

## Geo-environmental factors affecting the growth of Jambu Sitafal (Custard Apple) in the Satpura Region: A case study of Seoni District (Madhya Pradesh)

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### Abstract

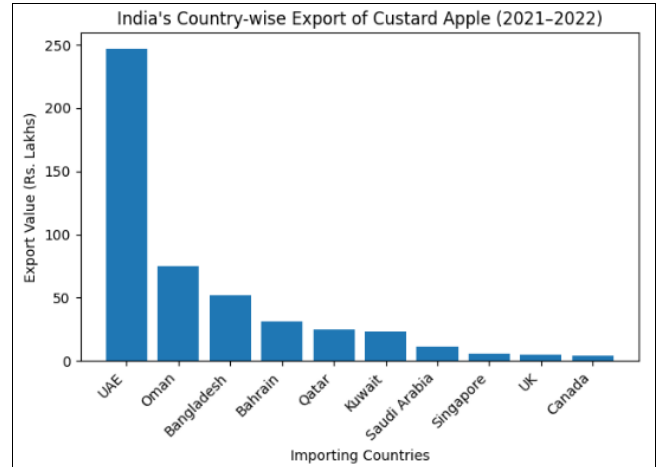
Jambu sitafal, or custard apple (*Annona squamosa* L.) has its importance as a dryland fruit crop of tropical/subtropical areas in India due to its nutrition; medicine; and economic attributes. Recent data has indicated that since the site for cultivation of custard apples has listed the Seoni district in the Satpura region of Madhya Pradesh as a prominent area due to its favourable geo-environmental attributes. In this paper, secondary datasets and geo-spatial studies will be synthesised into a single compilation. This compilation will provide an insight into the various geo-environmental factors affecting the growth and productivity of custard apples in Seoni district, with respect to soil characteristics, climatic variability, topography, and hydrology and land-use practices. Findings suggest that *A. squamosa*'s ecological needs are met by the combination of basalt forming the loamy soils, the gently sloping plateau terrain, the moderate elevation of the plateau and the tropical monsoonal climate. *A. squamosa* is adaptable to marginal soil conditions and semi-arid atmospheric conditions, thus being suitable for cultivation in this area known as the Satpura region. Lack of rainfall, lack of irrigation systems, fragmented land holdings and insufficient postharvest facilities represent major limitations on *A. squamosa*'s ability to produce goods efficiently or to export goods. The findings indicate that there is a critical requirement for integrated geo-environmental planning, improved agronomic management practices and climate-resilient approaches to promote the long-term viable expansion of custard apple production in this region. The paper presents valuable geographic information for use in dryland horticulture, regional development and sustainable agricultural planning for central India.

**Keywords:** *Annona squamosa* (Custard Apple), geo-environmental factors, Satpura Region, Seoni District, dryland horticulture, soil/climate interaction

### Introduction

Custard Apple or Jambu Sitafal (*Annona squamosa* L.), classified under the family Annonaceae, is a dryland fruit crop that grows primarily in the tropics and subtropics. This fruit is well-known for its sweet, creamy pulp, pleasant aroma, and high nutritional and medical values. Custard apples are high in carbohydrates, dietary fibre, calcium, phosphorus, iron, and vitamin C and are considered to have medicinal properties to treat heart disease, diabetes, and other metabolic disorders (Goutam *et al.*, 2019) [6]. Due to their adaptability to marginal soils and semi-arid conditions, custard apples have become an increasingly important crop for sustainable horticulture in central India's Satpura ecological zone.

The custard apple is becoming increasingly important from an economic point of view in both domestic and foreign markets. In 2021 India was the 9th largest exporter of custard apples in the world, exporting custard apples worth USD 95.80 million with the largest recipients being UAE, Bangladesh, Qatar, Oman and Bahrain (Ministry of Commerce, Government of India 2022). The value of exports from India for custard apples increased from 336.92 lakhs in 2020-21 to 485.08 lakhs in 2021-22, indicating that there is an increased global demand for this fruit. Madhya Pradesh produces a significant amount of custard apples, accounting for 74 crore worth of exports between April 2021 and March 2022 (DGCIS, 2022). Figure 1 may illustrate India's country-wise custard apple export destinations, while Figure 2 can summarize export trends from Madhya Pradesh.



