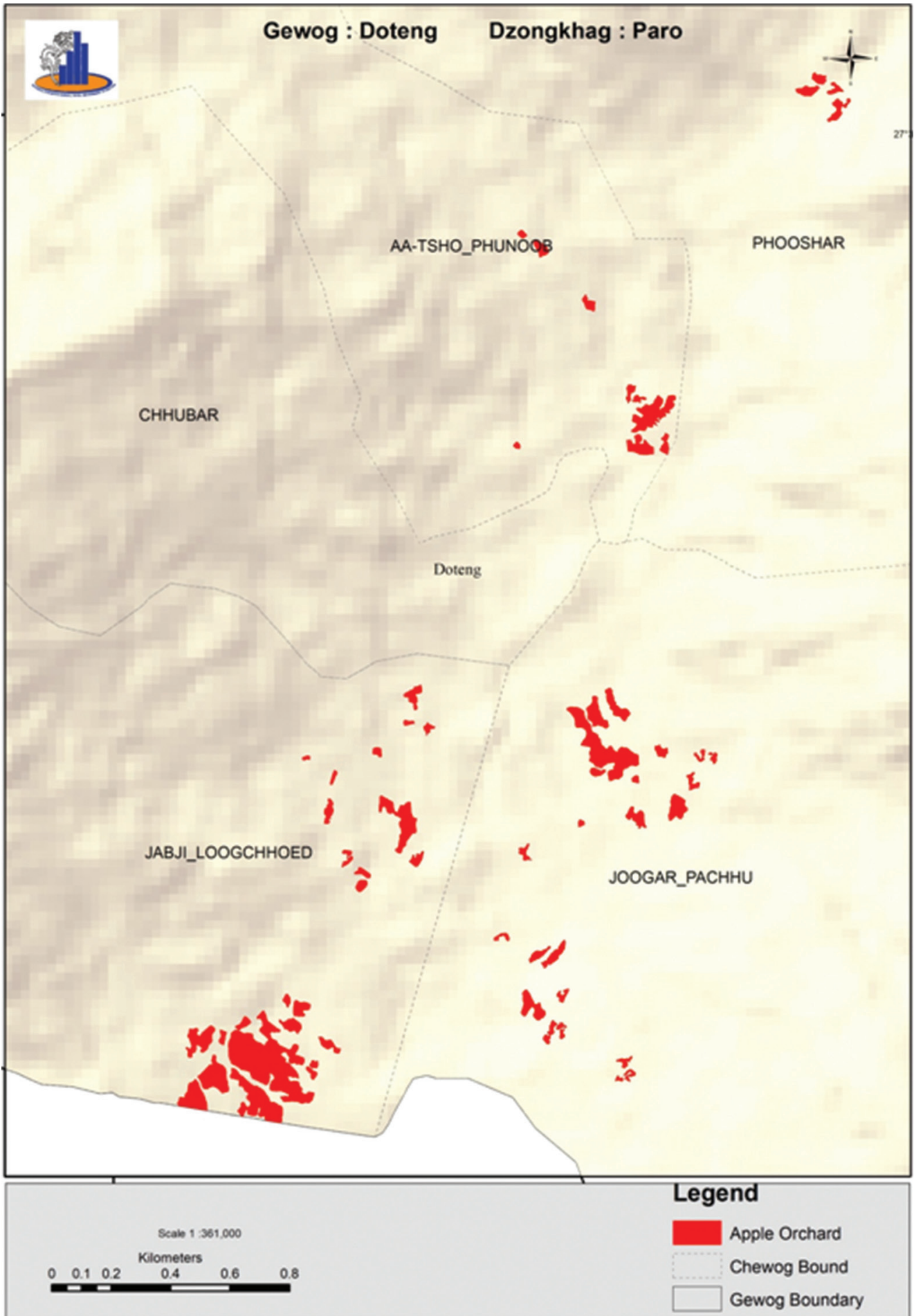


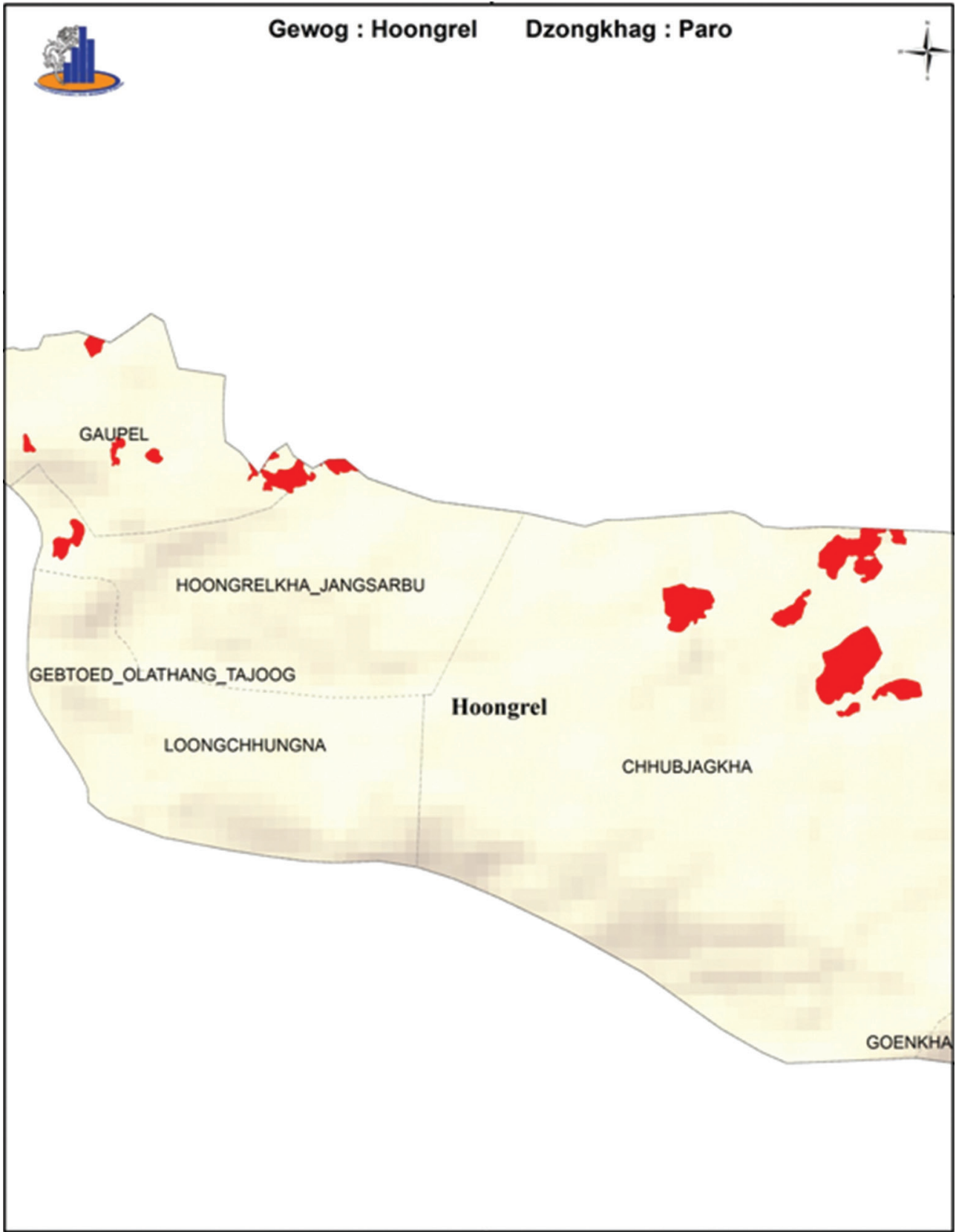
Map 4 Estimated area under apple cultivation in Paro dzongkhag











