

## Status, Distribution and Habitat Suitability Mapping of *Cycas pectinata* in Chure Range of Makawanpur, Central Nepal

Anil Bashyal<sup>1</sup>, Shreehari Bhattarai<sup>1\*</sup>, Jeetendra Gautam<sup>1</sup>, Rajesh Tamang<sup>2</sup> and Balram Bhatta<sup>1</sup>

<sup>1</sup>Faculty of Forestry, Agriculture and Forestry University, Hetauda, Nepal

<sup>2</sup>Ministry of Industry, Tourism, Forest and Environment, Province no. 1, Nepal

\*E-mail: sbhattarai@afu.edu.np

### Abstract

*Cycas pectinata* is an evergreen plant with no branches and having a single above-ground trunk. It is listed in the vulnerable category of IUCN and appendices II of CITES. The study was carried out in the Chure range of Makawanpur district, Central Nepal. Field data were collected to assess status, distribution and habitat variables. Data were analyzed through descriptive statistics and the analytical hierarchy process in integration with Arc GIS 10.2.2 to prepare habitat suitability maps. A total of 780 individuals of *Cycas* were recorded in scattered form. The major preferred habitat of this species was forest land having elevation range of 400 – 500m mostly on steep terrain with slope range from 25° to 55°, nearer of small gullies and far from human influences. This study revealed that, the Chure range was a suitable habitat for *Cycas* of which 40.52% area was highly suitable, 56.08% area was moderately suitable and 3.40% area as less suitable. Though it is in danger of extinction, very limited research about its status, distribution, reproduction biology, and habitat suitability have been conducted. This paper aims to determine the status, distribution and habitat suitability of *Cycas* in the Chure range of Makawanpur district.

**Keywords:** *Cycas*, Scattered distribution, Suitable habitat, Vulnerable

### Introduction

*Cycas pectinata* Buch.-Ham. is a dioecious tall palm-like tree growing up to 2-3 m high, with a single aboveground trunk and crowns formed by large, evergreen and pinnate leaves (Singh & Singh, 2010; Joshi et al., 2017). The male cones of this species are usually large, cylindrically ovoid, and yellowish or orange in maturity while female cones are huge and compactly filled with megasporophylls which are deeply pectinate and densely covered with hairs (Singh & Singh, 2010). Seeds are flattened ovoid, glabrous green when immature and orange-red at maturity (Pant & Osborne, 2002).

The plant is famous due to its multiple uses in ornamental, medicinal, food, and socio-cultural values. Local communities have been used various parts of the plant for several purposes since long back. Sago or stem starch obtained from the stem has been used as an alternative source of food for many centuries in many countries (Jones, 2002). The young, circinate, succulent leaves and young tubers are consumed as vegetables (Joshi et al., 2017).

Fertilized ovules or immature seeds are eaten as food and are also used as medicine for gastric problems (Patiri & Borah, 2007) whereas in some areas microsporophylls are also used to cure asthma while megasporophylls are used for treating piles (Das & Dutta, 2007).

The species usually grows at an elevation of 300 m to 1200 m in difficult terrains of Chure hills and lower foothills with medium to a tall forest on deep, often clay-rich and more fertile soils, usually in the moist understory in moderate to deep shade in central and eastern Nepal. It prefers tropical climate with wet, humid summers and milder, drier winters. Although often found on limestone substrates, it is by no means restricted to these, and it also occurs on granites and meta-sediments (Lindstrom & Hill, 2007; Nguyen, 2010). The forests of the Chure region in central and eastern Nepal provide important habitat for *Cycas pectinata* where they are found in either the forest of *Shorea robusta*, *Shorea-Schima*, or riverside up to 730m elevation. Bhuj & Joshi (2009) reported 36 plants of *Cycas pectinata* from 15 sites in the Churiya hills of eastern Nepal.

However, due to the continuous decline in a natural population, it is listed in Appendices II of CITES and the conservation status of the species is endangered (Joshi et al., 2017). The species is assigned to the Vulnerable (VU) category by IUCN due to an estimated decline in a habitat of more than 30% over the past 90 years (Nguyen, 2010).

A habitat is a unique place for a certain species to develop and it is often referred to as species-specific concept (Fischer & Lindenmayer, 2007). Mapping typically involves the identification and demarcation of the spatial extent of specific attributes. Geographical Information System (GIS) application has been adopted in ecological modeling as tools for producing the data needed in modeling on different spatial and temporal scales (Wu & Smeins, 2000), as platforms on which models are run and data stored (Hirzel et al., 2001), and as tools for extrapolating the results from point basis to spatial basis (Osborne et al., 2001).

