DEPARTMENT OF AGRICULTURE
Ministry of Agriculture & Forests

Important Guidelines for Staggered VegetableProduction in Bhutan
2018

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ROYAL GOVERNMENT OF BHUTAN

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National Vegetable Program
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Thimphu: Bhutan

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1. Introduction

Vegetable production – both in terms of quantity and diversity- and consumption has been increasing steadily over the years. In the years to come, demand for vegetables consumption is projected to increase further with increase in population, income, more awareness on nutrition and change in dietary habits. In 2016, 56,298 MT of vegetables were produced earning Nu. 652 million (Agriculture Statistics 2016). However, though Bhutan has diverse agro-ecological zones, vegetable production is concentrated in one season (mainly summer) leading to shortage during other seasons especially in winter. For instance, in 2017, Bhutan imported fresh vegetables worth more than Nu. 5 million (Bhutan Trade Statistics, 2017) particularly during winter. Hence, to address this issue, staggered vegetable production is necessary. This manual provides general guidelines for staggered vegetable production in the country. It is expected to provide useful guide to new vegetable growers, agriculture extension officers and researchers alike.

2. Classification of vegetable crops

Currently, more than 22 different types of vegetables are grown in the country. Required climatic and edaphic factors of crops vary by types and varieties. Among other factors, temperature and sunshine hours are two critical factors that are often difficult to manipulate, and that largely determines the cropping calendar. Hence, classifications of vegetables based on these two important factors are discussed.

2.1. Vegetable classification based on temperature

Temperature is one of the most important factors that determines the growth and development of crops. Therefore, vegetables are grouped into three categories based on their temperature requirement for optimum growth and development. Basically, crops that grow and develop well below 18^{o}C are cool season and those that do well above 18^{o}C are called warm season crops. Table 1 gives the specific temperature requirement of crops in general and must be noted that at variety level it could differ. **Hence, it is essential to understand the varietal characteristics.**

Table 1: Optimum temperature range for crop growth and development

Optimum temperature range (°C)	Crops
7 - 13 (Cool)	Asparagus, Cabbage, Cauliflower, Broccoli, Garlic, Lettuce, Onion, Pea, Spinach
13 -18 (Moderately warm)	Capsicum, Carrot, Chinese Cabbage, Common Beans, Mustard Greens, Radish, Tomato
18 - 30 (Warm)	Chili, Cucurbits, Eggplant, Okra

Source: AVRDC-The World Vegetables Centre

Usually, elevation is taken as a proxy for temperature since according to Lapse rate, for every 1,000-meter increase in elevation, there is drop in temperature by about 6.5^{o}C. However, in Bhutan, due to complex orographic features, it is the micro-climate that determines the crop suitability. For example, our studies show that there is at least 1^{o}C difference in temperature between northern and southern aspect. Hence, use of elevation as proxy for temperature should be considered with caution.

2.2. Classification based on photoperiod

In addition to temperature, day length (photoperiod) also influences the nature of crop growth and development such as development of leaves, initiation of flowering, and bulb formation etc. Thus, broadly, vegetables are grouped into three categories based on the response of the crops to photoperiod or day length (length of sunlight from sunrise to sunset). Based on reaction to the day length, ***short day plants*** are those that begin to flower when the days are shorter than the critical day length (usually 11 to 14 hours); ***long day plants*** begin to flower when the days are longer than the critical day length, and ***day neutral plants*** are not affected by the day length. Thus, photoperiod determines the season of the crops, too. For instance, long day onion variety should be planted in such a way that maximum growth is attained during the months when the day length is longer than night for productive bulb formation. Else, proper formation of bulb will not occur. For year-round production of crops, only **day neutral crops/varieties are suitable as long as required temperature is met. Hence, day neutral crops are ideal for year-round cultivation under protected environment.** Table 2 gives the general classification of crops by photoperiod and Table 3 crop maturity days which are critical information required for staggered vegetable production. However, at variety level, it might differ. Hence, need to understand the varietal characteristics.

Table 2: Classification of crops by photoperiod

Sl. No.	Crop	Photoperiod		
		Short day	Long day	Day neutral
1.	Asparagus			Flowering
2.	Beans (mostly)			Flowering
3.	Brinjal			
4.	Broccoli		Flowering	
5.	Cabbage		Flowering	
6.	Cauliflower		Flowering	
7.	Chilli			Flowering
8.	Chinese cabbage		Flowering	
9.	Cucurbits (mostly)			Flowering
10.	Garlic		Vegetative	
11.	Lettuce		Flowering	
12.	Onion		Bulb formation	
13.	Peas (mostly)		Flowering	Flowering
14.	Potato	Tuber formation		
15.	Radish		Flowering	
16.	Spinach		Flowering	
17.	Tomato			Flowering

Table 3: Duration of crop maturity (days) from date of direct sowing/transplant

Sl. No.	Crops	Days to maturity	Remarks
1.	Beans	50-60	Direct sowing
2.	Bitter gourd	55-60	Direct sowing
3.	Bottle gourd	60-70	Direct sowing
4.	Brinjal	50-70	Transplant
5.	Broccoli	60-80	Transplant
6.	Cabbage	70-120	Transplant
7.	Carrot	80-100	Direct sowing
8.	Cauliflower	70-130	Transplant
9.	Chilli	70-100	Transplant
10.	Chinese Cabbage	60-120	Transplant
11.	Cucumber	70-100	Direct sowing
12.	Garlic	160-170	Direct sowing
13.	Lettuce	50-70	Transplant
14.	Mustard Greens	90-100	Transplant
15.	Okra	65-70	Direct sowing
16.	Onion	160-180	Transplant
17.	Pea	60-100	Direct sowing
18.	Pumpkin	90-115	Direct sowing
19.	Radish	50-80	Direct sowing
20.	Spinach	50-60	Direct sowing
21.	Summer Squash	60-80	Direct sowing
22.	Tomato	70-90	Transplant

3. Crop failure in vegetable cultivation

Failure to develop parts of the crops that are consumed as vegetables is crop failure. For example, failure to develop curd in Cauliflower and Broccoli, head in Cabbage, and failure to develop bulb in onions are few of the examples. It happens when photoperiod and temperature requirement of a crop is not considered. For example, if a cauliflower (that requires low temperature to flower) is planted in summer, it will remain in vegetative phase and fail to form curd. On the contrary, if a heat tolerant Lettuce variety is planted in winter, it will lead to ***bolting*** (premature appearance of flower stems) leading to crop failure. And if the period for bulb formation for long day onion variety falls in winter, then it will fail to form bulb. However, in the field, since bolting is most commonly observed, it is discussed here in detail.

3.1. Bolting

Literally bolting means running away, and in gardening parlance, it means running away or deviating from its normal growth pattern. Technically, it is the premature appearance of flowers/flowering stems leading to unproductiveness. It occurs when:

- Cool season crop is grown in warm season or warm area
- Warm season crop is grown in cool season or cool area
- Heat tolerant variety is grown in cool season or cool area
- Cold tolerant variety is grown in warm season or warm area

3.2. Management of bolting

In the first place, carefully consider **3Ws** (when, where and what variety to plant) to avoid bolting. Once it has occurred, its management is a quite a challenge and may not be effective or economical. However, a few commonly practiced managements are:

- Removing of flowers/flowering stems
- Adding mulch or watering to control temperature

4. Strategy for staggered vegetable production

Vegetable crops, normally as noted earlier, have specific climatic requirements, and hence can grow only in the given place and time. However, it also means that, proper understanding of crop's physiology allows us to exploit it to our advantage like staggered production of vegetable crops through:

- **Capitalization on diverse agro-ecological zones (AEZ):** Bhutan has diverse agro-ecological zones due to wide range of elevations (90 to 7500 m above mean sea level) and mountain orientations (aspects). Given the diverse AEZ, variety of vegetables can be

produced at different times of the year. For instance, since Bhutan imports huge quantity of vegetables in winter, warmer areas can be utilized for production of winter vegetables to substitute imports. In addition, cooler regions have also huge potential to produce vegetables during summer season and export as off-season high value vegetables to India when it is too hot and humid to produce vegetables down there.

- **Adjustment of cropping calendar:** Normal cropping calendar can also be tweaked with the adoption of new varieties. For example, heat tolerant Cauliflower variety can be produced in summer season and short duration Radish variety can be produced in about 40 days as opposed to more than 60 days in the case of conventional variety. Further, these varieties are also useful for adaptation to climate change.

- **Protected cultivation:** Day neutral crops like Chili, Tomato and Cucurbits can be produced round the year as long as there is enough heat. Hence, the promotion of high value crops under greenhouse conditions will generate not only income but also contribute towards vegetables self-sufficiency.

5. Important agronomic practices

Important agronomic practices like spacing, seed rate, production potential and cropping calendar are essential to develop vegetable cultivation as an enterprise. Table 4 gives the details agronomics practices like spacing, seed rate and production potential.

Estimation of number of plants per unit area:

$$Number\ of\ plants = \frac{Total\ area\ (sq.m)}{Row\ spacing\ (m) \times Plant\ spacing(m)}$$

If the dimension of the field is known, use the following equation, which is more accurate:

$$Number\ of\ plants = \frac{(L + R) \times (B + P)}{R \times P}$$

Where, *L*= length of the field in meter; *B* = breadth of the field in meter; *R*= row spacing in meter and *P* = plant spacing in meter.

Calculation of seed rate per unit area:

$$Seed\ rate\ (kg\ per\ acre) = \frac{nP}{nS \times pG}$$

Where, *nP* = number of plants per acre; *nS* = number of seeds per kg and *pG* = expected germination percentage of the given seeds.

Table 4: Spacing, seed rate and yield of common vegetables

Crops	Spacing (cm)		Seed rate (gm)	Yield (tons/acre)
	Row to row	Plant to plant		
Asparagus*	90	30	800	1-2
Beans	60	30	12000	2-4
Bitter gourd	100	50	1900	3-6
Bottle gourd	120	60	1800	6-8
Brinjal	45	30	160	8-10
Broccoli	50	45	140	4-6
Cabbage	50	45	140	10-14
Carrot	30	7	470	8-10
Cauliflower	50	45	100	7-10
Chili	50	50	150	2-4
Chinese Cabbage	50	45	90	10-15
Cucumber	100	50	330	3-4
Garlic	30	15	280000	2-4
Lettuce	45	30	60	3-4
Mustard Greens	50	45	50	9-14
Okra	45	30	3000	4-5
Onion	20	15	500	8-10
Peas	50	30	14000	1-2
Pumpkin	200	100	600	2-4
Radish	30	15	2800	6-15
Spinach	20	20	2300	3-4
Summer Squash	100	60	2200	6-8
Tomato	50	45	80	6-9

*if the seedlings are planted instead of seeds, about 15,000 seedlings are required per acre.

