

Assessment of Yam (*Dioscorea* spp.) Diversity at Community Level in Nangkor Gewog under Zhemgang Dzongkhag

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Abstract

Yam (*Dioscorea* spp.) is an annual or perennial climbing plant with edible underground tuber. It includes 600 species of which 50 to 60 are cultivated, or at least gathered, for food or pharmaceutical purposes. There are however only 10 species for human consumption and economically significant. In Bhutan, yam plays an integral part in socio-economic and cultural aspects. However, there is limited information on yam diversity in Bhutan. Therefore, this study aimed to *assess domestic and wild yam species diversity*, its socio-cultural importance to the communities and its contribution towards food security.

The study was carried out in Nangkor gewog under Zhemgang dzongkhag. A total of 75 households were randomly selected from 308 households. Data was collected using semi-structured questionnaire, which comprised of both closed and open ended questions and were analyzed using descriptive statistical analyses in SPSS version 16.1

The survey found five species, which are water yam (*Dioscorea alata* L.), lesser yam (*Dioscorea esculenta*), white yam (*Dioscorea rotundata*), aerial potato yam (*Dioscorea bulbifera*) and yellow yam (*Dioscorea cayenensis*) in the gewog. *D. esculenta* and *D. alata* are the most commonly preferred species by the

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communities in terms of taste and nutritional value. The study found that yam has vital roles in the socio-cultural events and are indispensable during Prechula (Offering to local deity), Lochoe (annual ritual) and Losar (new events of year).

It was found that some of the respondents face 2-3 months of food shortage and one measure to cope with it is through collection of wild yams and tubers. Yams and tubers contribute 19% to food security although there is a gradual decline in utilization of this crop with the pace of socio-economic development. The availability trends in the wild are perceived to be decreasing by the respondents. The main causes perceived by 42% of the respondents is due to unsustainable harvesting practices, 38% due to increasing wild boar population and 20% with increase in human population leading encroachment of forest for development activities. Thus, it is necessary to have appropriate conservation strategies to maintain the species diversity in order to derive long term benefit.

Background

Yam belongs to the family *Dioscoreaceae* and the genus *Dioscorea*. It is an annual or perennial climbing plant with edible underground tuber. It is native to warmer regions of both southern and northern hemispheres. This genus includes about 600 species of which 50 to 60 are cultivated, or at least gathered, for food or pharmaceutical purposes (Norman, Pearson and Searle 1995). According to Nascimento *et al.* (2013) there are however only 10 species for human consumption and economically significant. Among those useful edible species, white yam (*Dioscorea rotundata*), yellow yam (*Dioscorea cayenensis*) and water yam (*Dioscorea alata*) are most economically important species in yam growing regions of Africa and in most part of the world (Vernier 1998). Further, amongst those economically important species, water yam (*Dioscorea alata*) is most widely distributed species globally (Mignouna and Dansi 2003).

Yams are widely distributed and found in tropical, subtropical and temperate regions of the world. It is the second important tuber crop in many parts of the world, especially Africa, after

cassava, and is extremely important to food security in regions of Southeast Asia and Pacific, as well as the tropical Americas (Okigbo and Ogbonnaya 2006). Yam is nutritious, comprising of 15-23% starch, 1-2.5% protein, 0.05-0.2% fat and other essential nutrients. In Africa and many tropical countries, the yams are staple food and major sources of income and have vital socio-cultural and culinary roles (Chukwu and Ikwelle 2000). The trends of consumer demand for yam are generally very high in this sub-region and yam cultivation is very profitable despite high production costs.

Worldwide yam production in 2011 amounted to 55 million tons grown on about 5 million hectares of land in about 47 countries in the tropical and subtropical regions of the world, of which Africa is the leading world producer with 94% of global production (FAO 2012). As per IITA (2009), the most of the world's production comes from West Africa representing 94%, with Nigeria alone producing 71%, equaling more than 37 million tons. Although yam cultivation is rising especially in Africa, but yield per unit area are declining due to increased land pressure associated with declining soil fertility and an increase in pest and disease levels (Tchabi *et al.* 2010).