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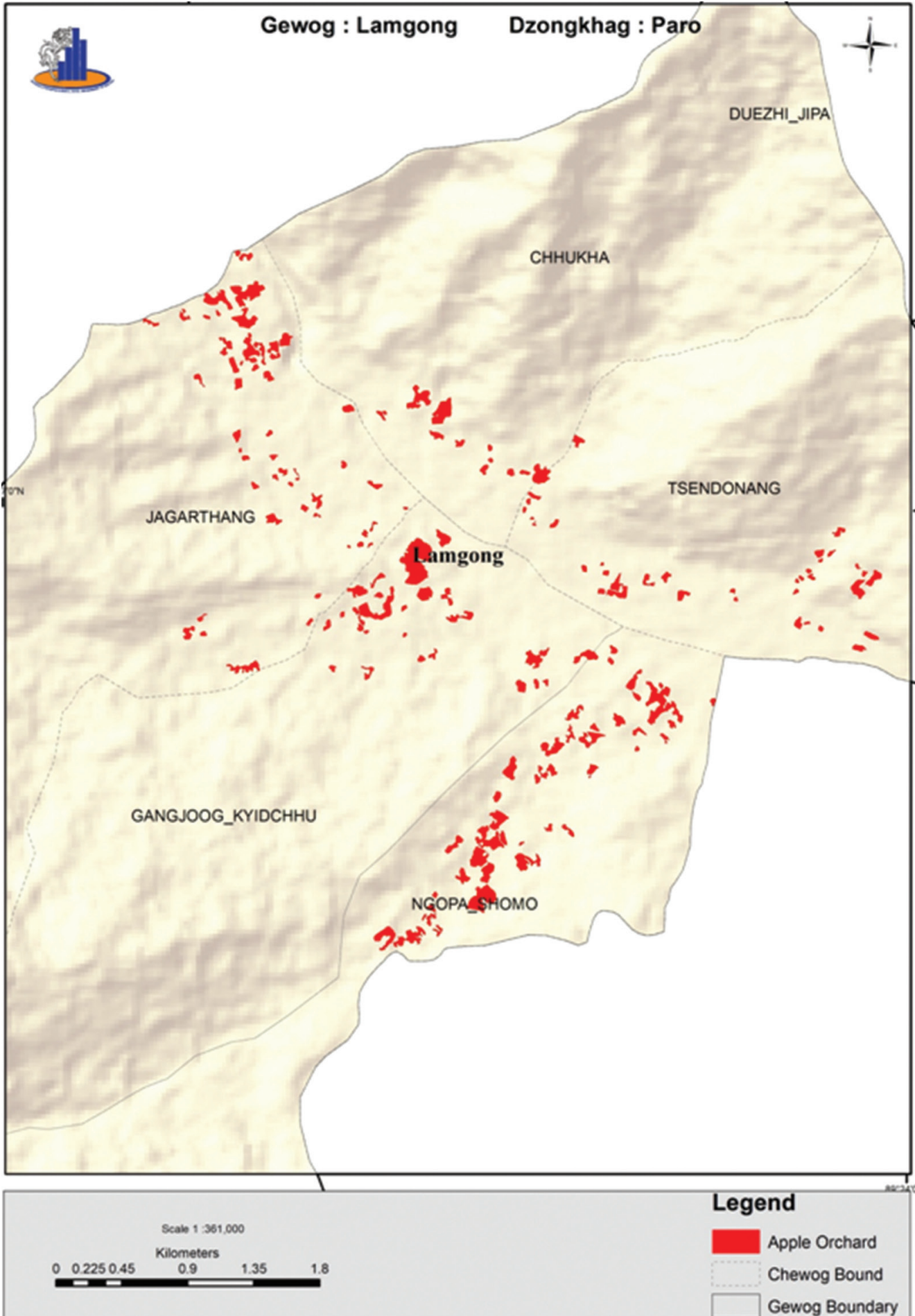
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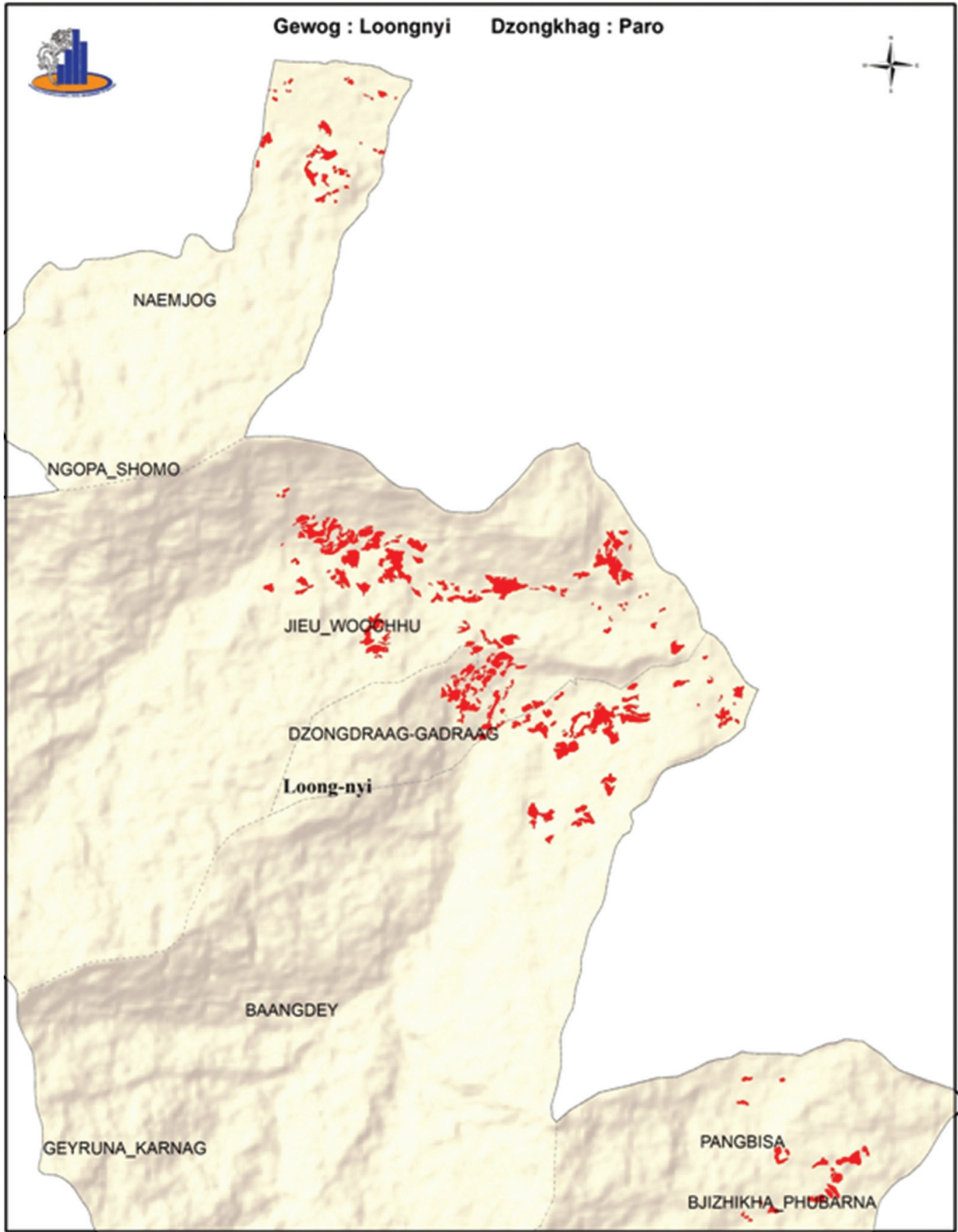
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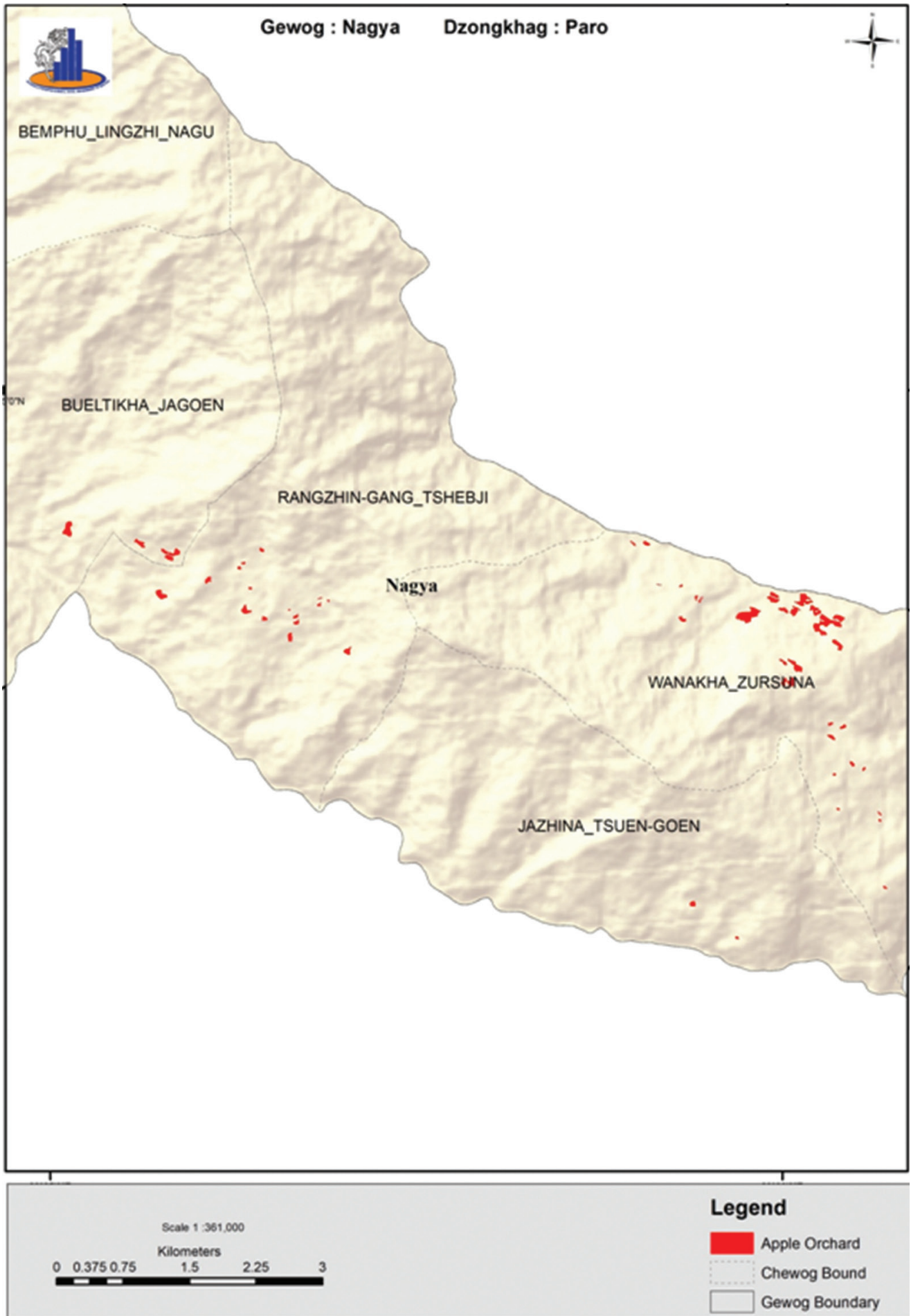
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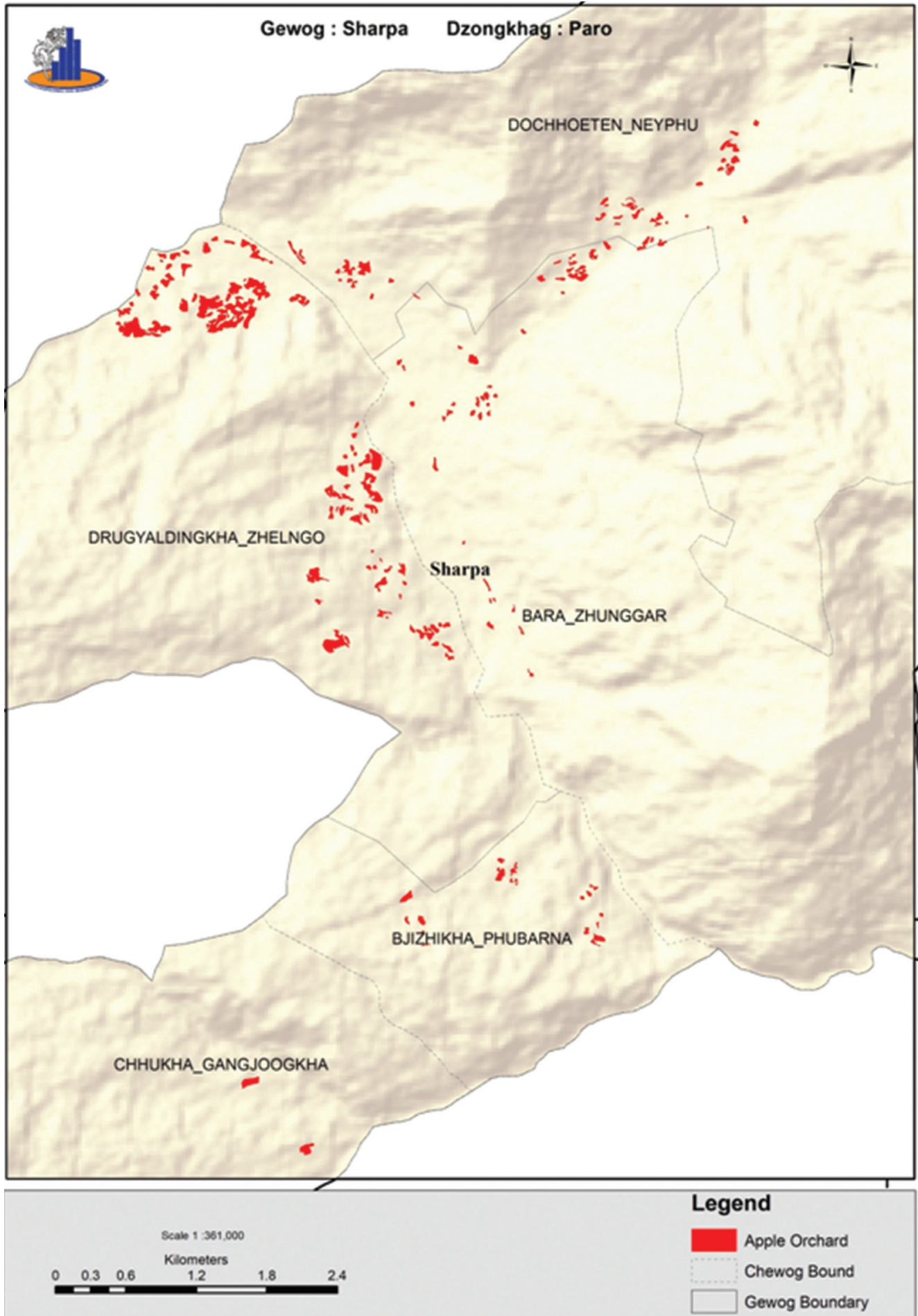
Legend