6. Cropping calendar

Cropping calendar is based on the elevation. As mentioned before, given our complex geographic features, cropping season may need to be adjusted based on the micro-climate of the given area. For identification of zones in the respective Dzongkhags, refer the maps in the annexure.

Table 5: Cropping calendar based on elevation for vegetables

Sl. No.	Crops	Planting season by zones			
		Zone I (Below 600 m)	Zone II (600 to 1400 m)	Zone III (1400 to 1800 m)	Zone IV (1800 to 2700 m)
1.	Beans	August to November	February to April	April to August	April to July
2.	Bitter gourd	February to April	March to May	March to April	June to July
3.	Bottle gourd	February to April	March to May	March to April	June to July
4.	Brinjal	September to October	March to April	April to May	June to July
5.	Broccoli	October to November	October to November	September to October	August to September
6.	Cabbage	August to October	September to October	June to October	May to October
7.	Carrot	October to November	August to September	May to September	April to August
8.	Cauliflower	October to November	September to October	July to August	July to October
9.	Chilli	August to October	February to March	April to May	May to June
10.	Chinese Cabbage	September to November	September to October	September to October	August to September
11.	Cucumber	February to May	March to April	April to May	June to July
12.	Garlic	October to November	September to November	August to September	July to August
13.	Lettuce	October to November	October to November	August to September	July to August
14.	Mustard Greens	October to November	September to October	July to September	May to August
15.	Okra	February to March	March to June	April to May	May to June
16.	Onion	November to December	November to December	October to November	September to October
17.	Pea	November to December	October to November	September to October	July to August
18.	Pumpkin	February to April	March to April	March to April	May to June
19.	Radish	September to October	August to September	July to September	May to August
20.	Spinach	October to November	September to October	August to September	July to September
21.	Summer Squash	February to May	February to March	March to April	May to June
22.	Tomato	September to October	February to March	March to April	May to June

7. References

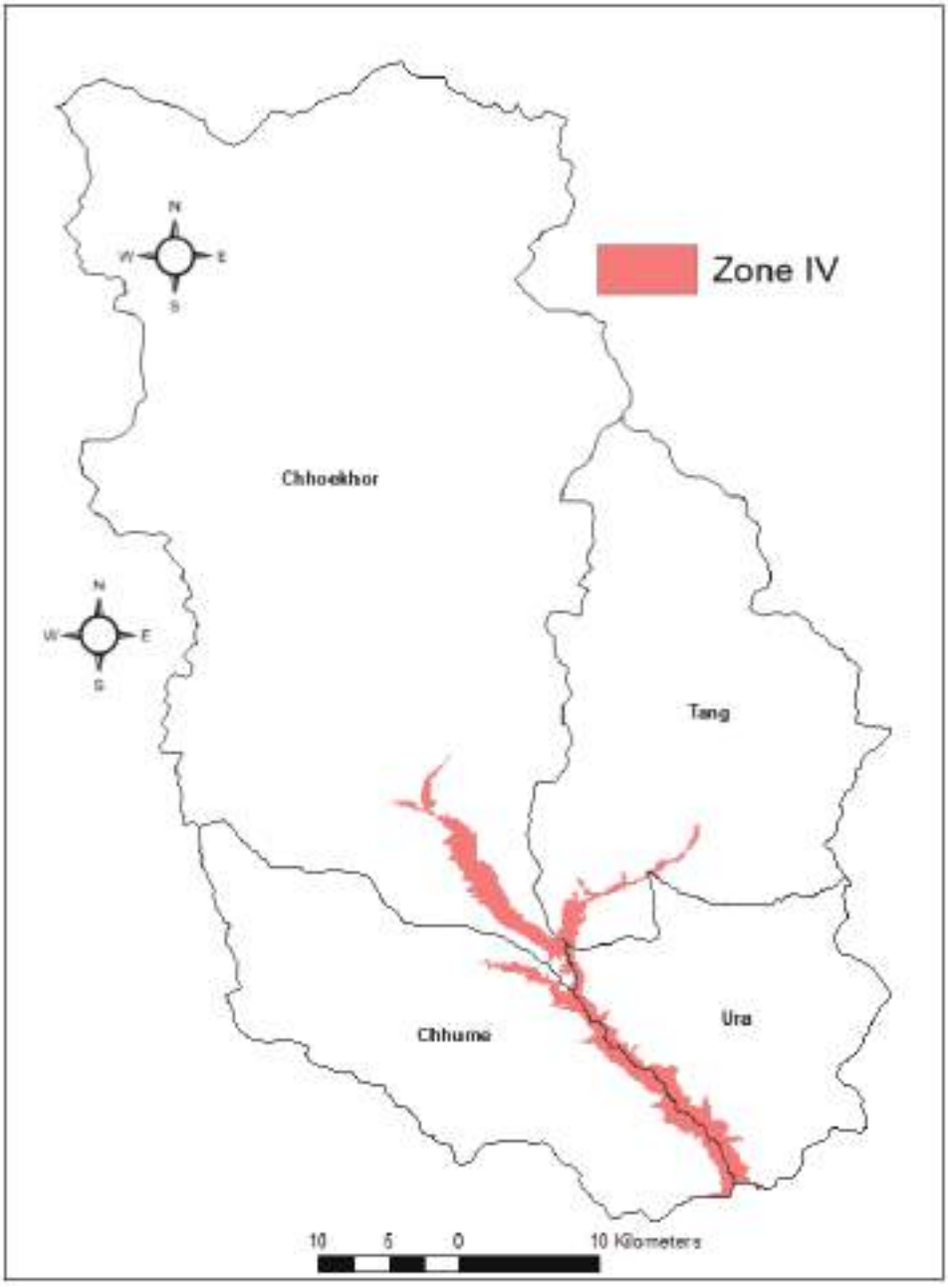
ARDC Wengkhar. (2017). *Staggered Vegetable Production Manual*. Mongar

ARDC Wengkhar. (2017). Important Guidelines for Vegetable Cultivation. RNR Extension Material 2017-2018

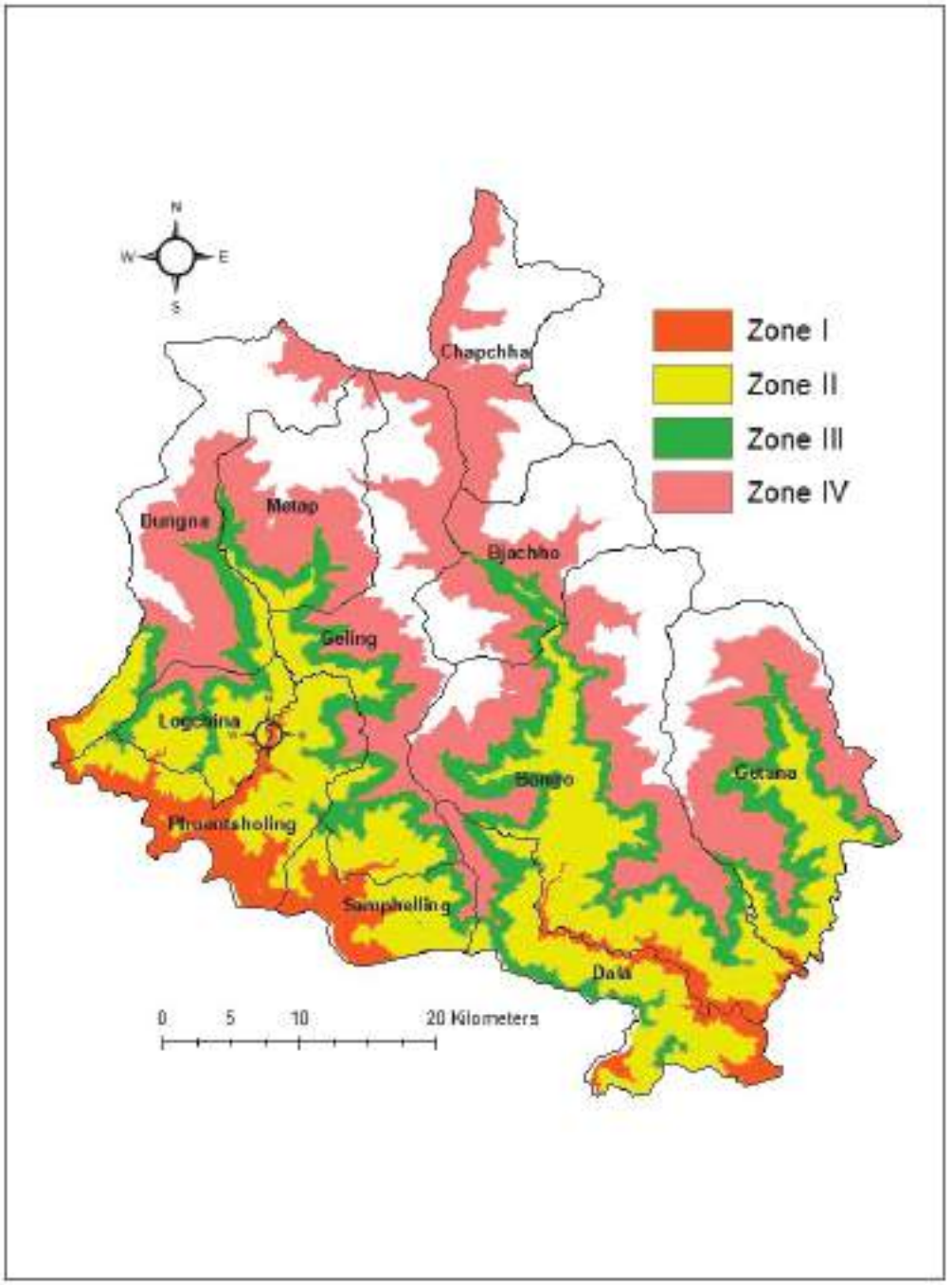
AVRDC. (1991). *Vegetables Production Training Manual.* Tainan: AVRDC.