The planet's biodiversity is important to human beings in many ways. Human beings are wholly reliant on the biodiversity for its potential resources for food, medicine, energy, industrial materials, building materials, vital services such as renewing the earth's atmosphere, absorbing pollutants and maintaining soil fertility (Okojie 1997). Similarly, traditional communities across the globe practice intense yam cultivation and consumption; this system provides a favorable environment for the generation and maintenance of genetic diversity of this crop (Nascimento *et al.* 2013). However, on other hand the socio-economic pressures faced by farmers or growers over the years have caused the loss of plant genetic resources, specifically yam crop (*Dioscorea spp*), and biodiversity losses can be severe and irreversible. Further, in most part of the world including African countries, where yam is currently grown, many potentially important varieties only exist in fields and there is a risk that diversity in species will disappear, destroyed

by conflicts of pressure on natural resources or natural disaster (Ezebuoro *et al.* 2012).

To tackle this challenge, farmers and crop scientists worldwide are engaged in a new effort to add 3,000 yam samples to international gene banks in IITA in Nigeria with the aim of saving the crop diversity that is consumed by 300 million people according to an announcement from the Global Crop Diversity Trust. Other international efforts include, United Nations Foundation and Bill and Melinda Gates Foundation (UNFBMGF) in supporting the global initiative to preserve yam biodiversity.

Bhutan has rich agro-biological diversity that has regional and global importance in the diverse ecosystems and ecological zones. Agro-biodiversity component includes agricultural and horticultural plants, such as cereal crops, vegetables, fruits and nuts that are native to Bhutan or introduced to Bhutan long time ago that they have developed unique genetic, morphological and ecological characteristics (NBC 2008).

Among the availability of rich diversity of high value agricultural and horticultural plants, diverse species of yams which has varied ecological and socio-economic importance exist across the country both in wild and domestic. Predominantly wild yam are used mostly for both household needs and sale in small quantities for additional source of household income, but some valuable species are also domesticated for subsistence and commercial use at household level. From time immemorial, yam is considered as the important means of supplementing food shortages and sources of nutrition for major remote populace. Such observations was further reported by Turkelboom *et al.* (2001), which states that the subsistence agriculture is often not sufficient to satisfy the food needs of the households. As the forest resources are in abundance and easily accessible, many farmers go to collect forest foods, such as wild yams, ferns, mushrooms and bamboo shoots. Recently, Dorji (2012) reported that the communities are indigenous user of wild foods such as yams and rely on it as supplementary food for 4-5 months from May-June to September when other staple food grains are deprived in most of the eastern part of Bhutan.

Yam crop plays an important socio-cultural and religious value in different parts of country, especially in southern and east central region. Also in Bhutan the study conducted by (Ngawang n.d) reported that wild yam species such as *Dioscorea bulbifera* and *Dioscorea deltoids* that has medicinal values are domesticated and cultivated in small scale in southern part of Bhutan.

In view of above, the objective of the study is to assess the diversity of yams at local level and to evaluate socio-cultural and economic importance towards the community. This will enable to have baseline data for development of conservation strategies programs in assuring diversity of crop's future and to carry out further research studies.

The study site was identified at Nangkor gewog under Zhemgang dzongkhag, in the view of the gewog having favourable diverse agro-ecological features for the existence of diverse species of yam. It was also reported that yam has a vital role in terms of both socio-economic and cultural life of the communities in the gewog.

Objectives

- To assess the domestic and wild yam species diversity in the gewog and their agro-ecological distribution.
- Evaluate the contribution towards food security and socio-cultural importance to the communities.

Research questions

In order to fulfill the above objectives, following questions was considered as the guidelines for the research study.

- Which species of yams (both cultivated and wild) are found within the locality and their trends of availability?
- What are the contributions of yam in Kheng community?

Materials and methods

The study was conducted in Nangkor gewog under Zhemgang dzongkhag which lies in the central and northern part of the dzongkhag and has an area of 493.8 km². The altitude ranges

from 1000 to 1800 meters above sea level. The survey was carried out in all the 10 villages considering the representation of various age group and gender as to assure to get quality data.

Sample size of 75 household for the survey was determined by using Yamane formula with 10% margin error level from 308 households. Sample households were randomly selected by using simple random sampling method of probability sampling techniques. Equal proportion of households' representation from villages was considered by taking 10% sample households through lottery system.

Semi-structured questionnaire comprising both closed and open questions were used to elicit information from farmers. Data collected include yam diversity, its distribution, farmer's preferred species, agronomic characteristics, culinary uses and socio-cultural and economic characteristics of yam species within their localities.