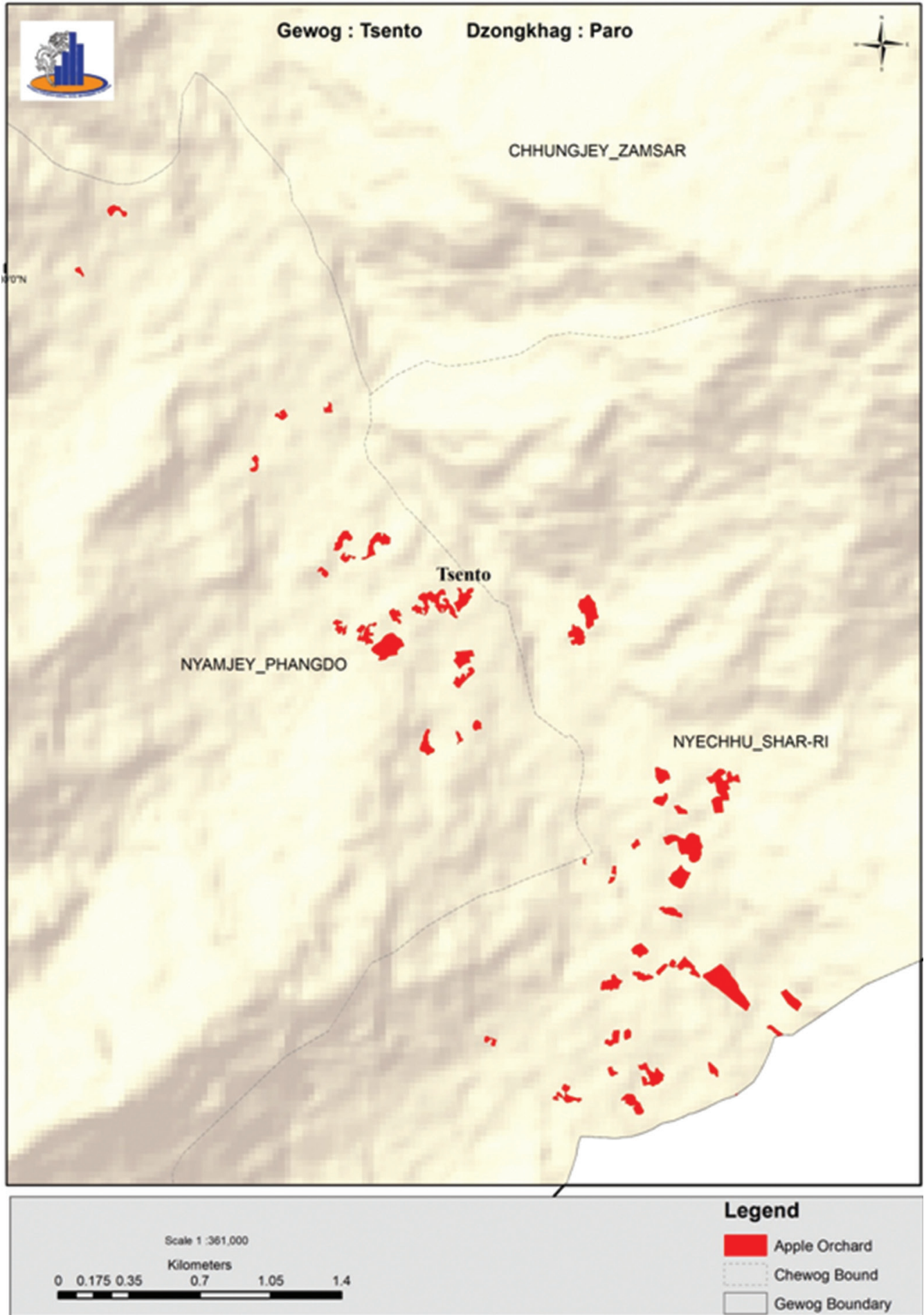
- Apple Orchard
- Chewog Bound
- Gewog Boundary