Land-use change is a major factor that modifies the habitat and can determine the distribution of species within an ecosystem (Musiega & Kazadi, 2004). As habitat indicates ‘where’ a species lives and ‘what’ is the environment type where a species lives, mapping and monitoring the wildlife habitat are the important aspects in assessing the quality of habitat

(Wintle et al., 2005). To avoid the extinction of endangered species, it is important to understand and manage their habitats (Ortigosa et al., 2000). Thus there is a need for information that can assist with locating suitable habitats in fragmented and degraded landscapes to aid the reintroduction of at-risk plant species (Questad et al., 2014). Integration of GIS, Remote Sensing, and Global Positioning System (GPS) technologies have proved to be effective in the assessment of habitat quality (Memarbashi et al., 2017). *Cycas pectinata* is one of the widest spread cycads that are now under threat and its populations are declining at pace as compared to any other species of *Cycas* (Singh & Singh, 2014). Though this species is in the vulnerable condition of extinction, very few similar research has been conducted of the species to document its habitat, status, and distribution. This paper aims to determine the status, distribution and habitat suitability mapping of *Cycas pectinata*, in the Chure range of Makwanpur district.

## Materials and Methods

### Study area

This study was carried out in Chure range of Makwanpur district (Figure 1) which covers 140,297 ha. of the southern part of Makwanpur

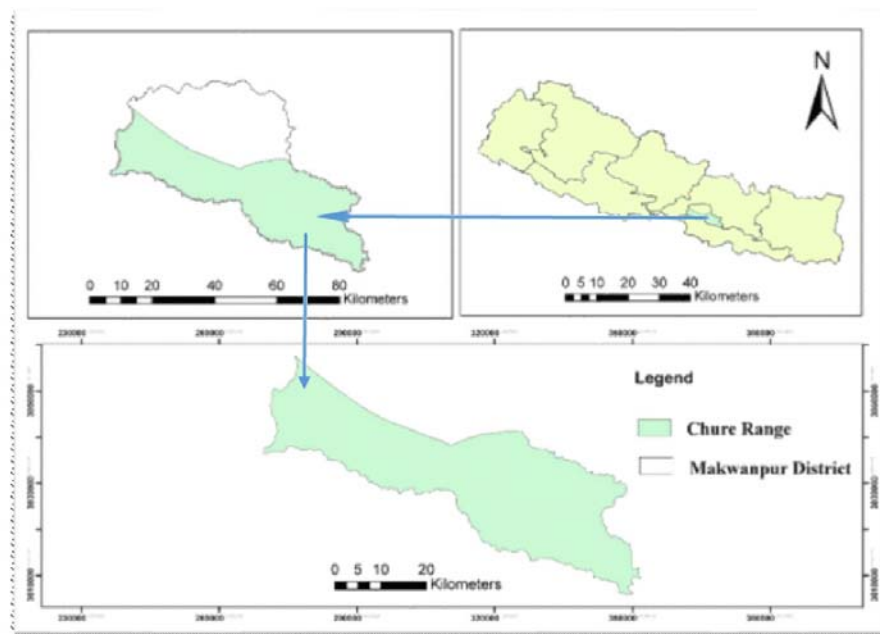


Figure 1. Map of Study Area

district (President Chure-Tarai Madhesh Conservation Development Board [PCTMCDB], 2015) mainly consisting of fluvial sedimentary rocks such as mudstone, shale, sandstone, siltstones, and conglomerates naturally being a very sensitive area (Ghimire, 2016). The climate of the Chure region ranges from tropical to warm temperate and is characterized by hot and sub-humid summers, intense monsoon rain, and cold dry winters where *Shorea robusta*, *Dalbergia sissoo*, *Acacia catechu*, *Adina cordifolia*, etc. were the major tree species (Department of Forest Research and Survey [DFRS], 2014) whereas Tamang, Chepang, Rai, Brahmin, Chhetri, etc. were the major ethnic groups (PCTMCDB, 2015).

### **Data collection**

A preliminary reconnaissance survey was carried out initially to identify the pocket areas of *Cycas*, identification and ranking of factors which affected the habitat of *Cycas*. Ten focus group discussions and key informant interviews with Divisional Forest Office, Plant Research Centre Office, local peoples and community forest user groups were carried out. Based on information collected from discussions, an extensive survey of the identified potentials area were conducted with local resource persons during March-April, 2019. The relevant habitat parameters like altitude, aspect, slope, associated species, soil type, nearest distance from the water body, road, and settlement were recorded. The GPS coordinates of all *Cycas* plant sighted were recorded for the mapping purpose. Secondary data were sourced from relevant journals, books and web pages.