**Fig 1:** Export from India – Top Country Wise HS CODE 08109040: CUSTARD-APPLE (ATA) (Source: Ministry of Commerce, India)

HS CODE	Commodity Description	April, 21 To March, 22 Value (INR) Cr.	April, 21 To March, 22 Value (US Million)
08109040	Custard-Apple (ATA)	74	1

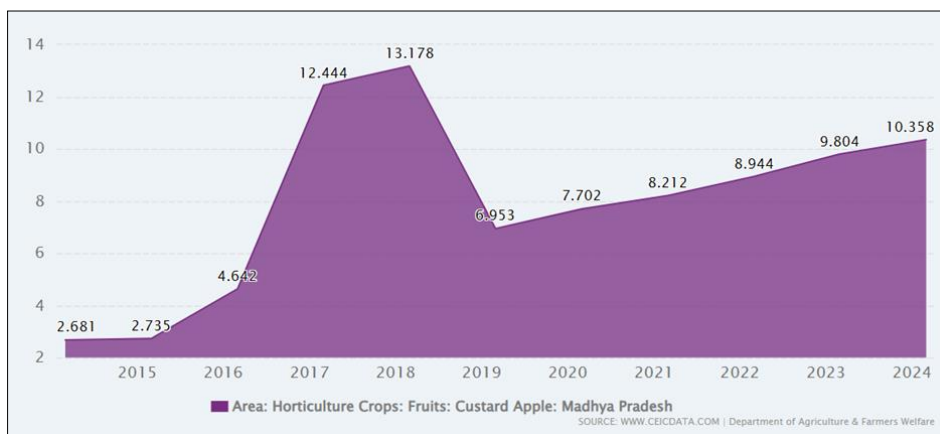
(Source: DGCIS)

**Figure 2:** Export trend from Madhya Pradesh, CUSTARD-APPLE (ATA)

Over the past ten years, Madhya Pradesh has become an important state in India where custard apples are grown. From 2014 to 2024, the amount of land used for custard

apple production in Madhya Pradesh increased from 2.68 thousand acres to 10.35 thousand acres, with a peak of 13.18 thousand acres in 2018, according to CEIC Agricultural Statistics (Ministry of Agriculture). The increasing amount of land dedicated to such an area will help ensure that

custard apple can be produced because they will be suitable for the geo-environmental conditions of Madhya Pradesh, especially that of the Satpura range. A time series chart of custard apple's production over several years in Madhya Pradesh is included in Figure 3.



**Fig 3:** Time-series graph showing trends in custard apple cultivation area in Madhya Pradesh from 2014–2024. (Source: <https://www.ceicdata.com/>)

The Satpura region, which covers the south region of Madhya Pradesh, has undulating plateaus and hills, as well as shallow and moderate depth soils, with a tropical monsoon climate. Elevations in the Seoni district (eastern part of Satpura range) range from 400 to 700 m above mean sea level, with moderate levels of rainfall (between 1200 and 1400 mm annually) and predominantly red and lateritic soil. The characteristics of this geographic area along with climate have created ideal conditions for dry land horticulture, specifically custard apple production. The custard apples produced from the Chhapara tehsil of Seoni district are recognised for their superior flavour and quality due to the unique physical environment, slope orientation and micro-climate within the production environment (Government of Madhya Pradesh, 2022).

Custard apple has both an ecological adaptability and the potential for producing economic benefit but there are many geo-environmental and infrastructure-related challenges associated with producing custard apple in this area, including short shelf life, lacking a cold-chain infrastructure, fragmented landholdings; inadequate market linkages and limited knowledge about international quality standards limits the productivity and export competitiveness of custard apple. Nevertheless, based on genetic variability of custard apple landraces recorded from Seoni and adjoining Satpura district, there are also large opportunities available through value-addition by agro-processing and/or genetic improvement as well as through expanding exports of custard apple (Goutam *et al.*, 2019)<sup>[6]</sup>. Consequently, a geo-environmental scanning report of Seoni District is both timely and necessary in this case. In addition, knowledge of the aspects such as soil type, land slope, rainfall variability, and availability of water, can assist in determining the ways of enhancing the production of custard apple for agricultural and community sustainability.

The present study investigates three questions regarding the geoenvironmental characteristics of custard apple (*Annona squamosa*) and its cultivation in the Seoni District. The questions are:

1. What factors characterize the geo-environment of the Satpura region and how are these factors related to custard apple growth?
2. How do soil, climate and topography interact in determining custard apple productivity within the Seoni District?
3. What are the deficiencies in geoenvironmental and horticultural research regarding custard apple cultivation?