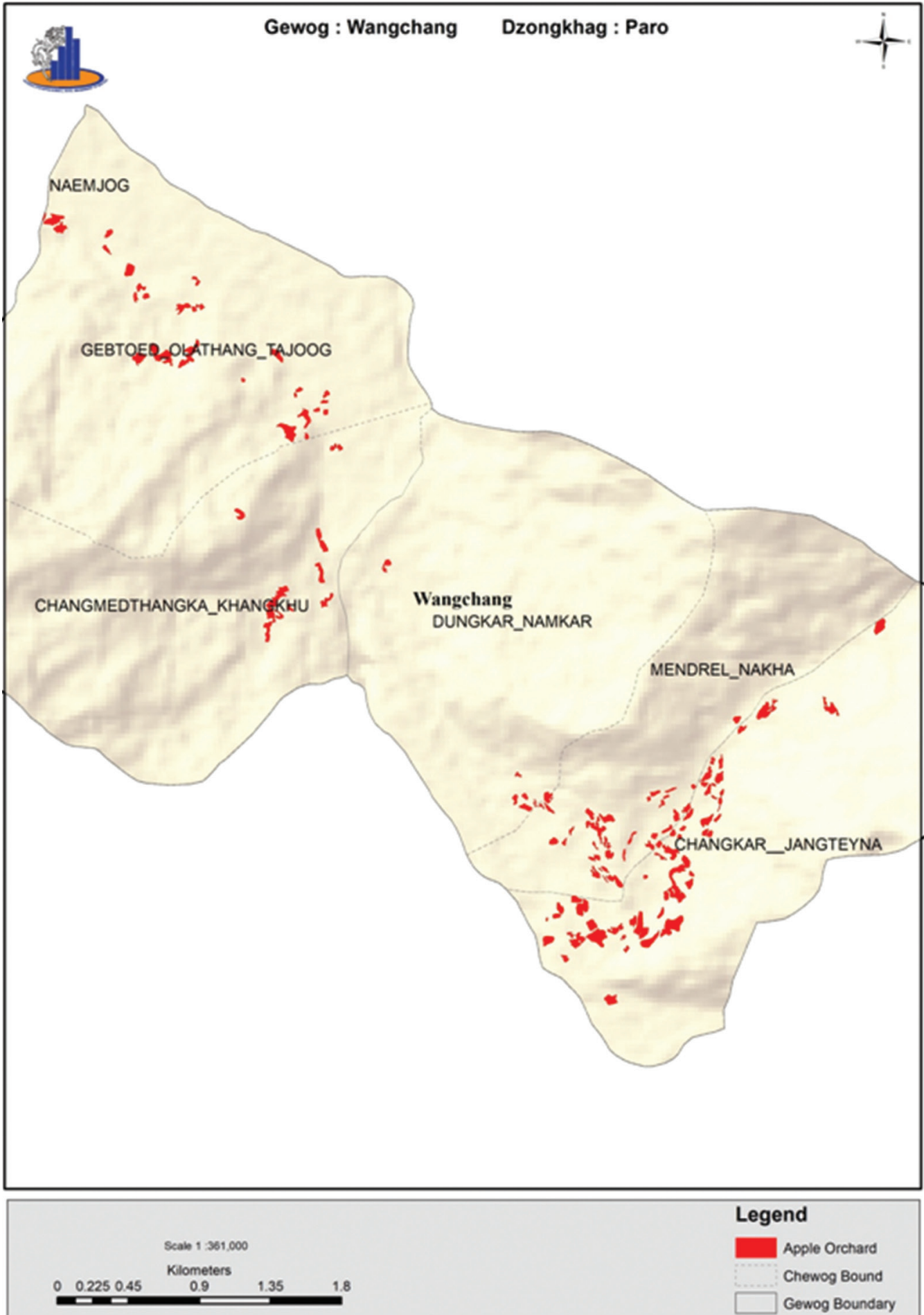




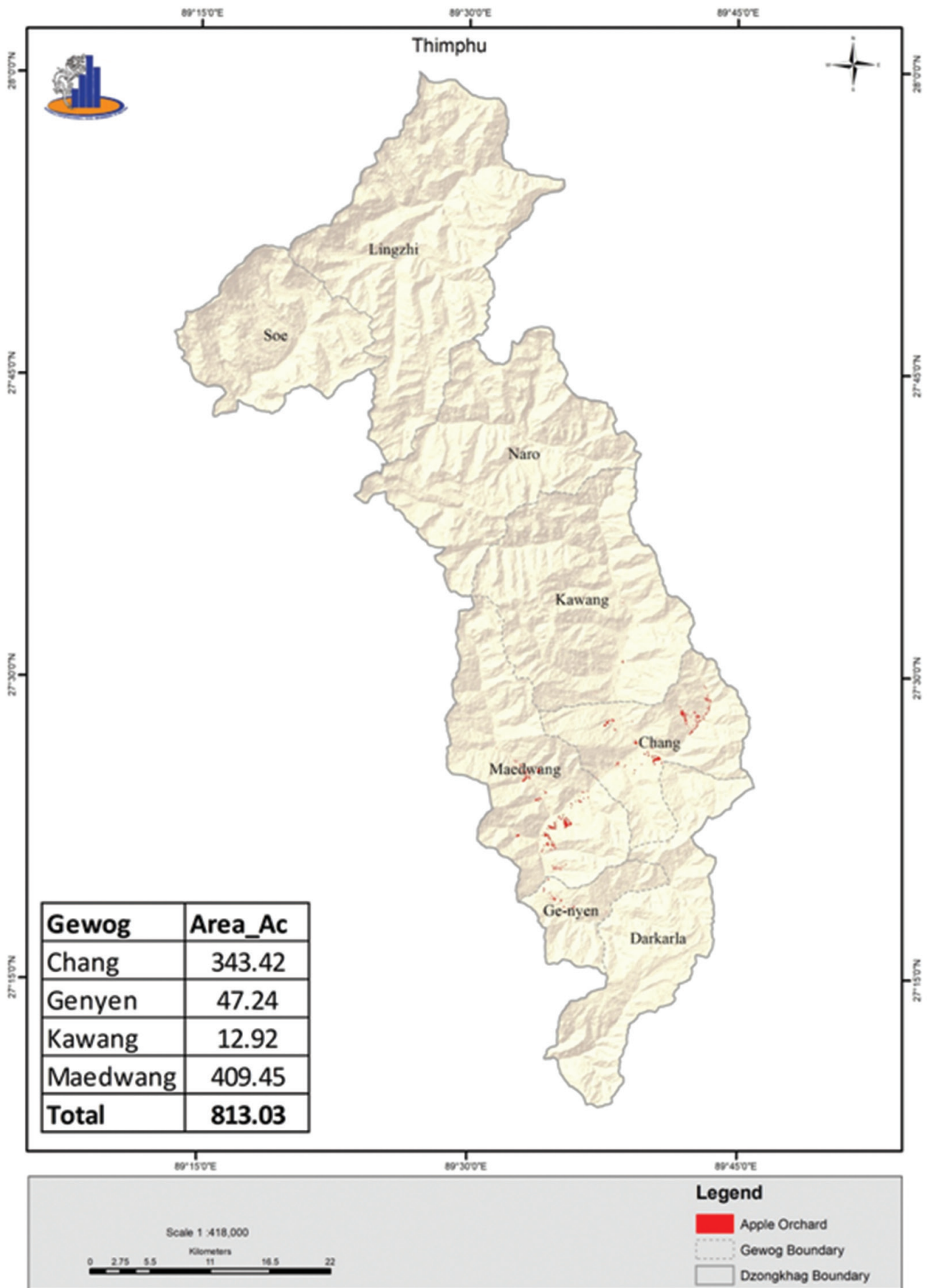


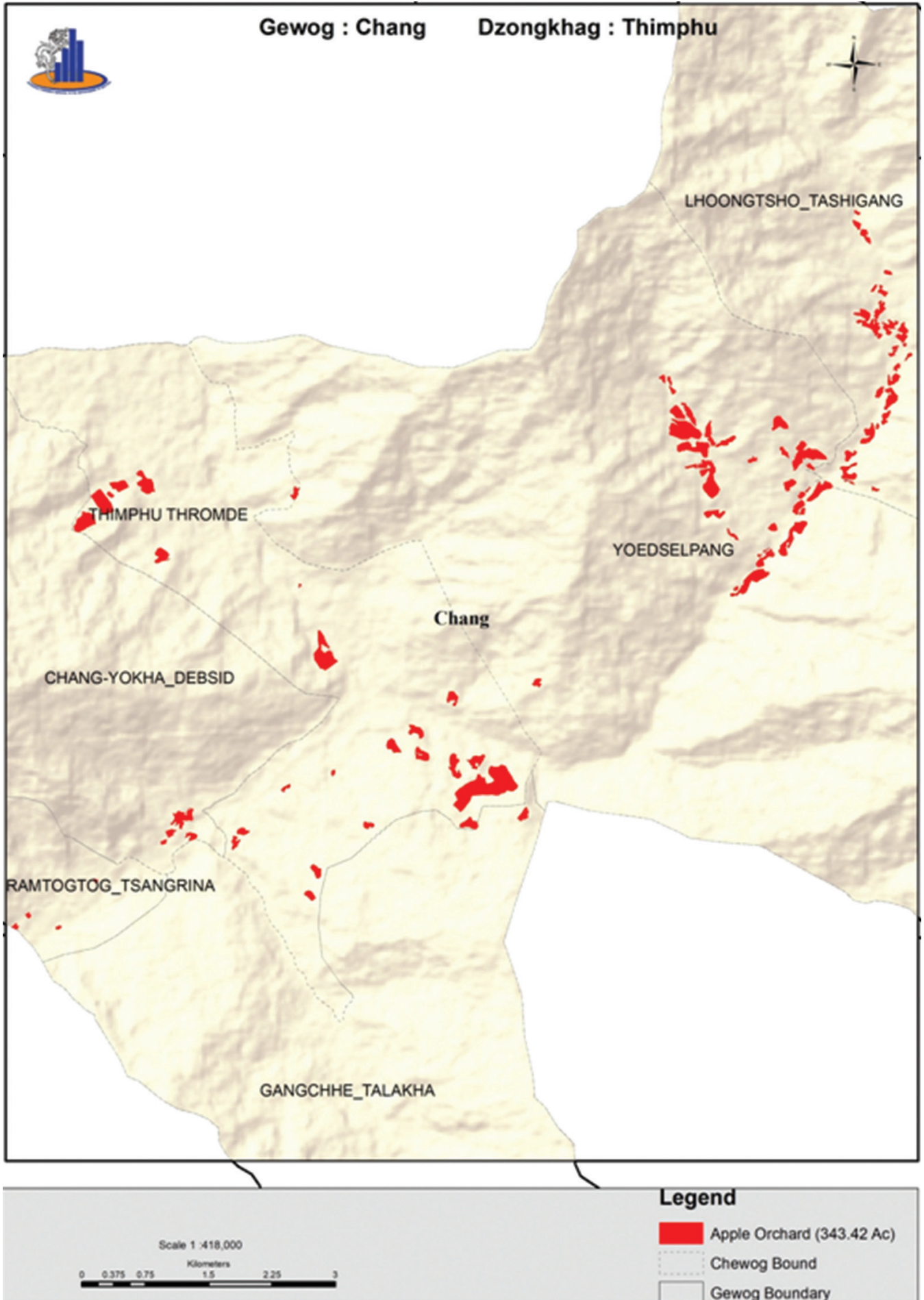


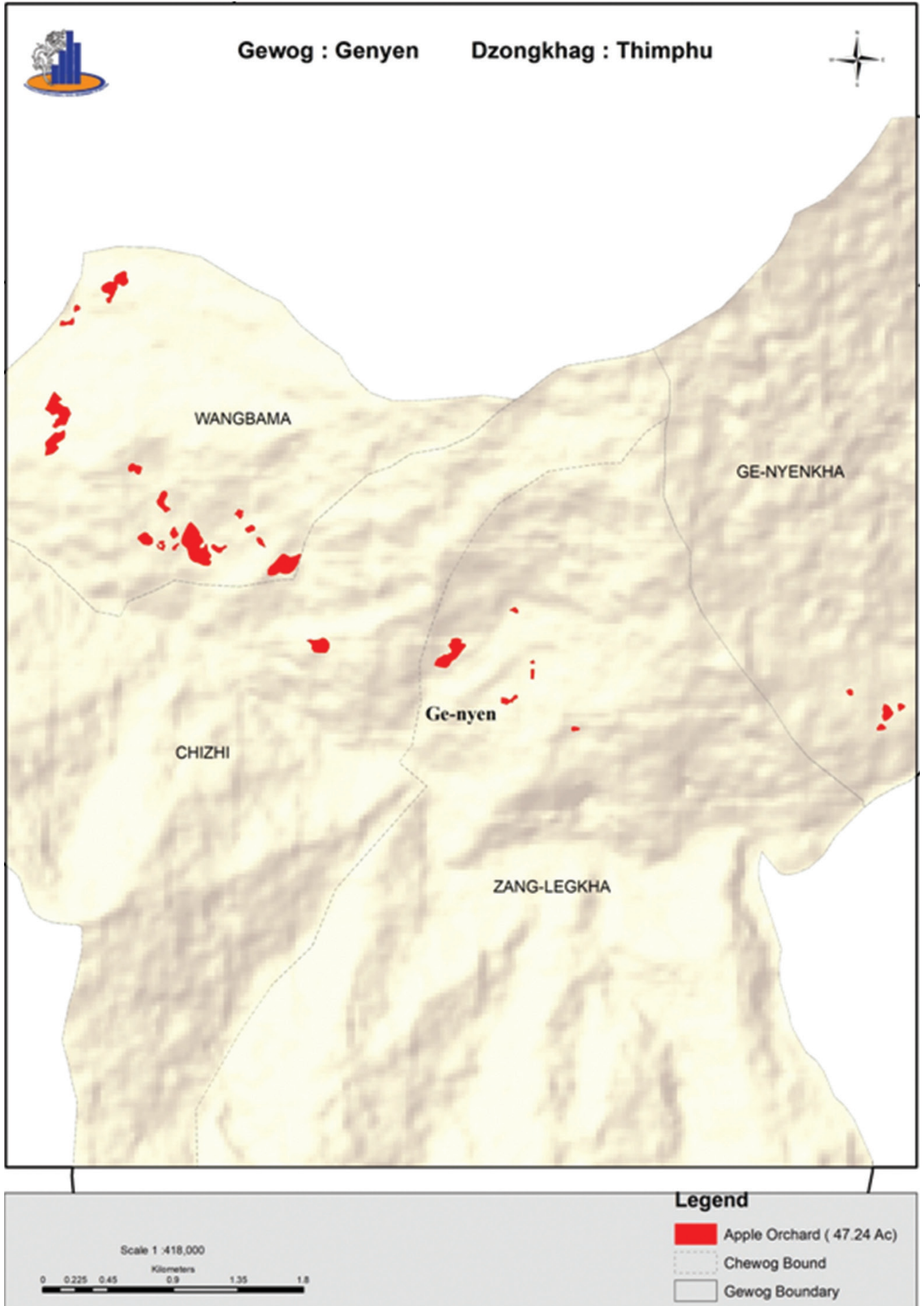