8. Annexure

Annexure 1: Vegetable Growing Zone, Bumthang Dzongkhag



Annexure 2: Vegetable Growing Zone, Chukha Dzongkhag



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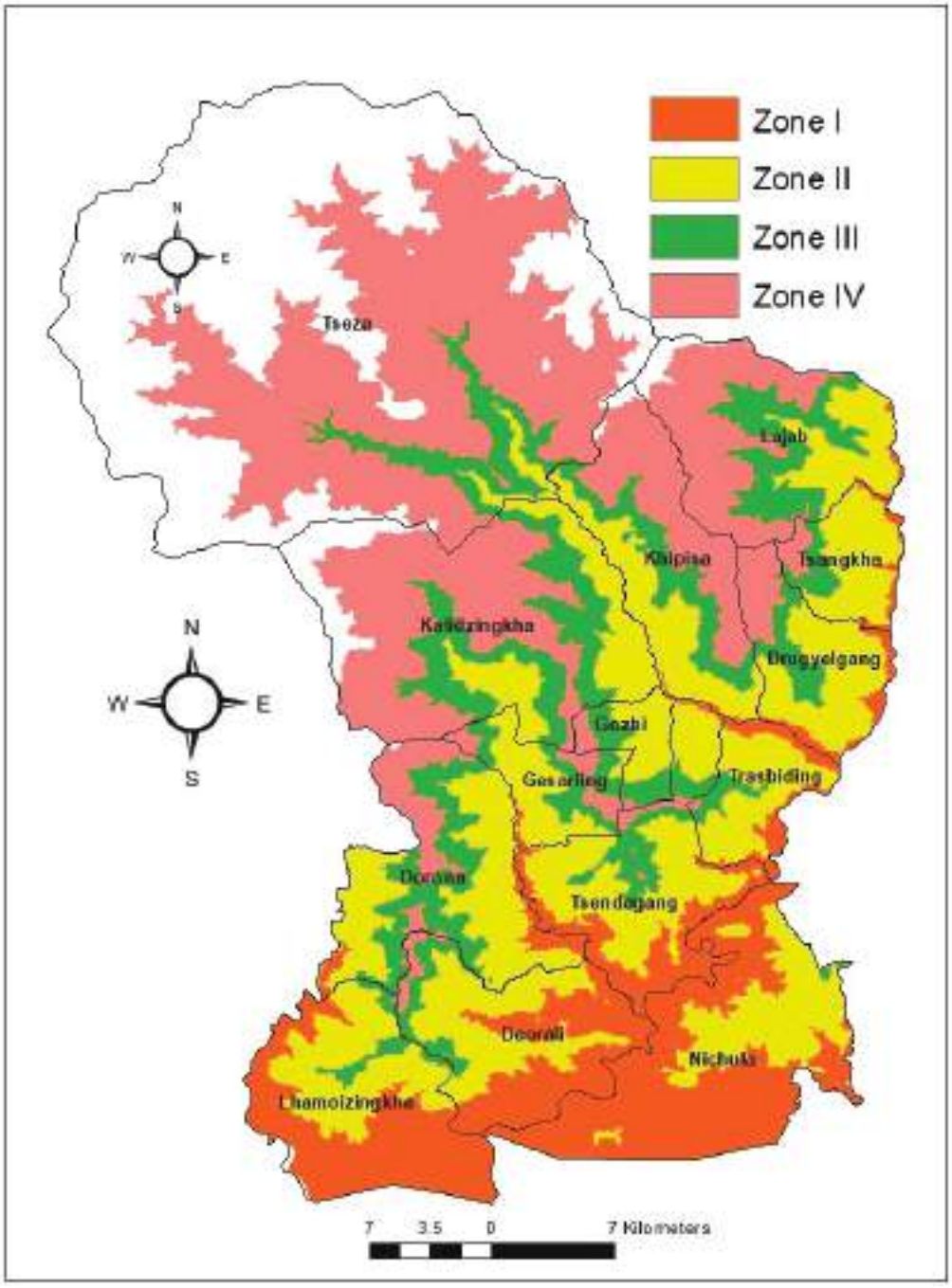

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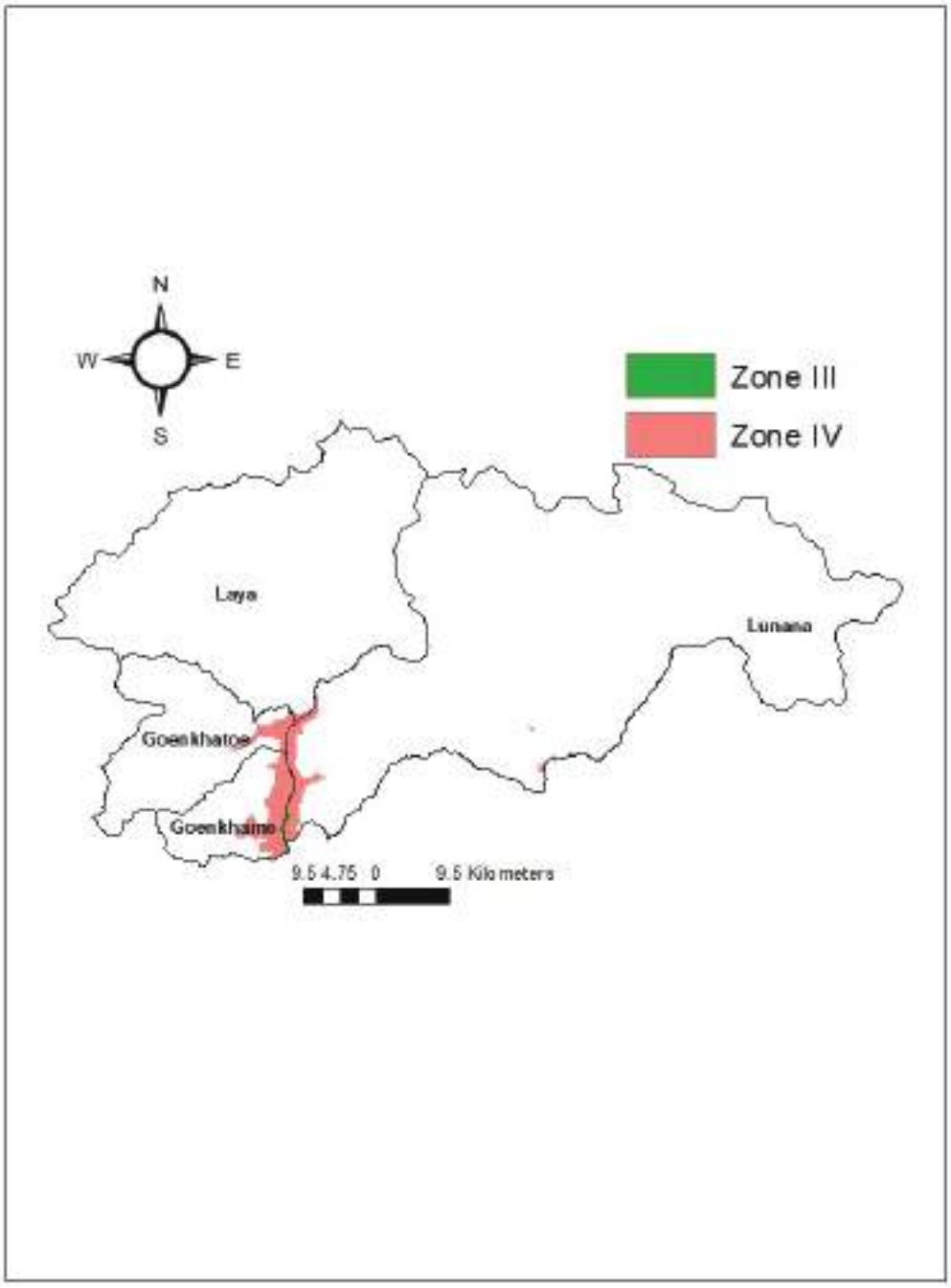
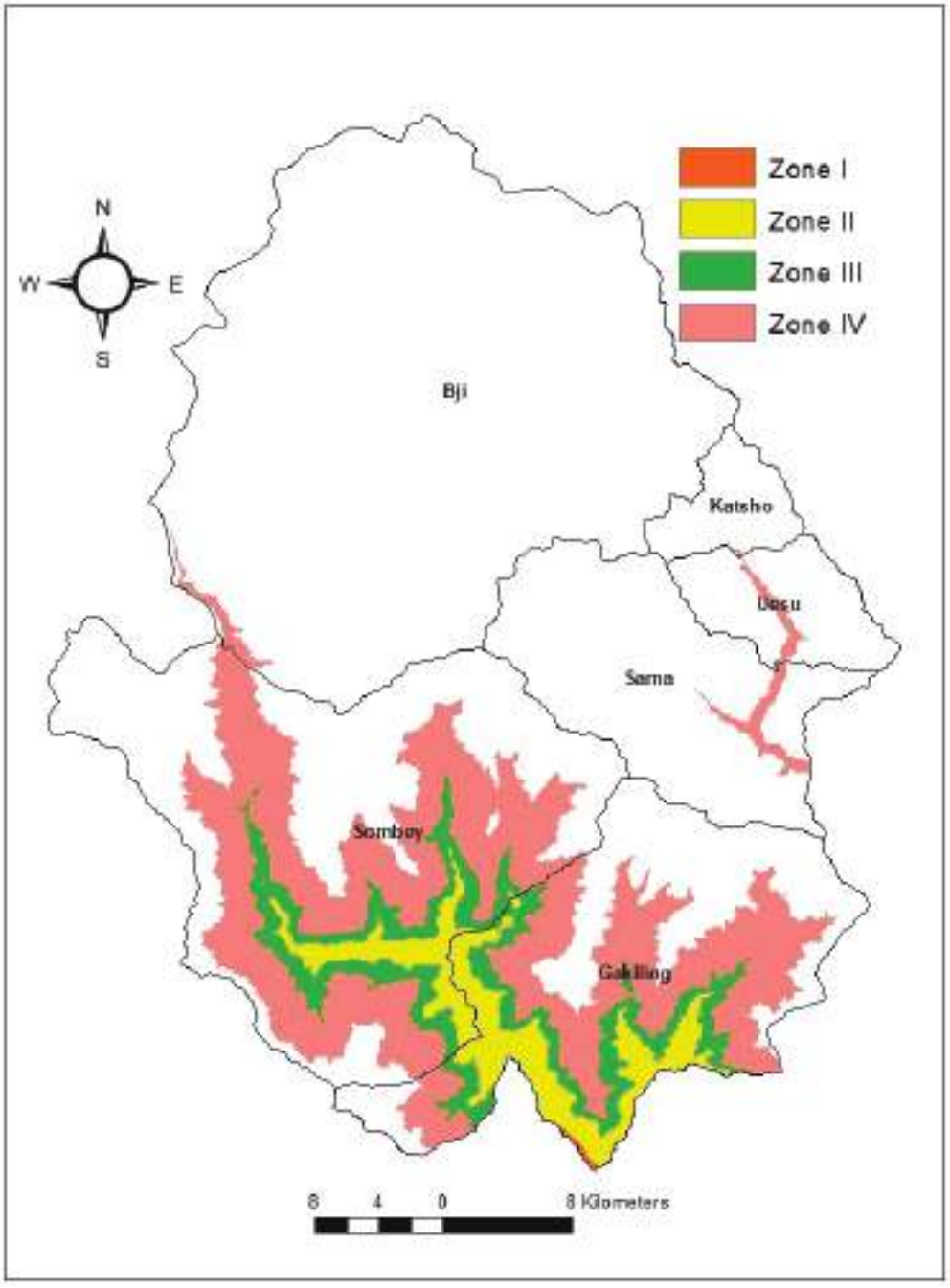
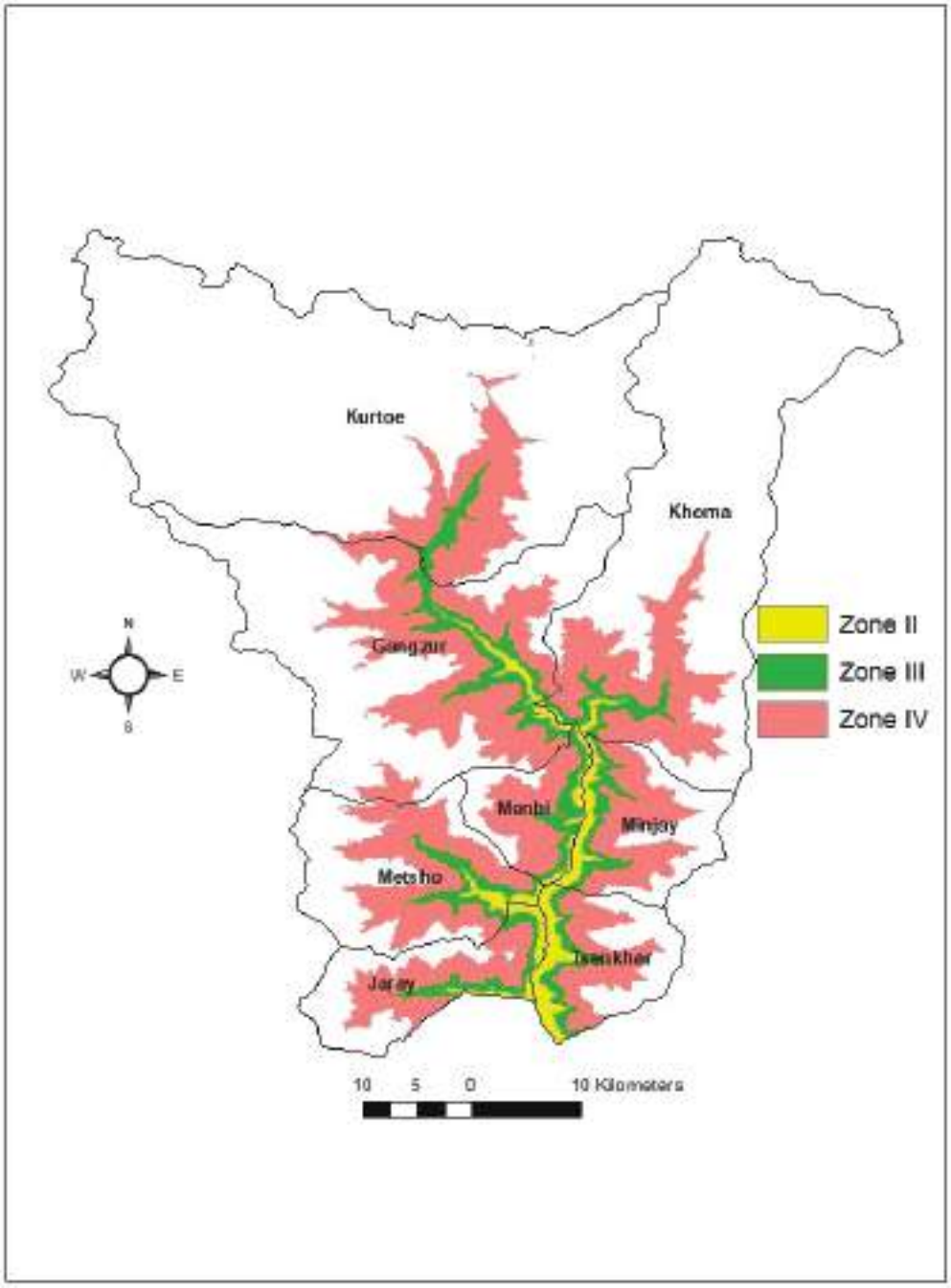