### **Data analysis**

All together nine variables viz. land use land cover, forest type, aspect, slope, elevation, proximity to the river, soil type, proximity to the road, and proximity to the settlement were perceived as their prominent influences in habitat dynamics of this species. Integration of Analytical Hierarchy Process and Arc GIS 10.2.2 was used for the suitability mapping purpose.

## **Results and Discussion**

### **Status and distribution of *Cycas***

All together 780 *Cycas* plants were recorded, out of which 16 were found as planted populations and 764 were found as natural populations. The highest number of *Cycas* were found as indeterminate i.e. male and female cone was not distinguished. The plants were not distributed uniformly rather in a patch or as a cluster and occurred in different micro-habitat with densely populated in each area found.

### **Habitat suitability based on multiple variables**

With the Classified Landsat OLI imagery of 2018, Aster Global DEM, SOTER, and Google Earth, the following nine layers were prepared and ranked as less suitable, moderately suitable, and highly suitable. The suitability classification was done based on focus group discussion, expert opinions, and field data collected during the March- April 2019.

### **Habitat suitability based on land use land cover (LULC)**

Forest was classified as a highly suitable area in which 82% of total *Cycas* were found. Agricultural land use was classified as moderately suitable where 15% of total *Cycas* were found. Other land-use classes were classified as less suitable where 3% of total *Cycas* were found (Figure 2A).

### **Habitat suitability based on forest type**

Sal forest was classified as the highly suitable forest type in which 82% of total *Cycas* were found. Ravine broad-leaved forest was classified as moderately suitable forest type 16% of total *Cycas*. Other forest types were classified as less suitable forest types in which 2% of total *Cycas* were found (Figure 2B).

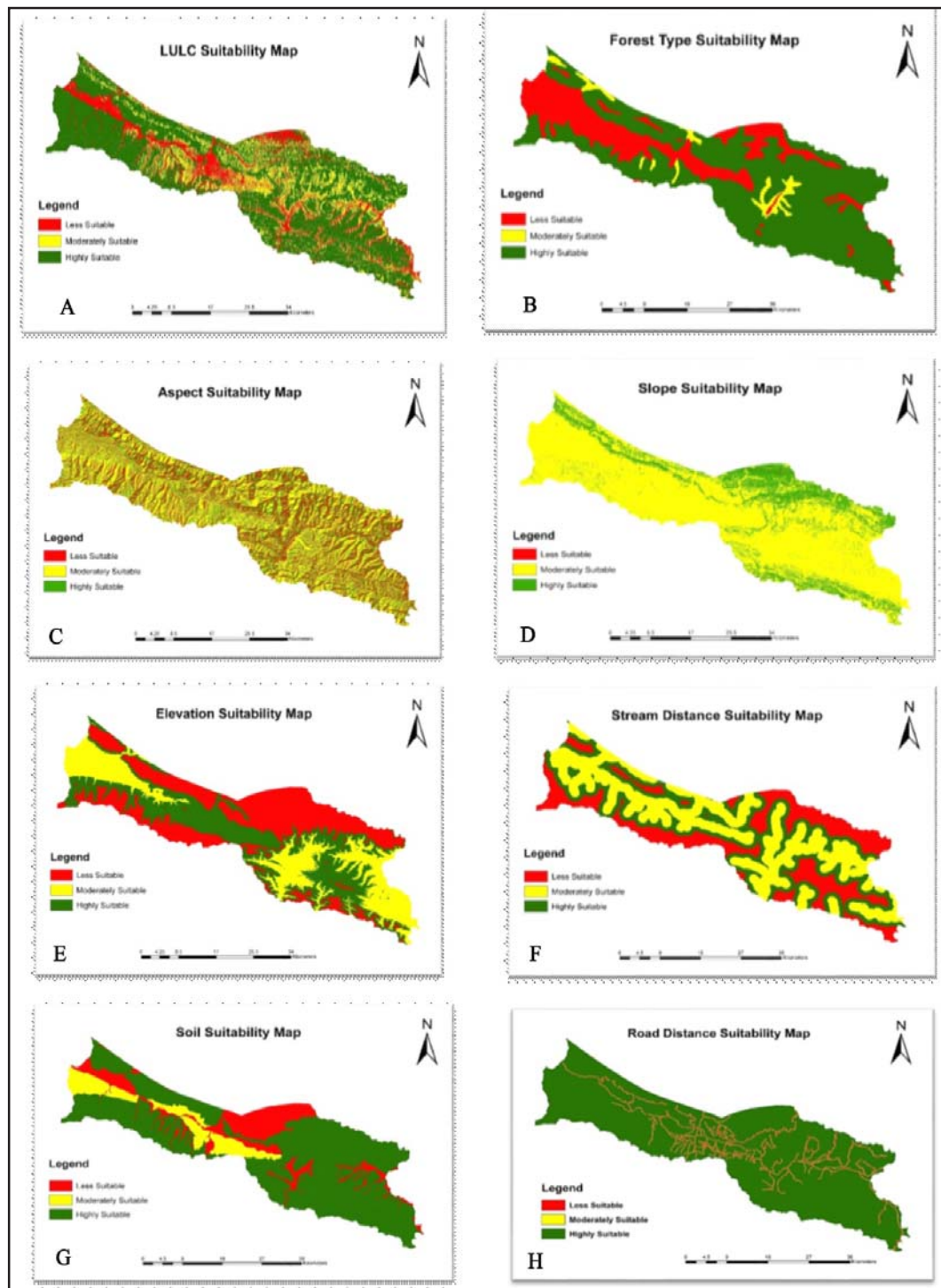
### **Habitat suitability based on the slope and the aspect**