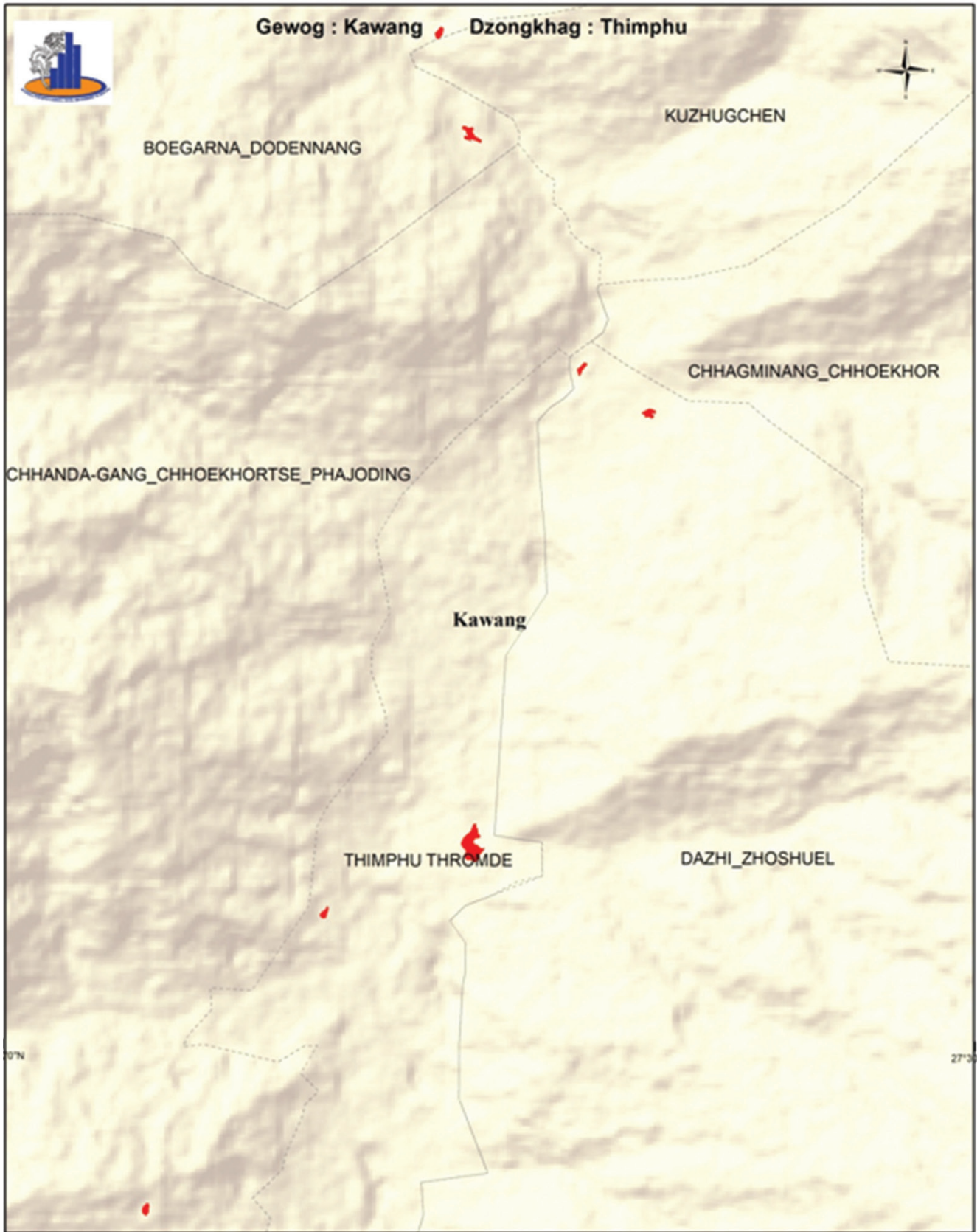


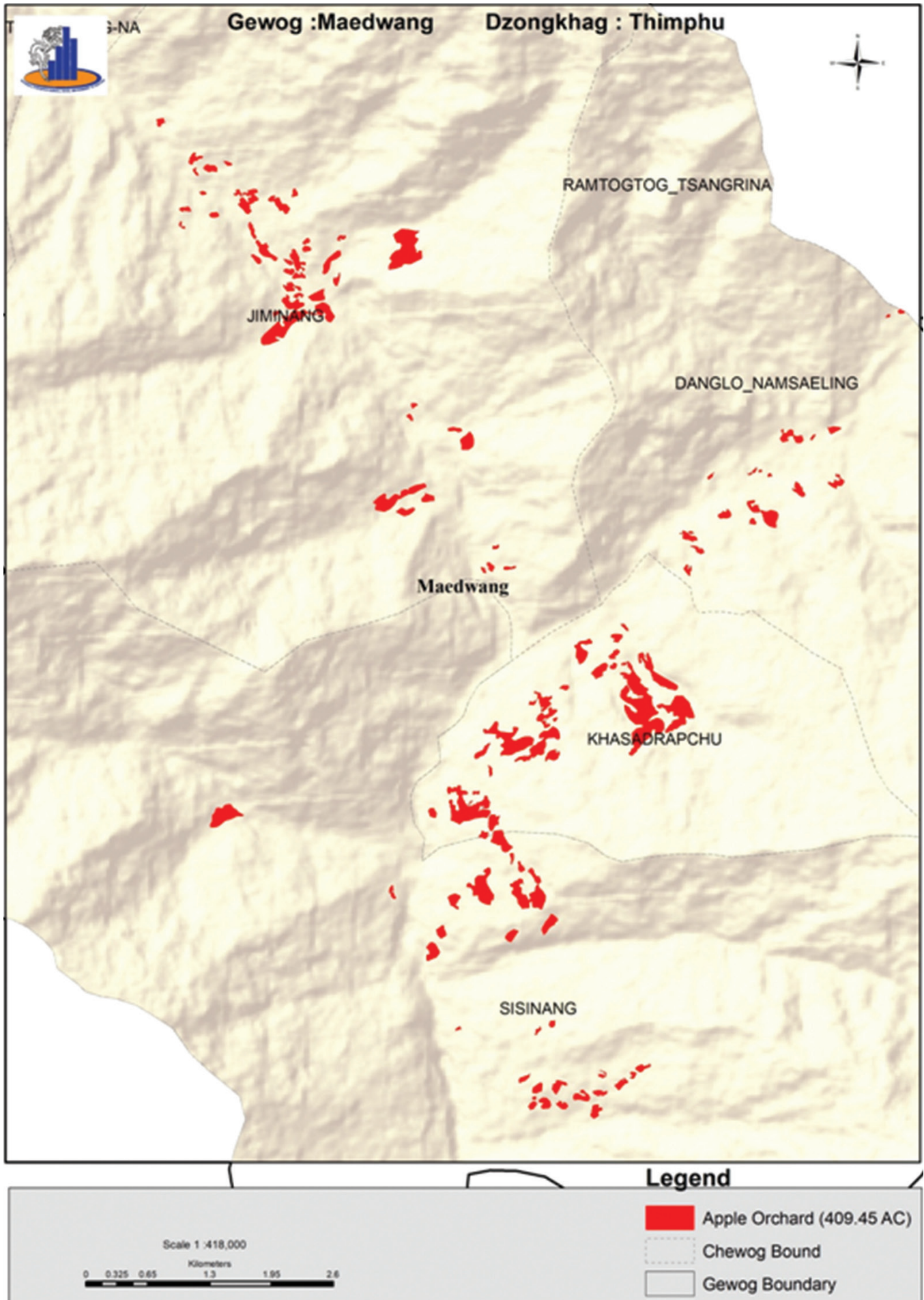
Map 5 Estimated area under apple cultivation in Thimphu dzongkhag