Annexure 6: Vegetable Growing Zone, Haa Dzongkhag



Annexure 7: Vegetable Growing Zone, Lhuentse Dzongkhag



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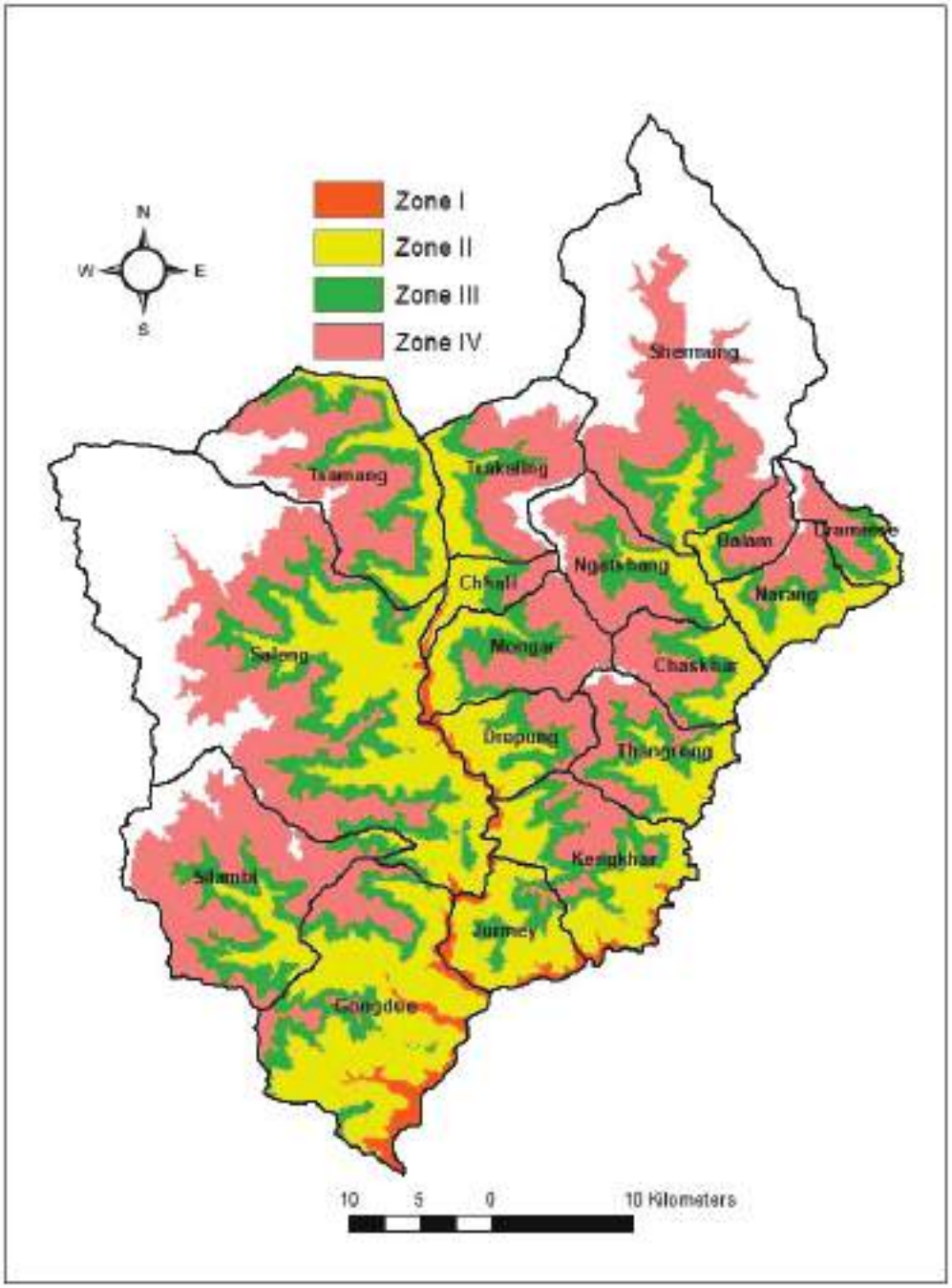

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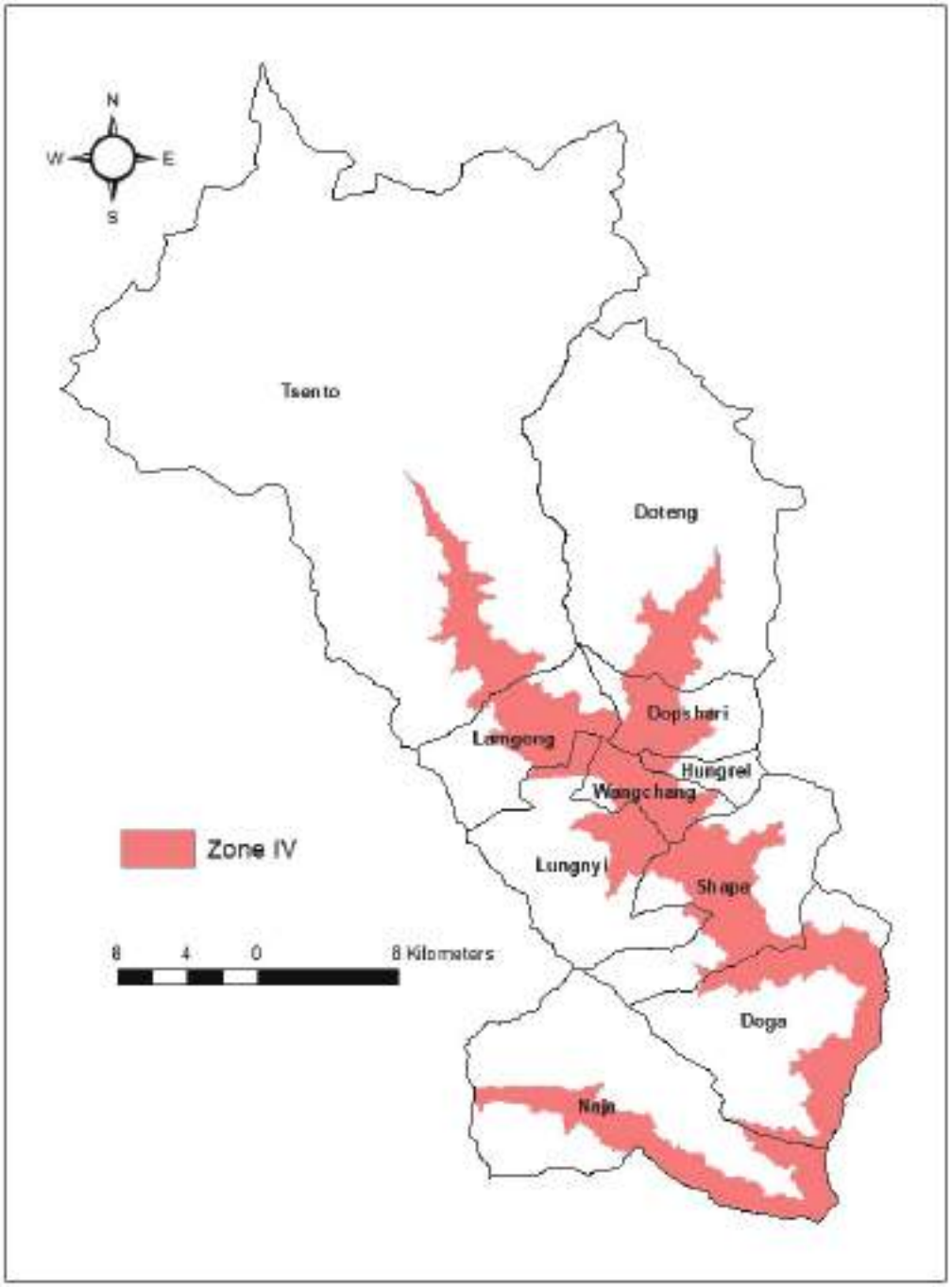