Slope class of 25°-55° was classified as highly suitable in which 62% of total *Cycas* were found. Slope class of 0-25 degree was classified as moderately suitable in which 20% of total *Cycas* were found and slope class of 55-90 degree was

classified as less suitable in which 18% of total *Cycas* were found ( Figure 5). Similarly, Northeast, Southeast, Southwest aspects were classified as highly suitable aspects in which 76% of total *Cycas* were found followed by North, West, and Northwest (Figure 2C & 2D).

### **Habitat suitability based on elevation**

Elevation of 400-500m was classified as a highly suitable area in which 80% of total *Cycas* were found. Elevation below 400m was classified as moderately suitable in which 12 % of total *Cycas*



**Figure 2:** Habitat suitability map: A. LULC suitability map; B. Forest type suitability map; C. Aspect suitability map; D. Slope suitability map; E. Elevation suitability map; F. Stream distance suitability map



were found. Elevation above 500m was classified as the less suitable area in which 8% of total *Cycas* was found (Figure 2E).

#### **Habitat suitability based on proximity to the river**

The area which is present in between 1000 to 2000 meter distance from the river was classified as the highly suitable area in which 63% of total *Cycas* were found. The area which is present below 1000m distance from the river was classified as the moderately suitable area in which 28% of total *Cycas* were found. The area which is present above 2000m distance from the river was classified as the low suitable area in which 9% of total *Cycas* were found (Figure 2F).

#### **Habitat suitability based on soil type**

Eroded Soil i.e. Dystric Regosols (RGd) was classified as highly suitable soil in which 98.33% of total *Cycas* were found, Well-drained Soil i.e. Haplic Phaeozems (PHh) was classified as moderately suitable soil in which 1.54% of total *Cycas* were found and other soil types were classified