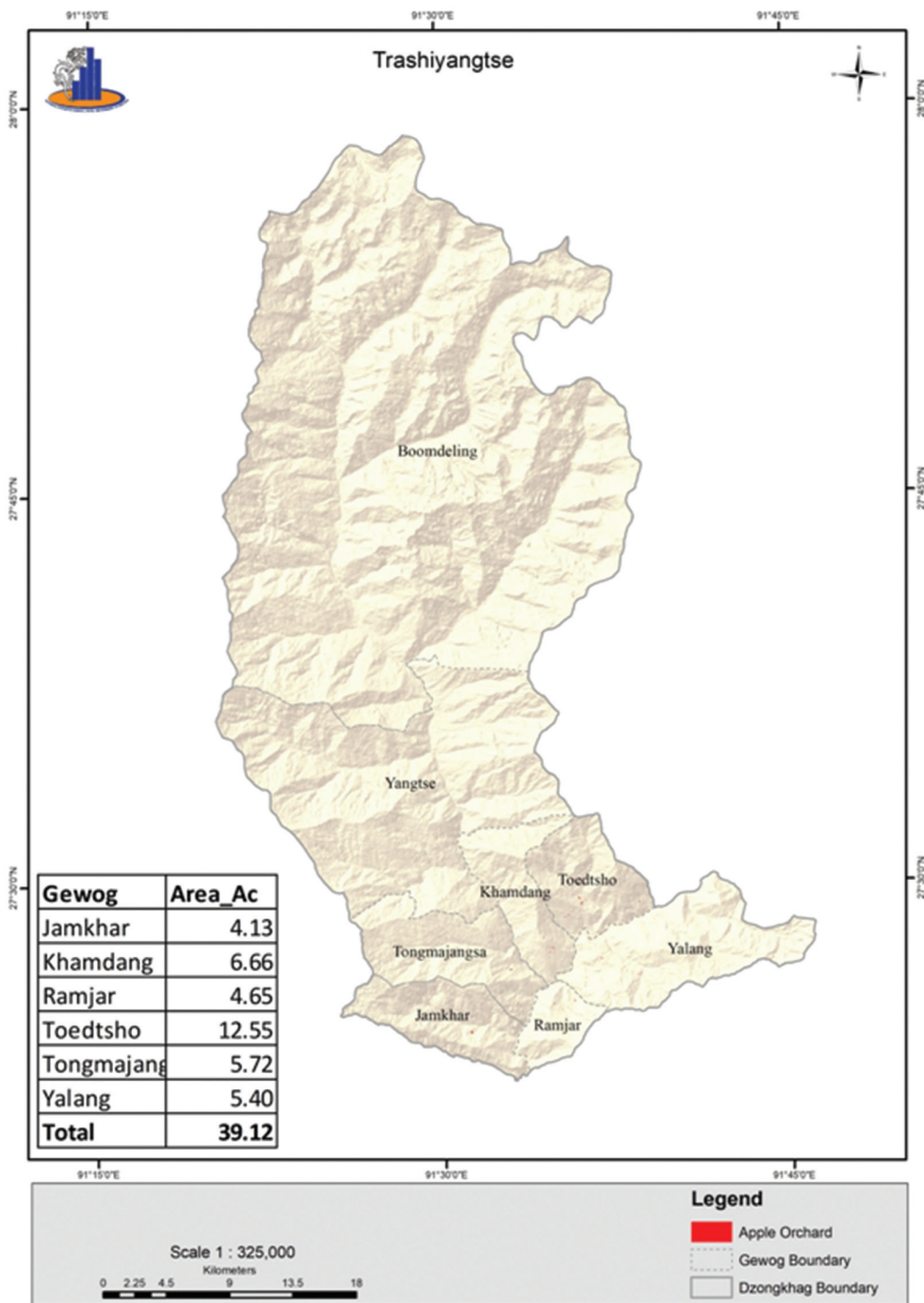


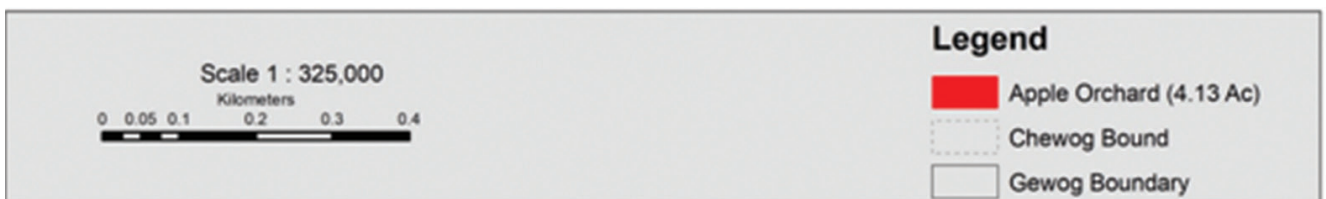
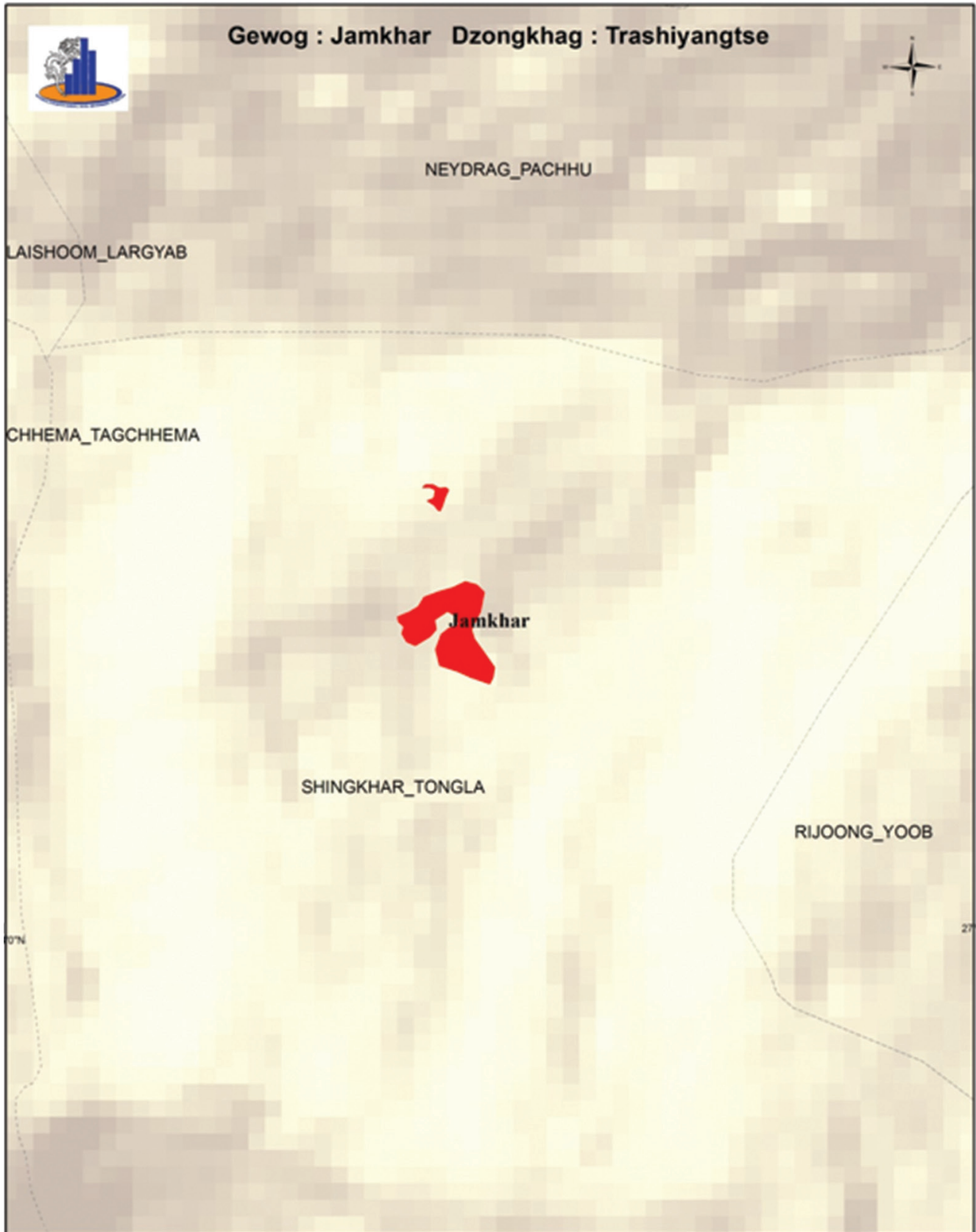