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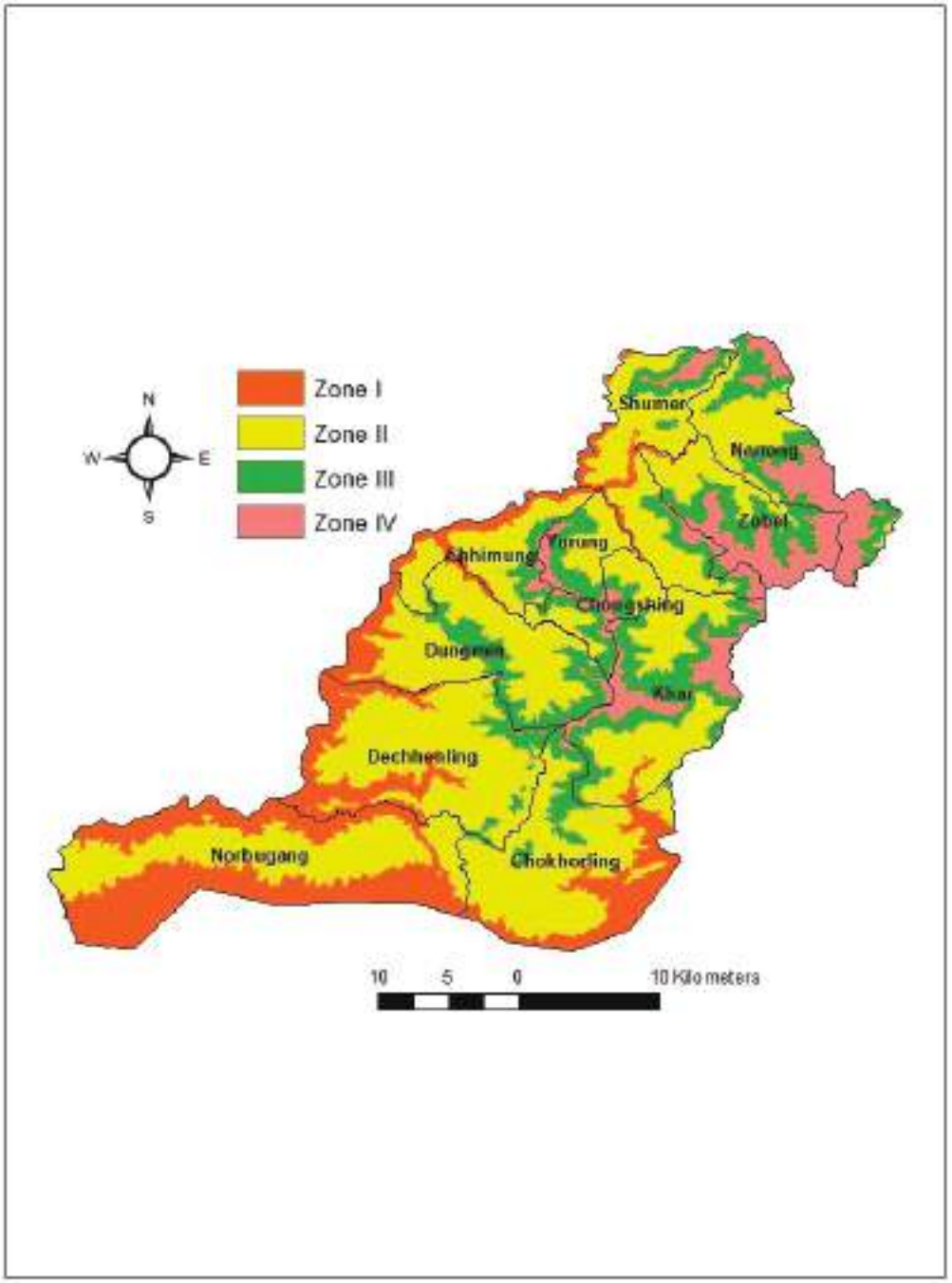

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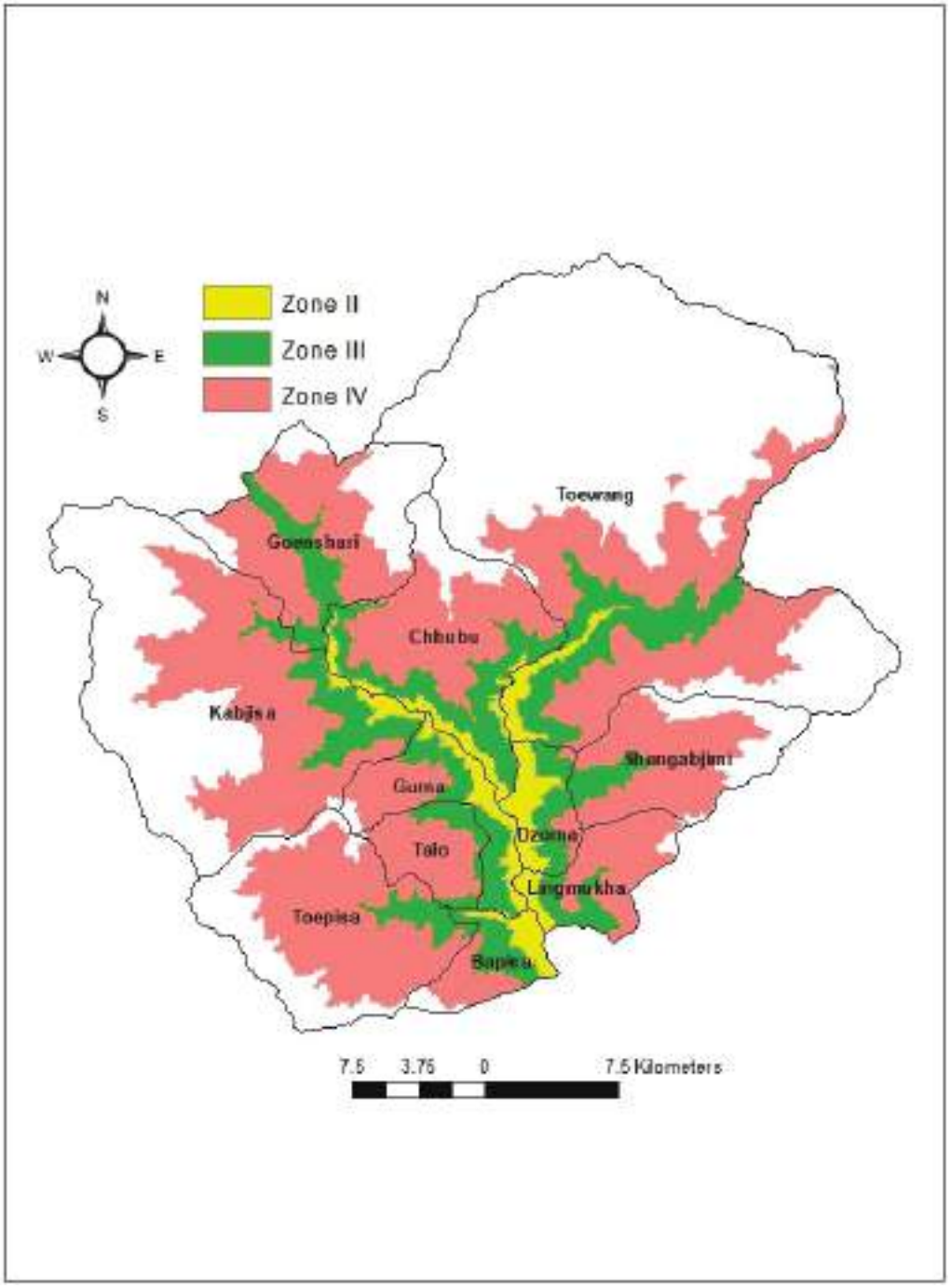

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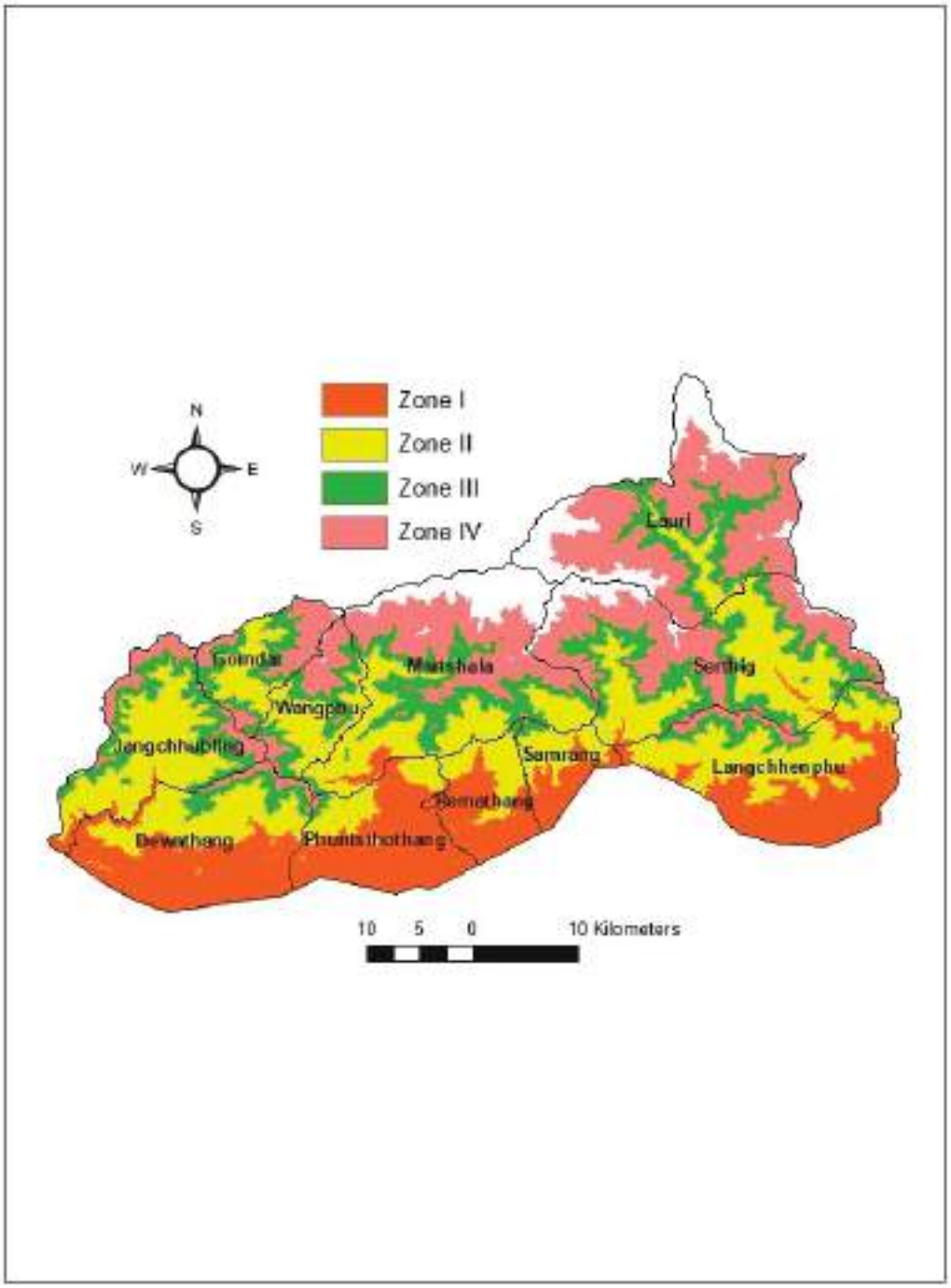