Field sample of yam species were identified by visiting the field or by collecting the samples with help of localities. Further the samples were identified by referring available resources and consultations of relevant resourceful persons.

Descriptive statistics analysis of SPSS version 16 was used to analyze the data and MS Excel spread sheet was used to generate the graphs and tables.

Results and discussion

Yam species diversity in communities

Among 10 edible species (Uwasomba *et al.* 2012), five species of yams named locally as Dawalaki (*D. alata* L.), Chormola (*D. esculenta*), Phurbaiki (*D. rotundata*), Siktum (*D. bulbifera*) and Kachimaki (*D. cayenensis*) are found and consumed by the communities in the gewog as shown in Table 1.

Table 1. Yam species diversity in Nangkor gewog

Local name	Botanical name	Morphological characteristics	Plates
Dawalaki	<i>D. alata</i> L.	Vigorous and bushy vine with dense foliage. Tuber is watery and skin purple in colour with superficial hairy roots. Generally cylindrical in shape but are found in variable shapes.	
Chormola	<i>D. esculenta</i>	Less vigorous with oval shaped leaves. The tubers are found in individual in large numbers but sometime found in cluster with superficial roots. The inner flesh is white in colour.	
Phurbaiki	<i>D. rotundata</i>	Vigorous and bushy vine with ovate in shape. The tuber is usually cylindrical but also in variable in shapes with brown smooth and white flesh in colour.	
Siktum	<i>D. bulbifera</i>	Perennial large vines with broad leaves and long length vines. Bulbils are round or oval in shape with brown skin colour and white flesh.	

Kachamaki *D.cayenensis* Vigorous and bushy vine with oval creeping canopy shape. Tubers vary from oval to cylindrical shape with yellow flesh.



Agro-ecological distribution of the yams found in the wild

The diverse and favorable natural environment of gewog has favoured for richness of wild yam. The vegetation cover within the gewog ranges from warm mixed broadleaved to cool broadleaved forest with elevation range of 1100 to 1700 meter above sea level. Soil type varies from sandy, sandy loam, clay, clay loam and rocky or stony. The agro-climatic condition varies within the gewog with dry sub-tropical, warm humid and temperate type.

Species diversity and distribution with respect to vegetation cover

As indicated in Table 2, there are three types of vegetation categorized under the gewog. The 52% of the respondents reported that *D.alata* species are abundant in cool broadleaved and 48% had said it is available in warm mixed broadleaved vegetation. In case of *D. esculenta*, 59% of the respondents stated it is found in cool broadleaf and 41% has reported to be found in warm mixed broadleaf forest. The *D.bulbifera* species is said to be found in cool broadleaf forest by 64% of the respondents and in warm mixed broadleaf forest by 36% of the respondents. *D. rotundata* species is said to be found in cool broadleaved and warm mixed broadleaved vegetation. *D.cayenensis* it was found growing in the shrubs. The above findings relates to the report of Ugwu *et al.* (1991), which states that yams are cultivated and found in wild throughout the tropics, subtropics and temperate zones in cool broadleaf and warm humid mixed vegetation cover in West Africa. The existence diversity of yams species in the gewog are mainly because the 28% of areas lies under warm humid subtropical

and 27% of areas under cool temperate zones of the total area (Dukpa 2012).

Species diversity and distribution with respect to soil type

As shown in Table 3, 71% of the respondents have reported that *D.alata* is found abundantly in the sandy loam, 20% of the respondents said it is found in clay loam and 9% of the respondents in stony areas. With to *D.esculenta*, majority of the respondent (62%) reported it is mostly found in sandy loam, 22% in stony areas and 14% in clay loam. Similarly, among 14 respondents those collects *D.bulbifera*, majority of the respondents (64%) reported that species are abundant in clay loam and rest of the respondents perceived to be found in sandy loamy types. *D.cayenensis* is reported to be usually found in sandy loam. Both *D.rotundata* and *D.cayenensis* are said to be commonly found in sandy loam and clay loam.

In overall, the study has found that majority of the respondents found diversity of yams thrives well in sandy loam type of soils. Similarly, according to the study carried out by Ezebuoro *et al.* (2012) in Nigeria, found that most of the edible yam species performed well and obtained maximum yield in sandy loam than other types of soil such as clay, clay loam and sandy.