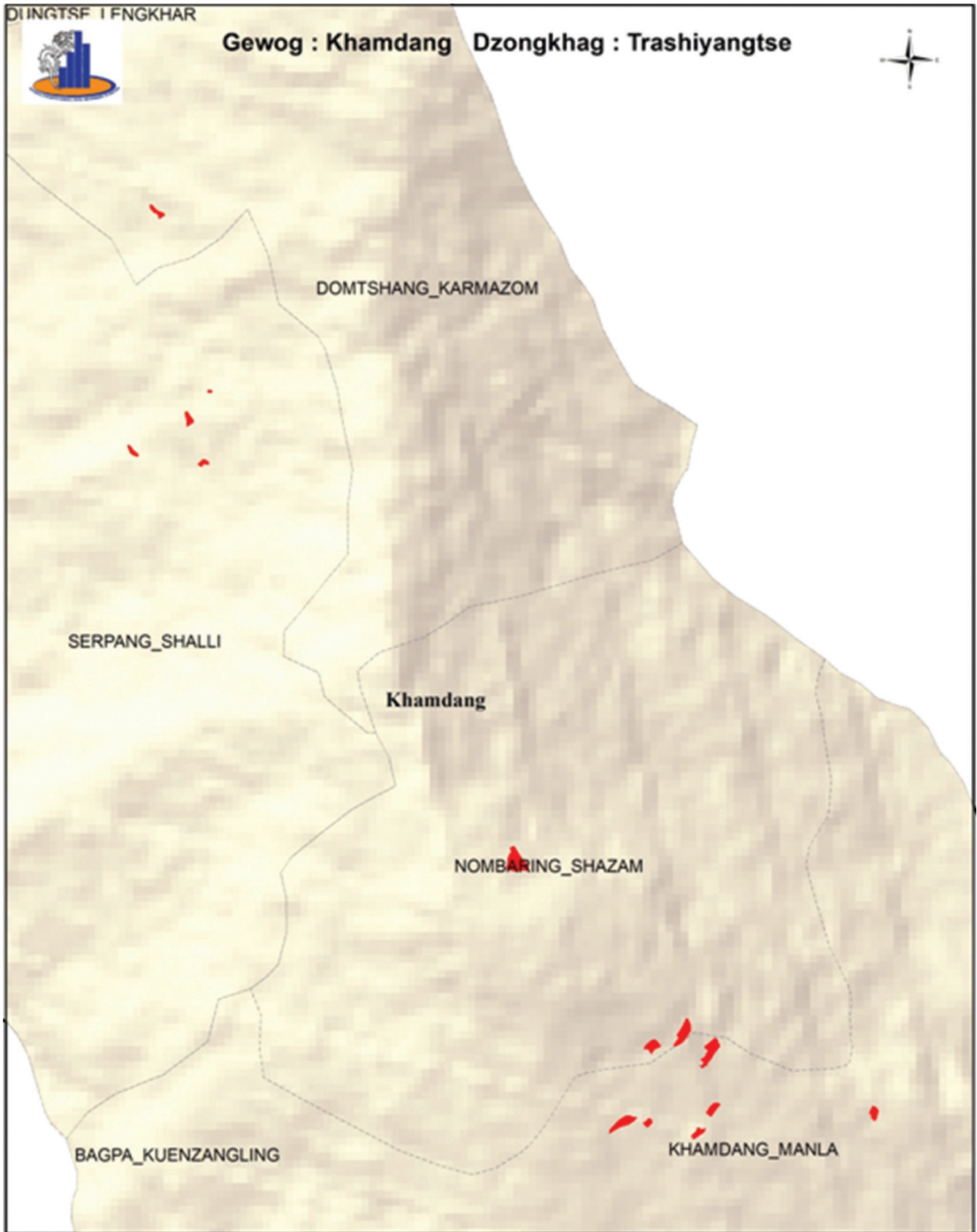




Map 6 Estimated area under apple cultivation in Trashi Yangtse dzongkhag







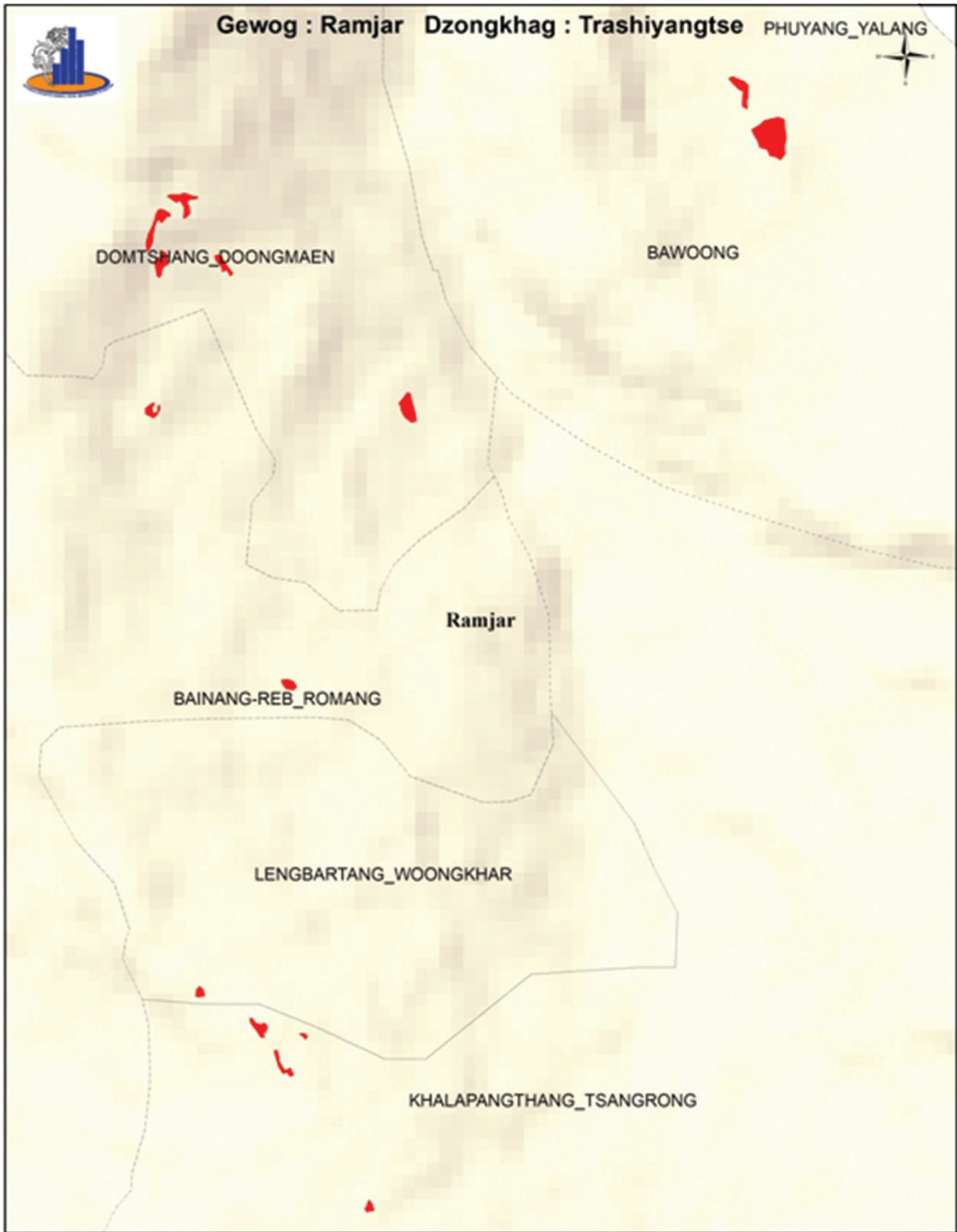
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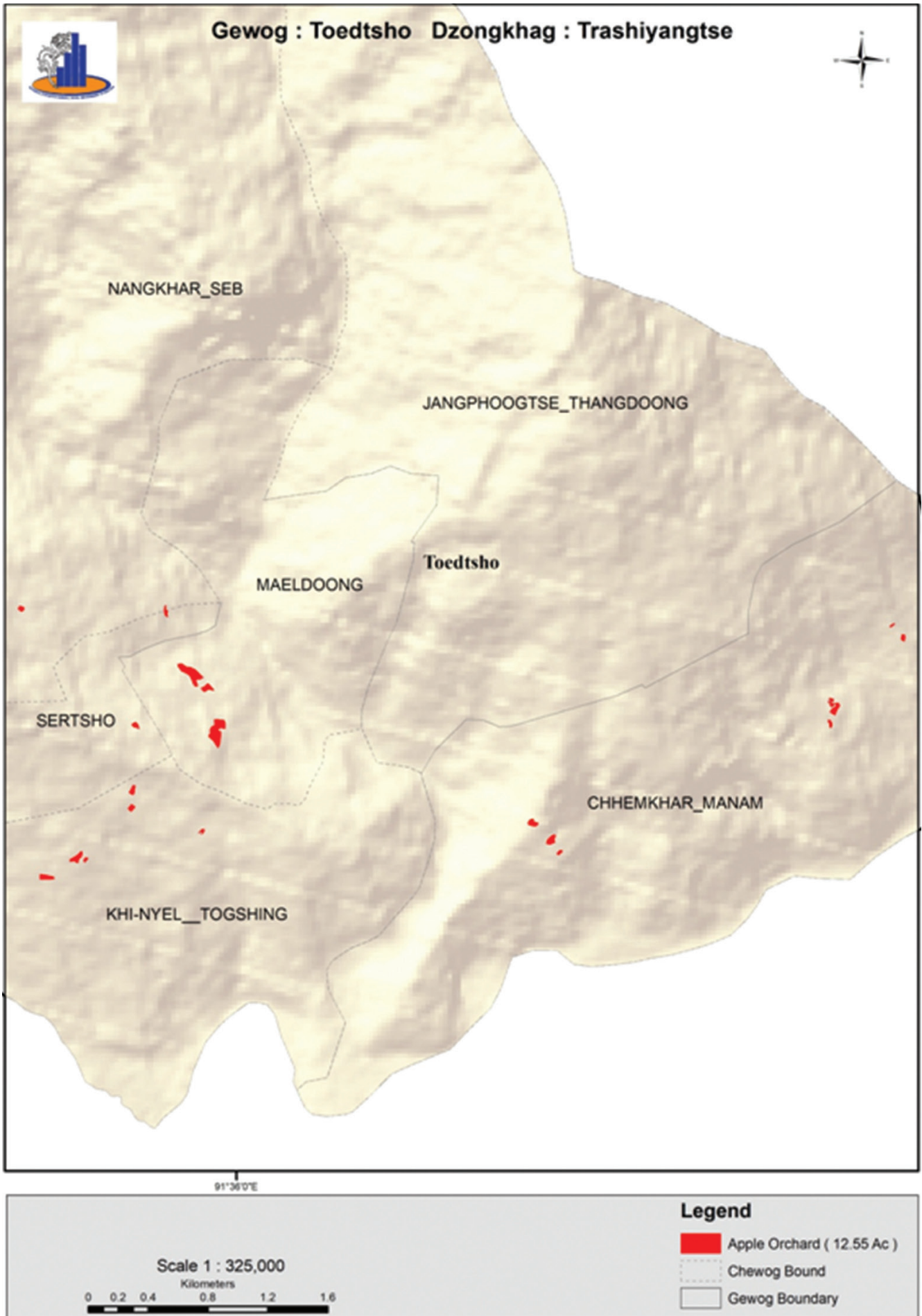
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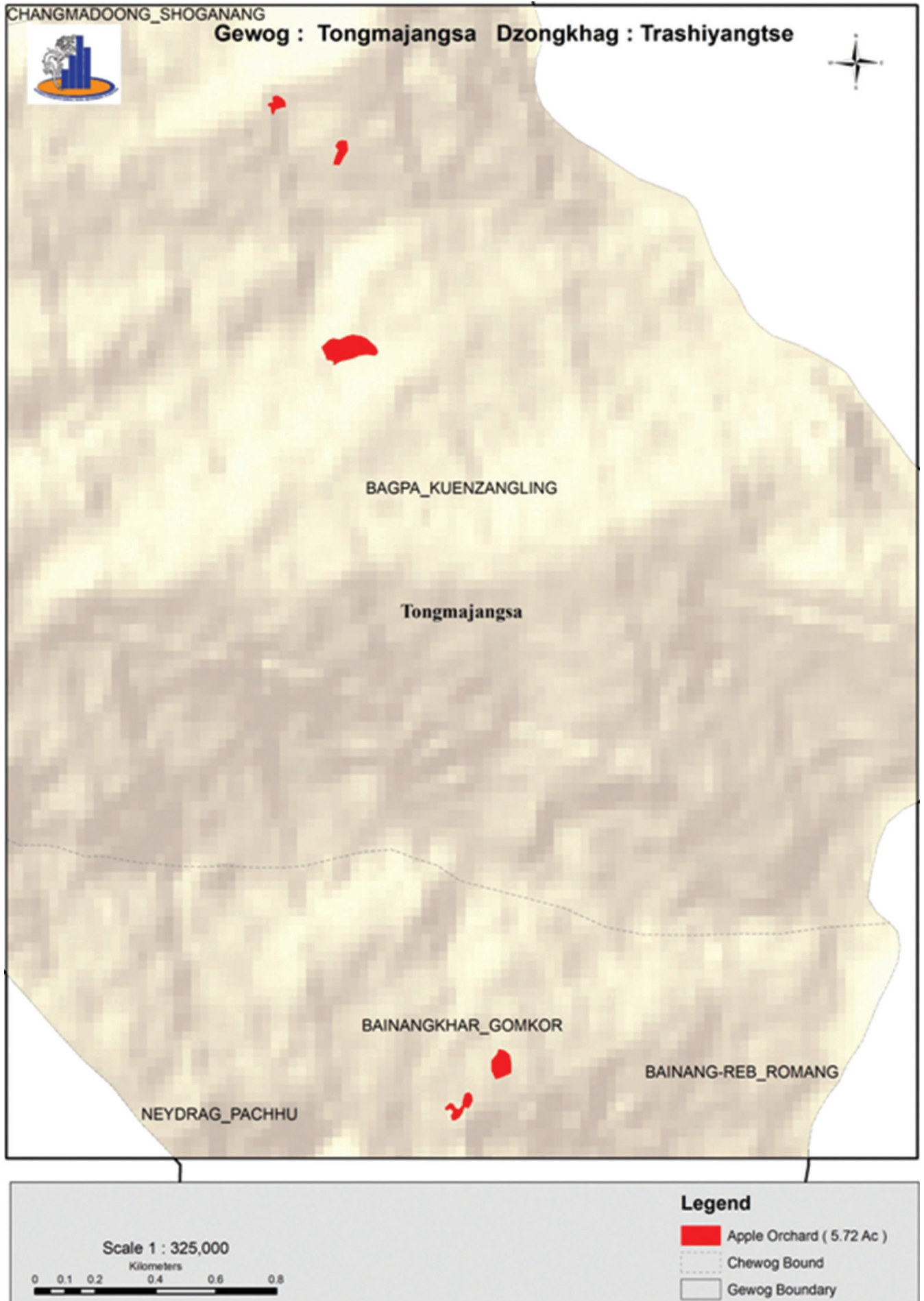