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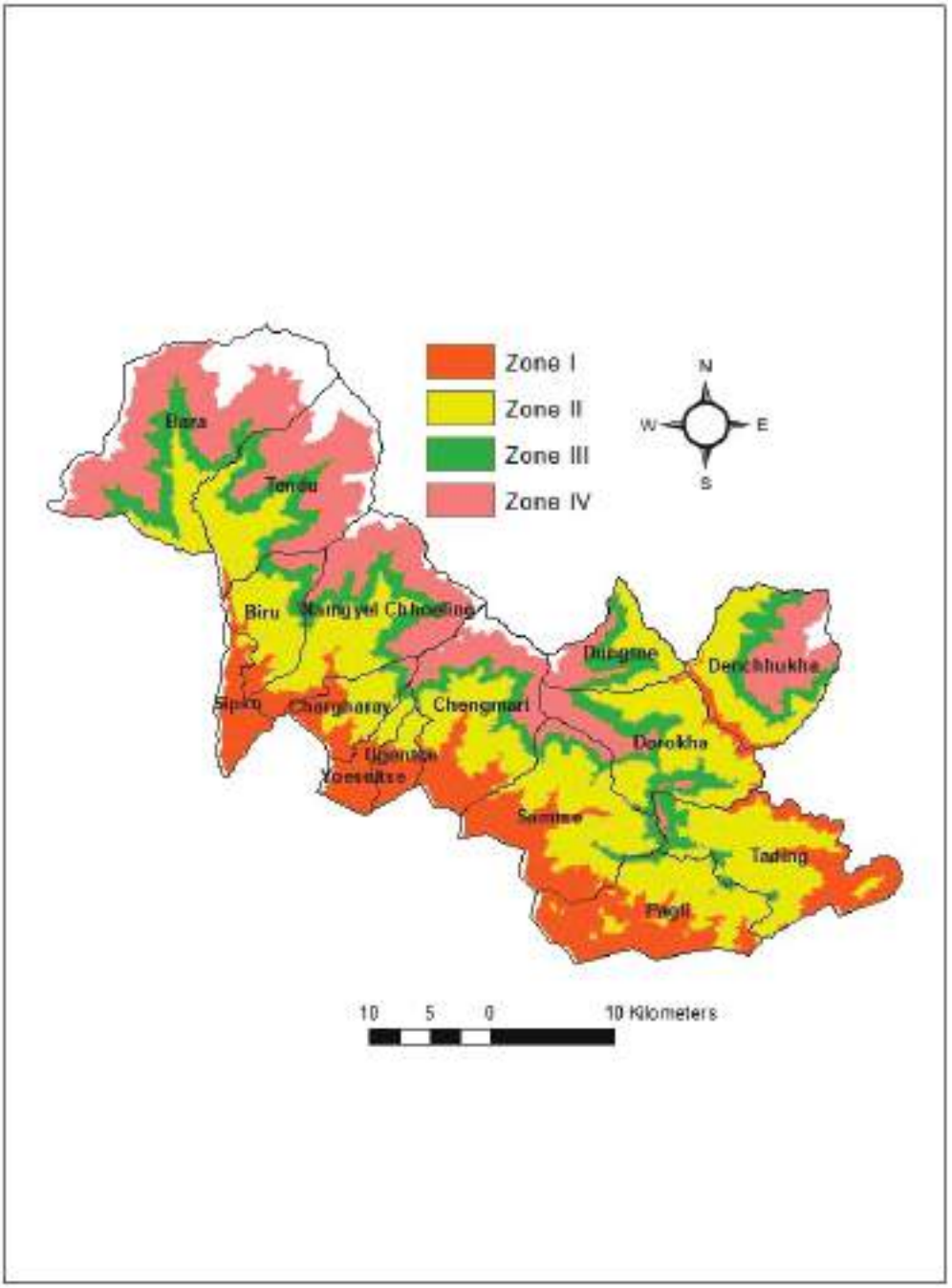

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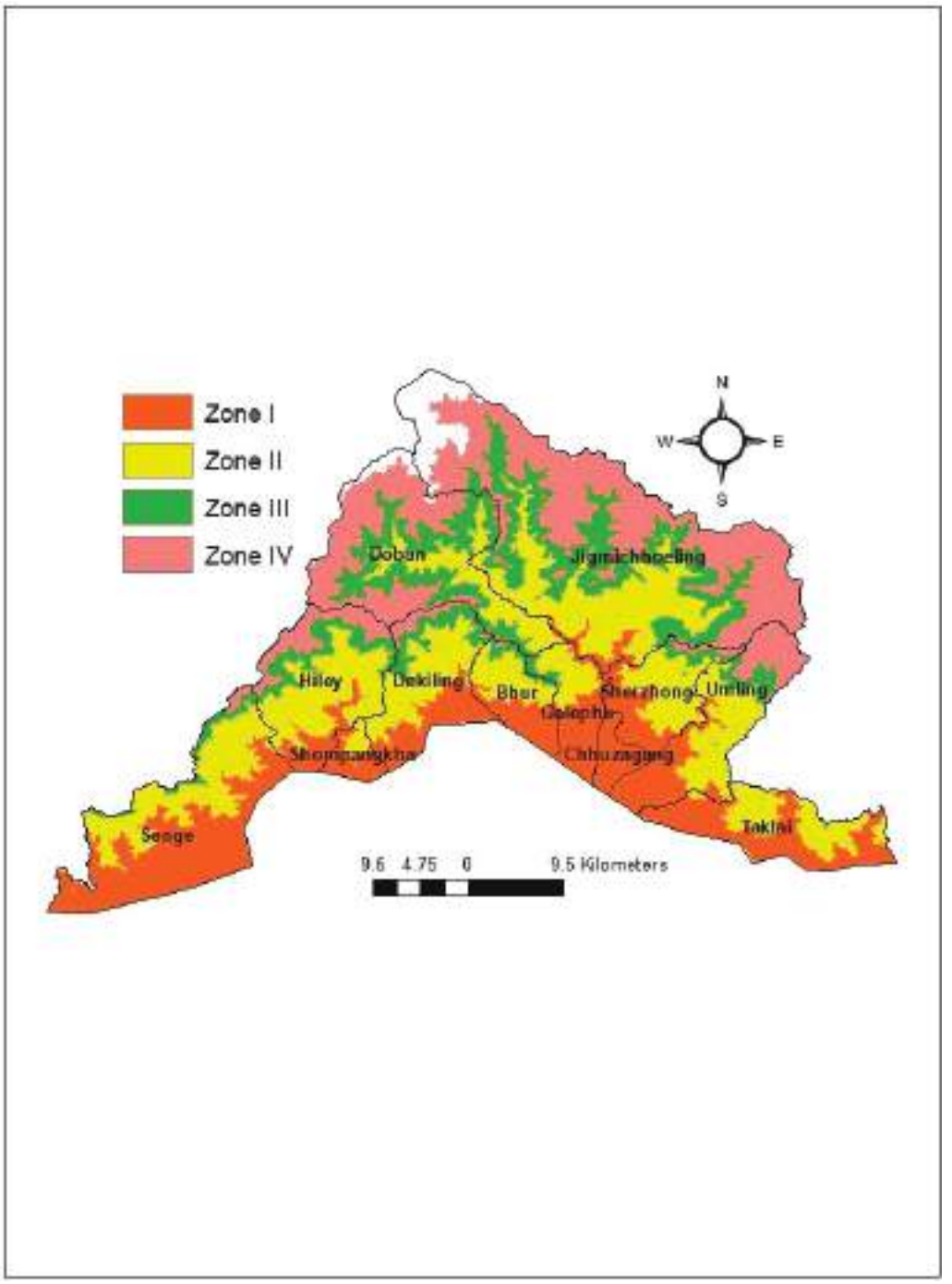