The study aims to combine existing literature regarding custard-apple ecology, to review the geographical and environmental background of the Satpura area, and to reveal research gaps and policy-relevant information to help enable sustainable horticultural development in Seoni District, Madhya Pradesh.

### Geo-Environmental Context of Satpura & Seoni

#### 1. Physical Geography: Topography, Geology, and Geomorphology

Satpura is one of the most important geographic areas of Central India and includes highly complex topography and rugged structural plateaus along with a variety of denudational landforms. The Satpura Conservation Area (SCA) is a very heterogeneous ecological mosaic. The SCA includes all protected and managed forests, agricultural landscape and human settlements. The SCA displays evidence of continuing ecological and anthropological interactions over time (Pant 2003)<sup>[10]</sup>. Diversity within the landscape of the Satpura Conservation Area is extremely important in determining the formation of soils, hydrology, and agricultural potential.

The Seoni District is located in the eastern section of the Satpura plateau, covering a region of roughly 8754 sq. km within latitudes 21°35'–22°58' N and longitudes 79°12'–80°18' E (Kumar *et al.*, 2019)<sup>[9]</sup>. Most of the terrain in this district is classified as flat or slightly sloping. A spatial analysis conducted using Cartosat DEM data shows that more than 71% of the district has a slope between 1–3% (very gently sloping) and 3–8% (gently sloping) (Fig 4) which makes the growing conditions highly suitable for

growing many types of horticultural products such as custard apples by reducing surface water runoff and increasing moisture content in the soil (Kumar *et al.*, 2019) <sup>[9]</sup>.

The geological make-up of the area is primarily comprised of Basalts of the Deccan Trap series with nearly 95% of the lithological make-up (Fig.5) of the district being derived from vesicular Basalts (34.58%), compact Basalts (31.34%) and Gneisses (28.63%) making them significantly contributing to the lithological make-up of the region (Kumar *et al.* 2019) <sup>[9]</sup>. The vesicular basalt areas are particularly valuable when considered in terms of agriculture due to the increased porosity of the basalt allowing for better groundwater recharge and greater soil fertility which in turn provides an ideal environment for exploiting dryland fruit cropping such as *Annona squamosa* (Sugar Apple).

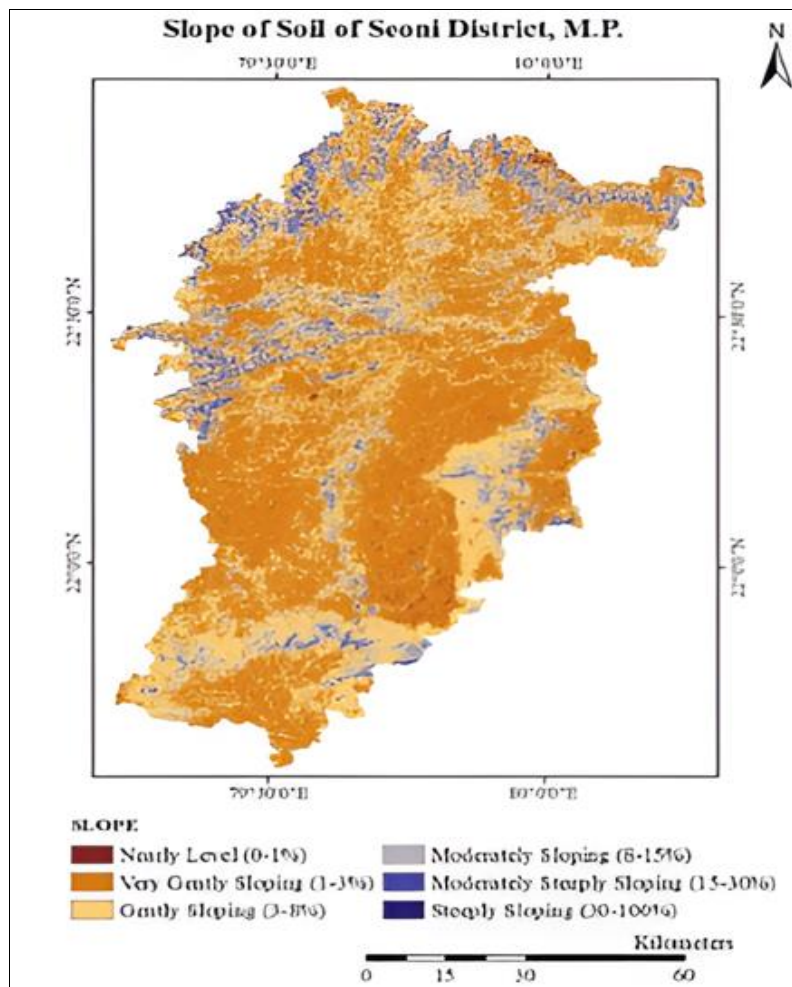
In terms of geomorphology, the Seoni District can be broadly divided into four different types of morphology, with the most common type being the middle elevation plateau (43.31%), and other types including pediplains (17.36%), structural plateaus (15.90%) and denudational plateaus (13.32%) (Kumar *et al.*, 2019) <sup>[9]</sup>. Orchard development will occur in areas that are on pediplains or have gently undulating (flat) surfaces, whereas denudational slopes are generally not ideal for orchard development due to the risk of soil erosion.