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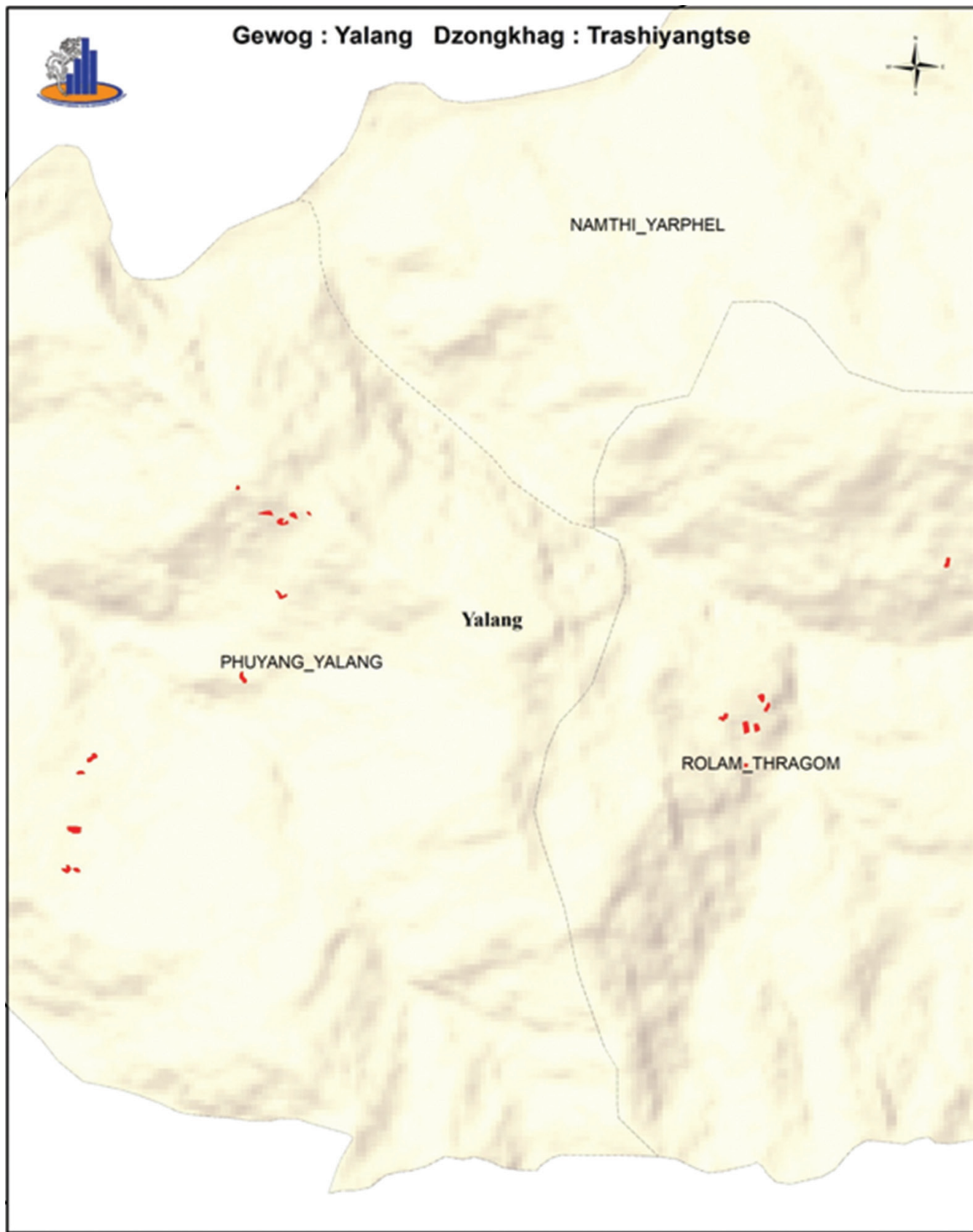
Legend

- Apple Orchard (6.66 Ac)
- Chewog Bound
- Gewog Boundary









Scale 1 : 325,000
Kilometers
0 0.175 0.35 0.7 1.05 1.4

Legend

- Apple Orchard (5.40 Ac)
- Chewog Bound
- Gewog Boundary