Table 2. Distribution of species in different vegetation types

Species	N	Cool broadleaf (%)	Mixed broadleaf (%)	Shrub (%)
<i>D.alata</i>	54	52	48	0
<i>D.esculenta</i>	63	59	41	0
<i>D.rotundentata</i>	2	50	50	0
<i>D.bulbifera</i>	14	64	36	0
<i>D.cayenensis</i>	1	0	0	100

Table 3. Percent yam species found in different soil types

Species	N	Clay loamy	Sandy loam	Stony
<i>D.alata</i>	54	20	71	9
<i>D.esculenta</i>	63	14	62	22
<i>D.rotundentata</i>	2	50	50	0
<i>D.bulbifera</i>	14	64	36	0
<i>D.cayenensis</i>	1	0	100	0

Status of yam cultivated and available in wild

Overall perception of domestication in community

The respondents were asked on the status of the yam cultivation over the past 10 years in the gewog. 77% of the respondents reported that the cultivation is constant and 23% reported the decrease in cultivation (Figure 1). The reason for reporting yam cultivation as remaining constant was mainly because of its abundance in the wild, for which domestication is not required. Decline in cultivation is mainly perceived due to socio-economic development and replacement by other valued cash crops. Similar decline reported on the decrease in cultivation of the yam species like *D.esculenta* has been almost abandoned in Ghana due to farmers choosing to plant non-indigenous crops as well as due to change in socio-economic conditions (Henriques 2012).

Perception on status of different wild yam species

As shown in Table 4, among the respondents who collect *D. alata*, 52% reported that this species has decreased, 43% reported that it has remained constant and only 5% reported that it has increased. Regarding *D.esculenta*, majority (59%) of the respondents has reported that this species is decreasing and 40% had stated that it has remained constant. Similarly, in case of *D.bulbifera*, it was found remaining constant by majority (71%) and 29% of the respondents perceives that this species has decreased. With regard to *D.rotundata* and *D.cayenensis*, it is reported that there was decrease in case of *D.rotundata* and in case of *D.cayenensis* it remained constant.

Over all, there is a decreasing trend on the availability of the yam species in the wild over past 10 years. The possible causes as perceived by the farmers are shown in Figure 2.

Table 4. perception on the availability of species

Species	N	Increased	Decreased	Constant
<i>D.alata</i>	54	5	52	43
<i>D.esculenta</i>	63	1	59	40
<i>D.rotundata</i>	2	0	10	0
<i>D.bulbifera</i>	14	0	29	71
<i>D.cayenensis</i>	1	0	0	100

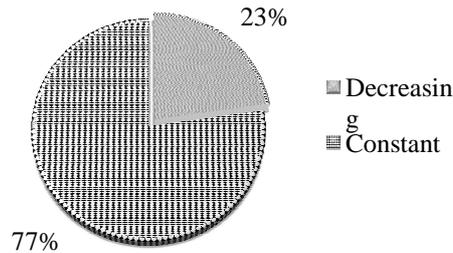


Figure 1. Perception on status of yam cultivation

Possible causes of decrease in yam availability

The perceptions on decreased availability of yam species are reported mainly due to three main possible causes among various reasons. The first important cause as reported by 42% of the respondents is due to unsustainable harvesting practices. The current practices include haphazard collection of species available within the locality that has led to destruction of whole plants, thereby preventing adequate regeneration to occur within the natural habitat. The second important reason as reported by 38% is due to increasing population of wild pigs feeding on the wild yams compared to the past. The increasing pressure of wild pigs feeding on the yams around the vicinity of settlement is assumed to be because of deprivation in food availability in the natural habitat. The other possible perception for decreasing trend reported by 20% of the respondents is due to the increasing population on the utilization of the natural

resources for various purposes such as extraction of timber and non-wood forest products and encroachment of forest for both agriculture and infrastructure developments.

Those above possible causes correlates with the statement of Uprety *et al.*(2012), that in Nepal and other Himalayan regions, the wild edible plants are threatened due to various ever increasing human activities on the natural resources such as expansion of agricultural lands, developmental activities, extraction of natural resources like mining, timber harvest, fuel wood collection, unsustainable agricultural practices and overgrazing, which had led to loss of the natural habitat, thereby resulting to loss of biodiversity.