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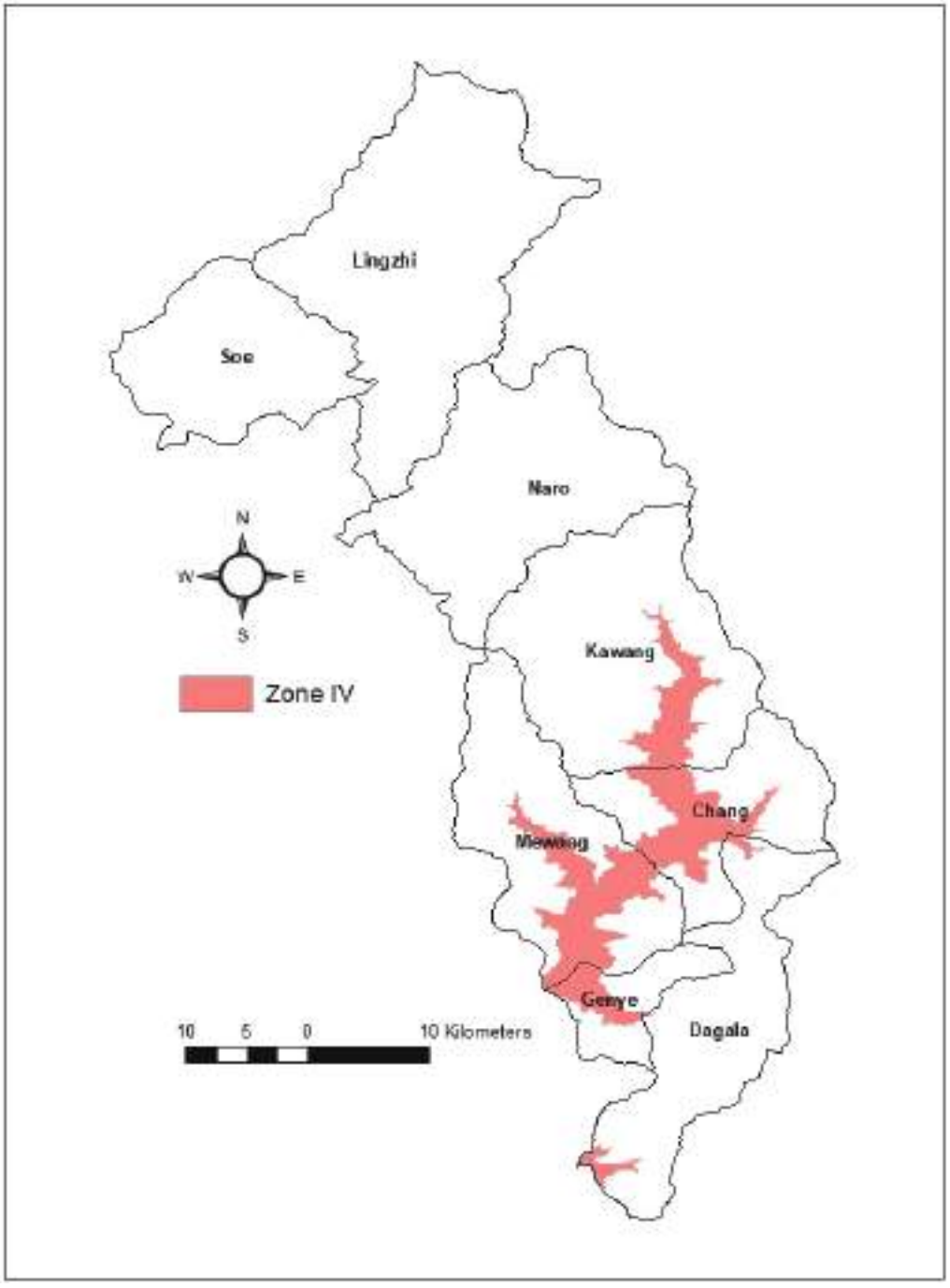

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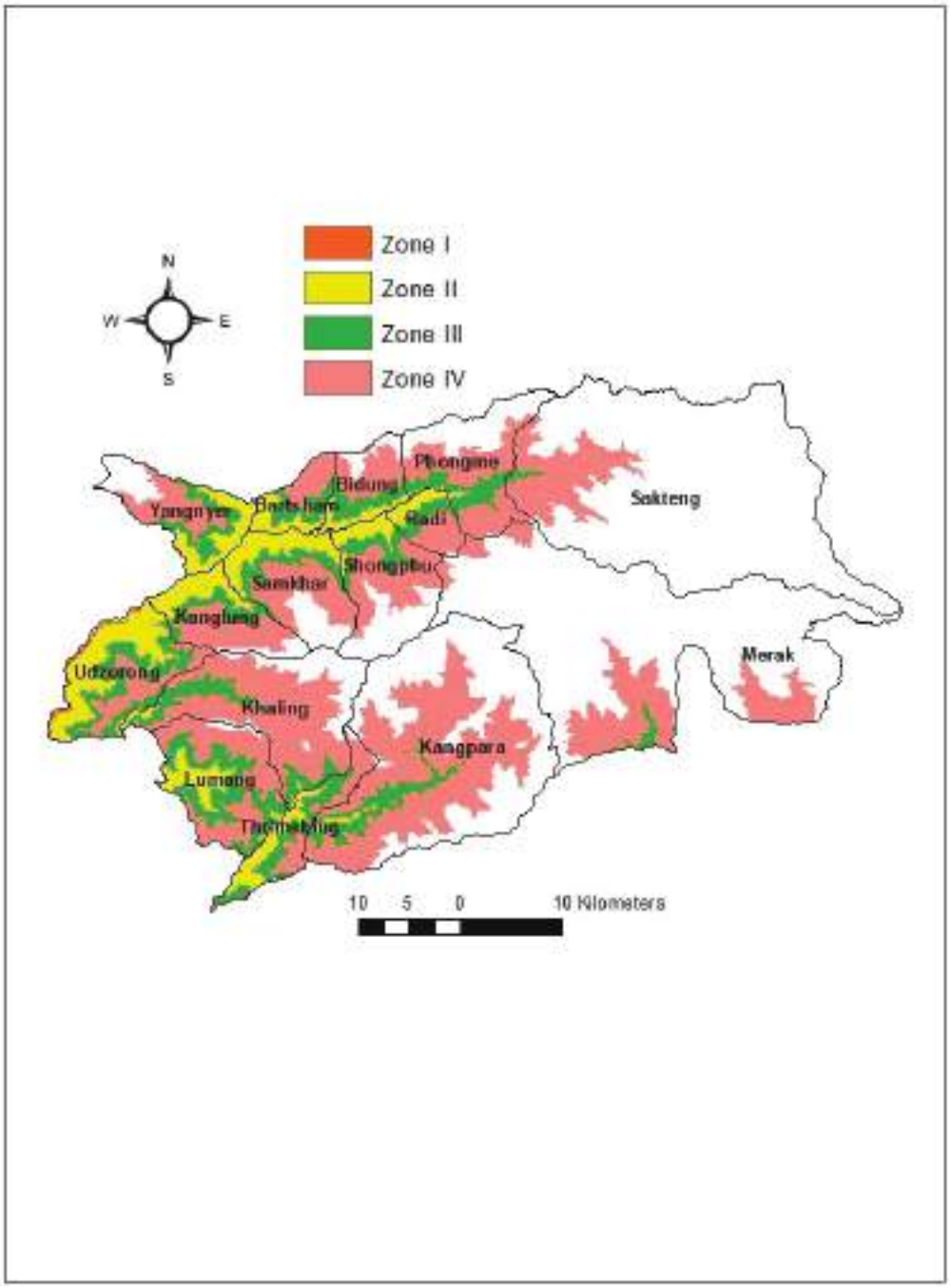

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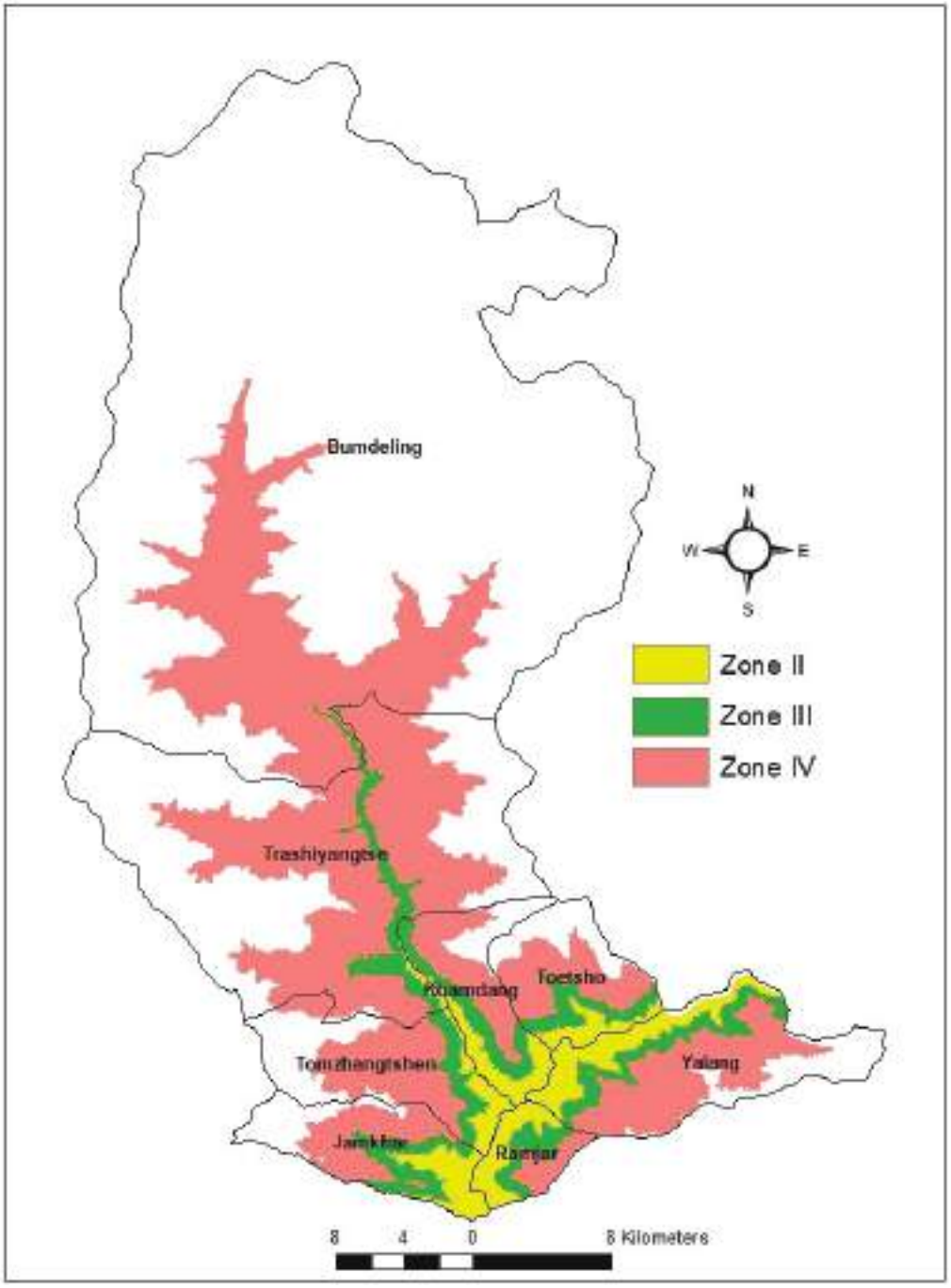