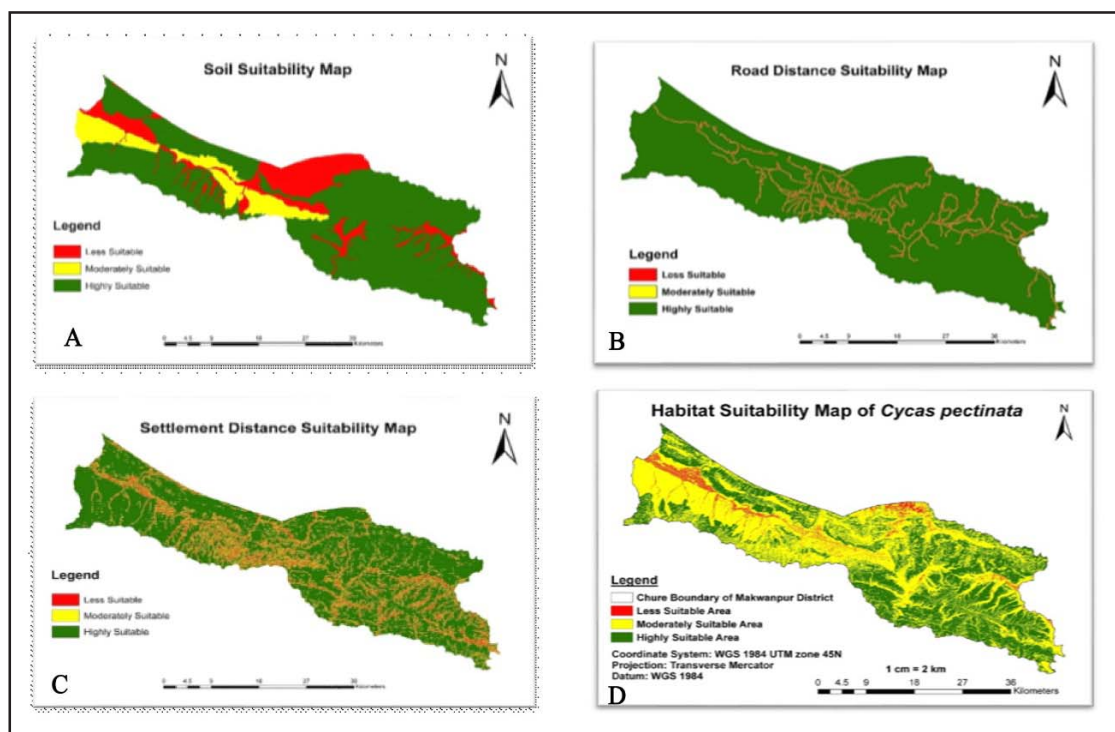
as less suitable soil in which 0.13% of total *Cycas* were found (Figure 3A).

#### **Habitat suitability based on proximity to road and settlement**

The area which is present above 100m distance from both road and settlement was classified as highly suitable to flourish the species. About 75% of the total population was found about 100m far from the settlement. The population declined largely on proximity of the road and settlement (Figure 3B and 3C) thus indicating the impact of unplanned road construction and settlement in this and other similar threatened species.

#### **Habitat suitability based on combined variables**

The final suitability map was prepared by overlaying layers of nine factors using a weighted overlay procedure according to their weight obtained from AHP. The Red, Yellow, and Green color indicated the less, moderately, and highly suitable habitat for *Cycas* respectively (Figure 3). Out of 1, 40,297-hectare area of Chure, 40.52% falls under the highly



**Figure 3:** Habitat suitability map; A - Soil suitability map; B - Road distance suitability map; C - Settlement distance suitability map; D - Combined variables suitability map

suitable area, 56.08% falls under moderately suitable area and 3.40% falls under less suitable area (Figure 3D).

### Field verification of habitat suitability map

After making the final suitability map, the map was analyzed through field verification. Out of total *Cycas* sighted during field verification, 38.20% were found on the highly suitable area, 61.80% were found on the moderately suitable area and no *Cycas* were found on the less suitable areas (Figure 12). Similar to the finding of this study, Bhujju & Joshi (2009) recorded 36 plants of *Cycas pectinata* from 15 sites in the Chure hills of eastern Nepal along with the altitudinal range up to 750m as an understory of *Shorea robusta*, *Shorea-Schima* forest.

### Conclusion

The distribution of the species was observed in patches or clusters in different micro-habitat with densely populated in each area found. All together 780 number of *Cycas* were recorded. Out of which 27 were male, 35 were female and the rest of them being indeterminate. The number of reproductive plants was not proportional to the number of individual plants. The *Cycas* were distributed more in the elevation range from 400 m to 500 m in the Northeast, Southeast and Southwest aspect. These were found mostly on steep terrain with slope range from 25° to 55° nearer of small gullies that are medium to near distance from perennial river sources. The habitat which was far from human influence was preferred most. Based on this study it can be concluded that about 40.52% of the total Chure area of Makawanpur is highly suitable, 56.08% moderately suitable and 3.40% to be less suitable habitat for *Cycas*.

### Recommendations

- Limited research and information gap on population status, range of distribution, reproduction biology, phenology, and threats to the species are causing them to be less prioritized so extensive survey and scientific exploration are

necessary for proper documentation and conservation.

- The identified potential suitable areas for *Cycas* should be developed as a pocket area and conservation of these areas is of utmost importance.
- Care should be given to conserving the habitat of *Cycas* during infrastructure development.
- As *Cycas* is listed in CITES Appendices II, a conservation action plan should be formulated and implemented to conserve this historic species.
- A community-based *Cycas* conservation program should be encouraged in the potential areas of *Cycas* habitat.

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