Further, Aryal *et al.* (2013) reported that despite the significant contribution towards food requirement of the remote people of Himalayan region by the uncultivated plants such as edible *Dioscorea spp.*, the availability of these species have declined over time due to lack of research and development activities.

Table 5. Perception on availability of species (in percent)

Species	N	Increased	Decreased	Constant
<i>D.alata</i>	54	5	52	43
<i>D.esculenta</i>	63	1	59	40
<i>D.rotundata</i>	2	0	10	0
<i>D.bulbifera</i>	14	0	29	71
<i>D.cayenensis</i>	1	0	0	100

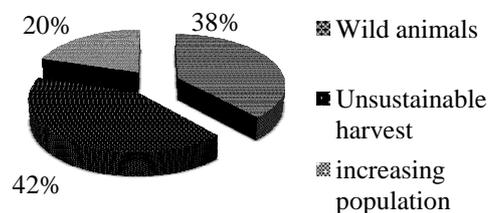


Figure 2. Possible causes of yam availability

Food security

Contribution towards food grain self sufficiency

The study has analyzed that majority (89%) of the respondents are not sufficient in food grain and only 11% are sufficient with the food grain produced in a year. It is reported that 64% of the respondents are in food deficit for duration of 2-3 months, followed by 23% less than one month and 3% within 4-5 months (Figure 3).

The food shortages reported are mainly due to insufficient grain produced especially rice and maize for the household consumption. Major limiting factors on food grain deficit are due to crop failure, limited cultivable land, labor shortage, low yield and crop damage by wild animals. Thus, the requirement is met through various measures.

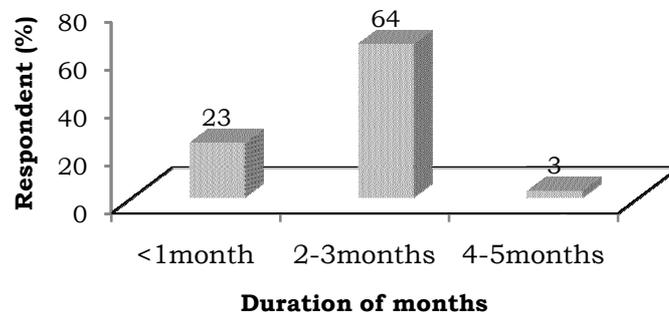


Figure 3. Duration of months

Similarly, MoAF (2012) reported that 53.3% are sufficient and 46.7% are not sufficient in food grain in Nangkor gewog and found that household food requirement is met from various means such as off-farm business, sale of wild vegetables and substituting it with wild tubers.

Measures to cope with food grain shortage

As indicated in Figure 4, it was found that food grain shortages are met 72% from off-farm business, 19% from collection of wild

tubers and root crops such as yams and Taro, 5% contributed by the sale of cultivated and wild vegetables usually villages nearby roadside and 4% through remittance of cash by employed relatives of families. This finding is in line with (MoAF 2012), which has reported that off-farm activities contributes 80% of the farmer's source of income for livelihood in the gewog.

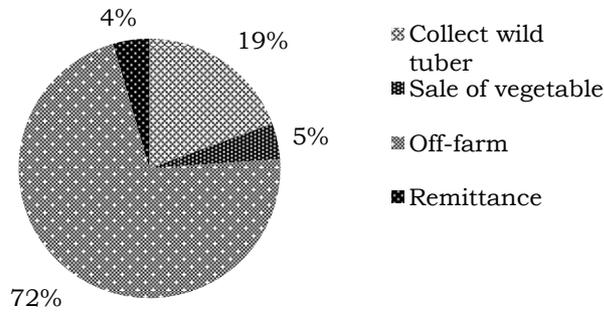


Figure 4. Various measures to cope with food grain shortage

Socio-cultural importance of yams and the species preferred

During the study, it was revealed that similar to other gewogs and communities, Nangkor gewog has its unique traditions and culture that has been bestowed throughout generations and still followed. Any of those socio-cultural ceremonies and festivals involved crops which are often directed to several gods and ancestral spirits of the family. The three most important socio-cultural events in which the yam crop is indispensable are briefly described.