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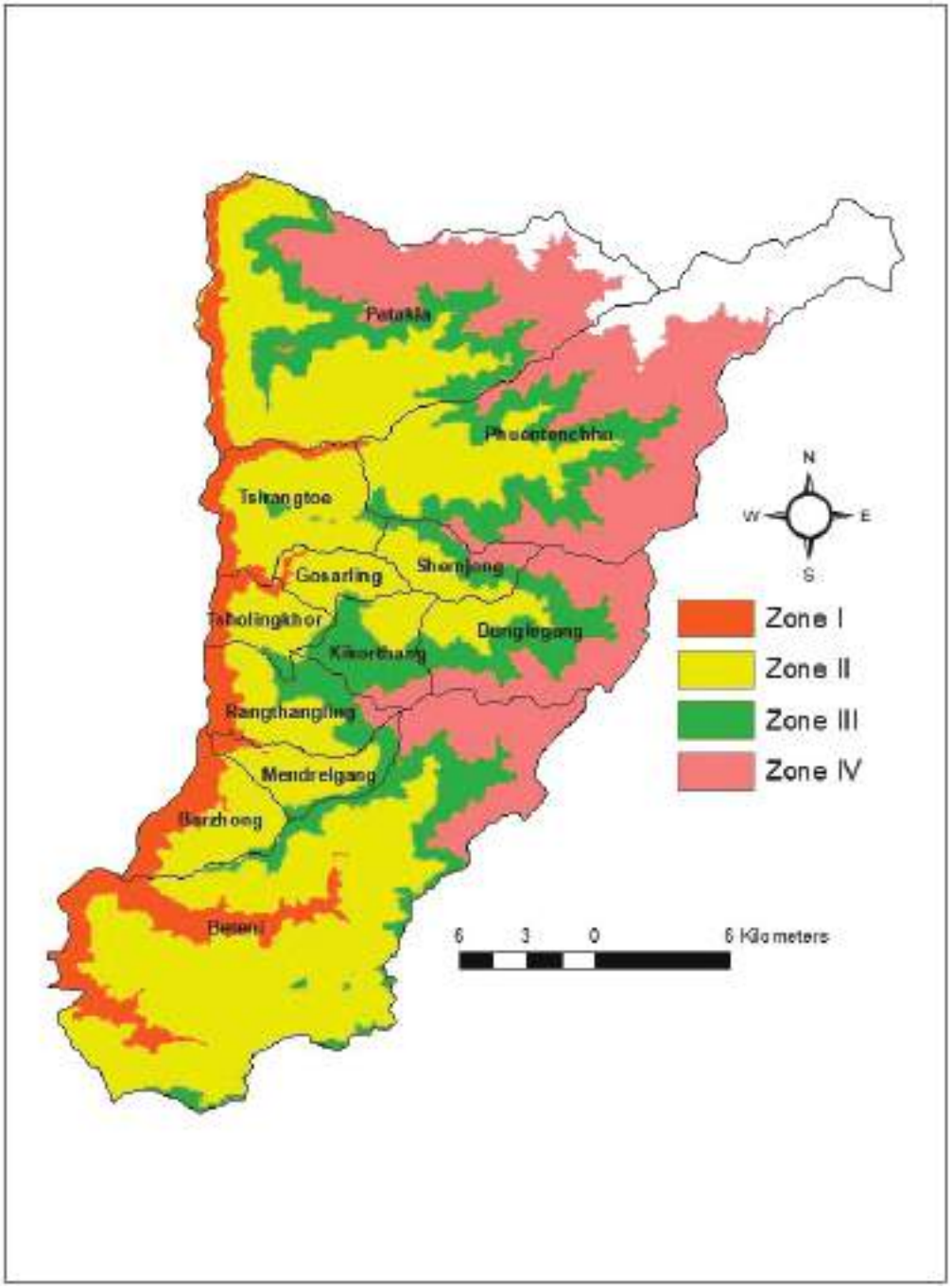

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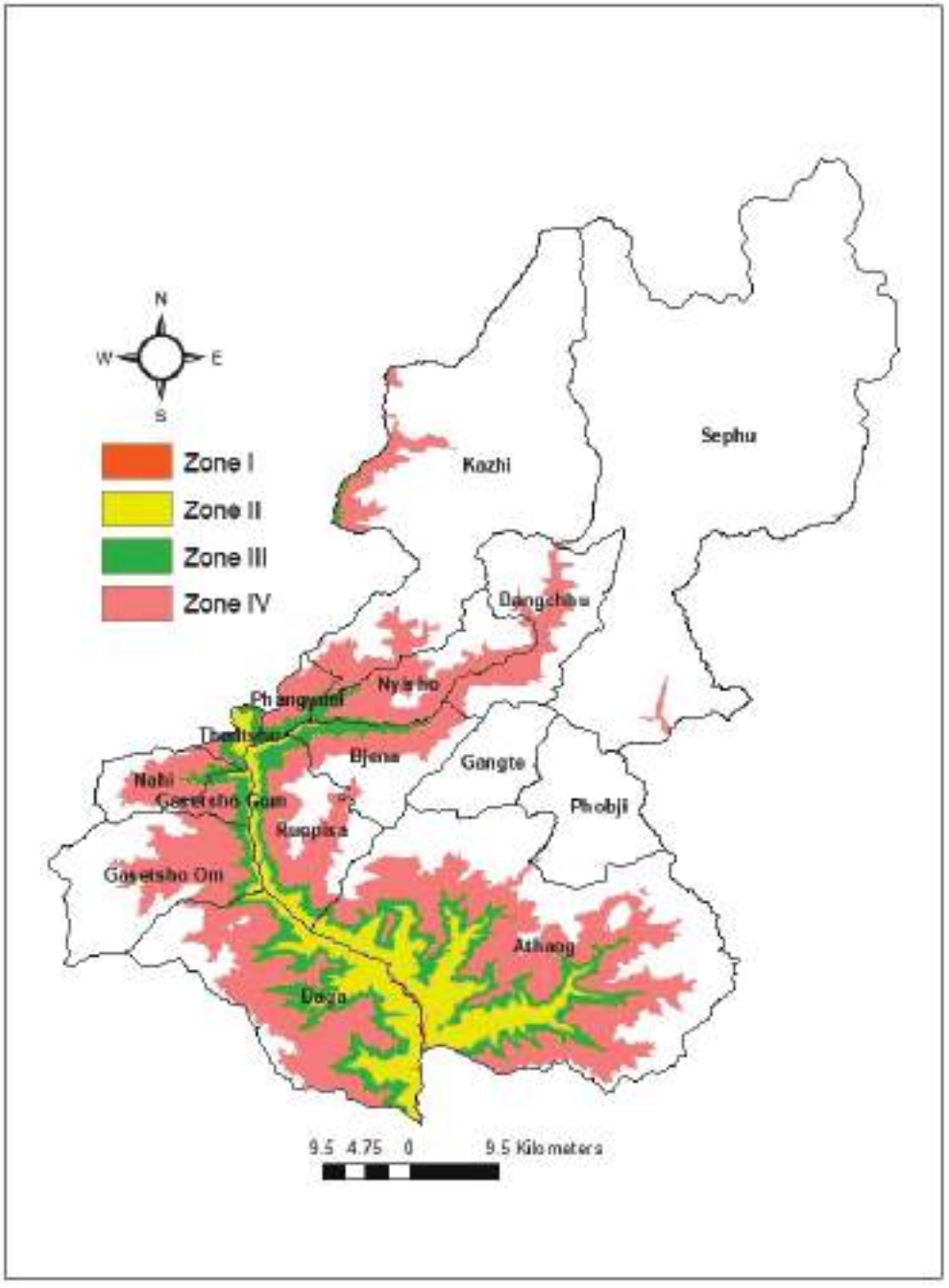
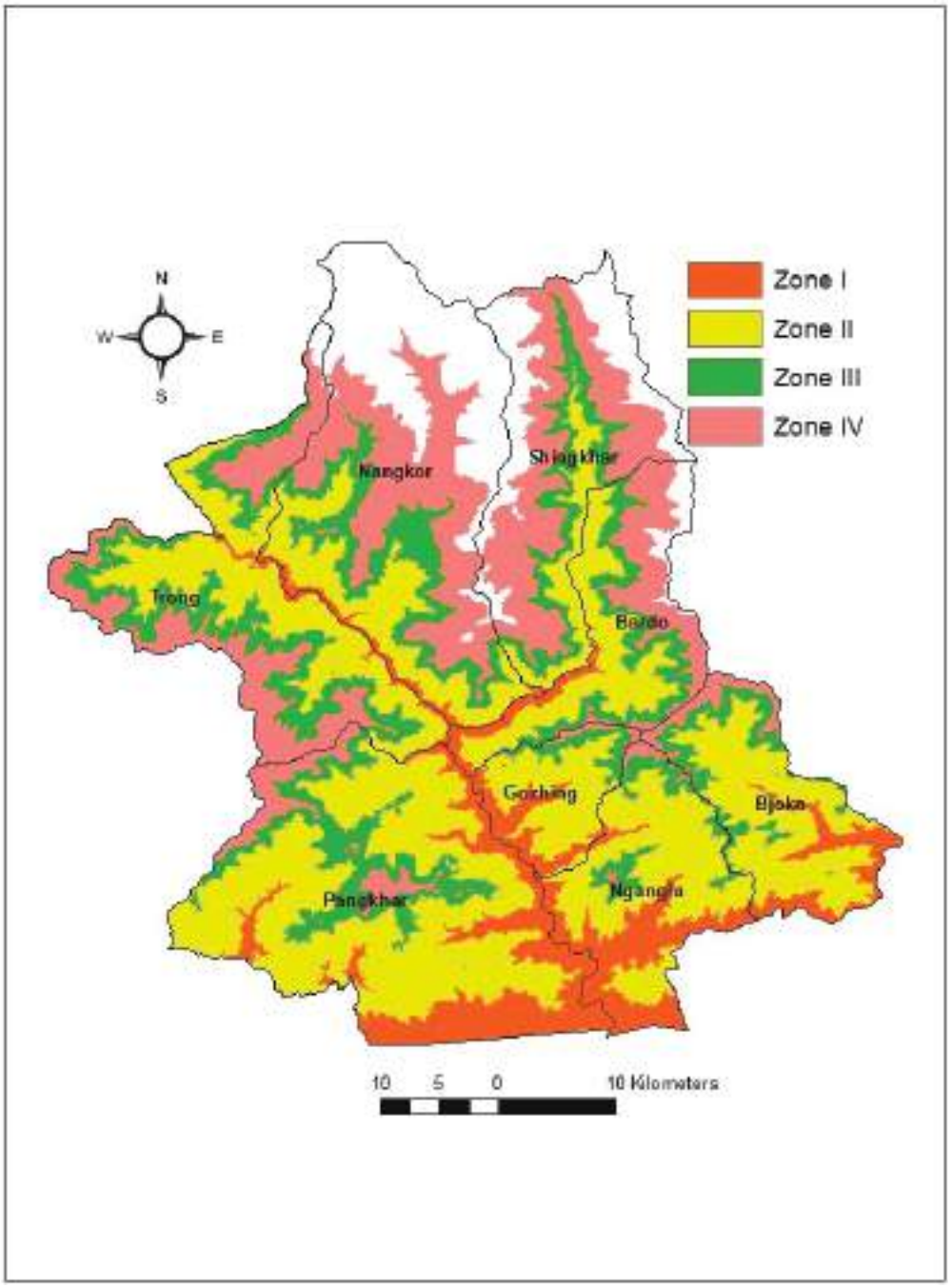


Annexure 20: Vegetable Growing Zone, Zhemgang Dzongkhag



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