Prechula (Offering to local deities): This is the worship festival ceremony to the local deity which is annually performed by almost all the communities of the gewog coinciding with 10th day of the Bhutanese first month. The monks or lay monks preside Prechula ceremonies in the local monastery (Lhakhangs) as to renew the personal relationship between a person or a community and the deity, conciliate its fierce aspects and ensure the protection of its benevolent aspects. The local believes that it was followed from time immemorial which was devoted after

local deity has been subdued by Guru Padmasambhava (Great Buddhist Master), who transformed them into guardian protector of the doctrine. During this ceremony, boiled yam tubers are offered as religious cakes in the altars of every household in the community and also need to contribute to the monastery where common ritual is held.

Locheo (Annual ritual): This is an annual ritual performed by households to bestow blessings and to do away unforeseen evil deeds of the household members. As reported by the respondents, the yam tuber is one of the integral parts of offering with other food and snacks items offered during annual ritual ceremony.

Losar (Local festivals): This is the festival or event where the family members gather and celebrate to mark the important days such as New Year, ending day of the year and mark the nine evils day. During these events, it is said that yams are one of the important menu among other food items, which are usually eaten boiled or as porridge.

The predominance of yam in the socio-cultural life of the communities have been consistent in accord with Okigbo and Ogbonnaya (2006), which states that yams are one of the most highly regarded food products in sub-tropical and tropical countries and are closely integrated into social, economic, cultural and religious aspects of communities.

As shown in Table 6, it was found that *D.esculenta* is the most preferred and commonly used (84%) whereas 16% of the respondents prefer *D.alata*, and are often used when *D.esculenta* are not available. *D.esculenta*, preferred over other species mainly due to smooth skin with white flesh and good taste, which are believed to have significant traits preferable during traditional offerings.

As shown in Figure 5, 44% consider offering of yams during Prechula ceremony as vital and indispensable than other occasion. 35% of the respondents still consider and offer during the annual rituals and 21% consume during Losar.

Table 6. Species preferred for different cultural values

Species	Frequency	Percent
D.alata	12	16.0
D.esculenta	63	84.0

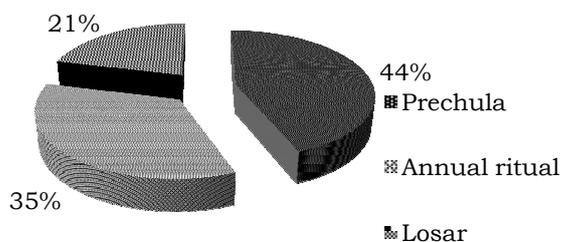


Figure 5. Socio-culture attributes of yam

Conclusion and recommendations

The study found five important species namely Dawalaki (*D.alata*), Chormola (*D.esculenta*), Phurpaiki (*D.rotundata*), Siktum (*D.bulbifera*) and Kachimaki (*D.cayenensis*) in Nangkor gewog. But *D.esculenta* and *D.alata* species are commonly preferred and used. The yam contributes significantly to socio-economic and cultural aspects of the community and has been an integral part for the livelihood of rural farmers in the gewog.

Despite the favorable agro-ecological condition for domesticating yams in the gewog, 85% of the respondents still harvest from the wild. It was found only *D.alata* and *D.rotundata* species are cultivated by 15% of the respondents in small scale.

Although abundant in the wild, there is indication that the availability is declining because of various factors such as unsustainable harvesting practices, increasing number of wild

animals' feeding and increasing pressure on the natural forest due to increasing population.

In terms of food grain security, it was found that 89% of the respondents are unable to meet the food grain requirement in a year for almost 2-3 months, and the shortage is met from various measures. Among those coping measures, the average contribution of yam and wild tubers to supplement food shortage was 2-3 months a year with 19% of the households relying on uncultivated wild food sources during food shortage.

Through this study, it was found yam plays a vital role in socio-cultural aspects such as rituals, ceremonies and festivals. Yam is found as an integral part of people's livelihood in the gewog.

In course of carrying out this study, it was found that there is a need to create awareness on sustainable harvesting practices strategies in order to conserve the species diversity in the natural habitat. Also, it is expected that this information on species diversity provides the baseline for further similar study in other parts of gewogs and dzongkhags in order to know the species diversity in the country and to come up with appropriate conservation strategies. Accordingly, further study on species diversity in other parts of the country is recommended as to document crop species diversity for the nation.

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