## 2. Climate Patterns: Temperature and Rainfall

The climate in the Satpura region has three main seasons: summer, monsoon and winter; it is primarily classified as tropical monsoonal. Rainfall throughout the Seoni District averages between 1200 and 1400 mm every year predominantly from the south-west monsoon season between June to September. As such, while summers are relatively warm, winters remain relatively mild and create ideal thermal environments for custard apples to grow, as they would thrive under these conditions for fruit due to their tropical origin where dry and wet seasonality is clearly evident (Pant, 2003; Goutam *et al.*, 2019) <sup>[6, 10]</sup>. Seasonal rainfall variability, however, significantly influences soil moisture availability and fruit productivity.

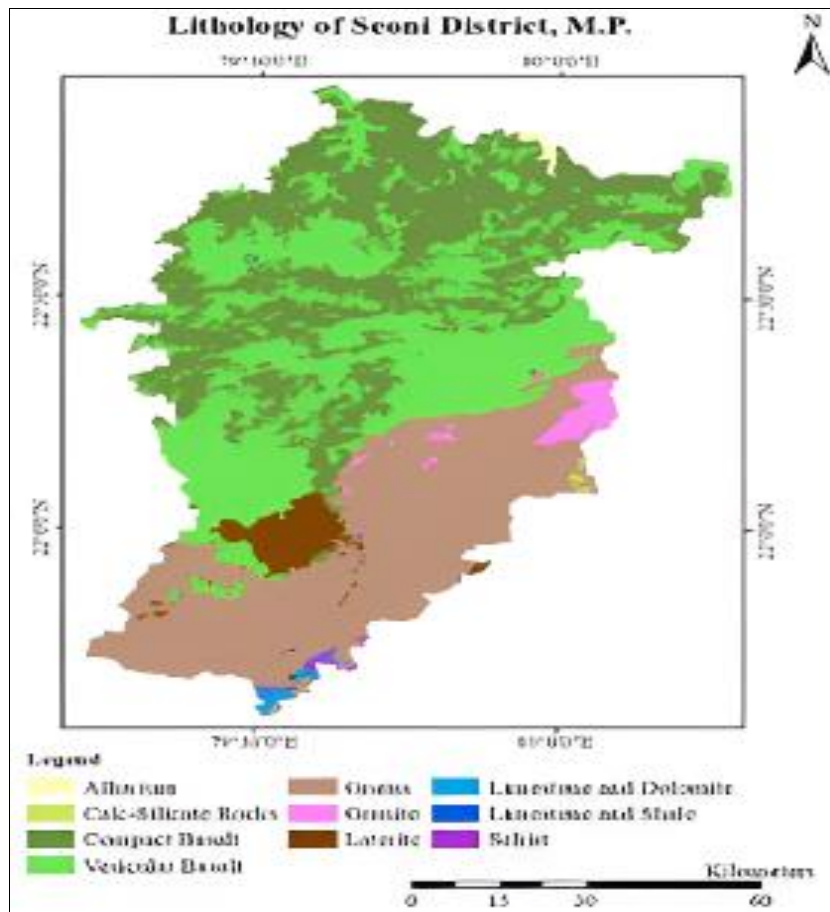
## 3. Soil Types and Spatial Distribution

The soils of Seoni District vary considerably depending on the parent material, slope and drainage conditions present. The main soil types (Fig. 6) are loamy (32.09%); fine textured (21.00%) and clayey (19.19%) soils making up a total of over 72%; of the districts total soils (Kumar *et al.*, 2019) <sup>[9]</sup>. Because of their balanced texture, moderate water holding capacity and adequate aeration Loamy soils can be well suited to grow custard apples. Sandy soils are negligible (0.003%); therefore, there will be a reduced risk of excessive drainage and nutrient loss.



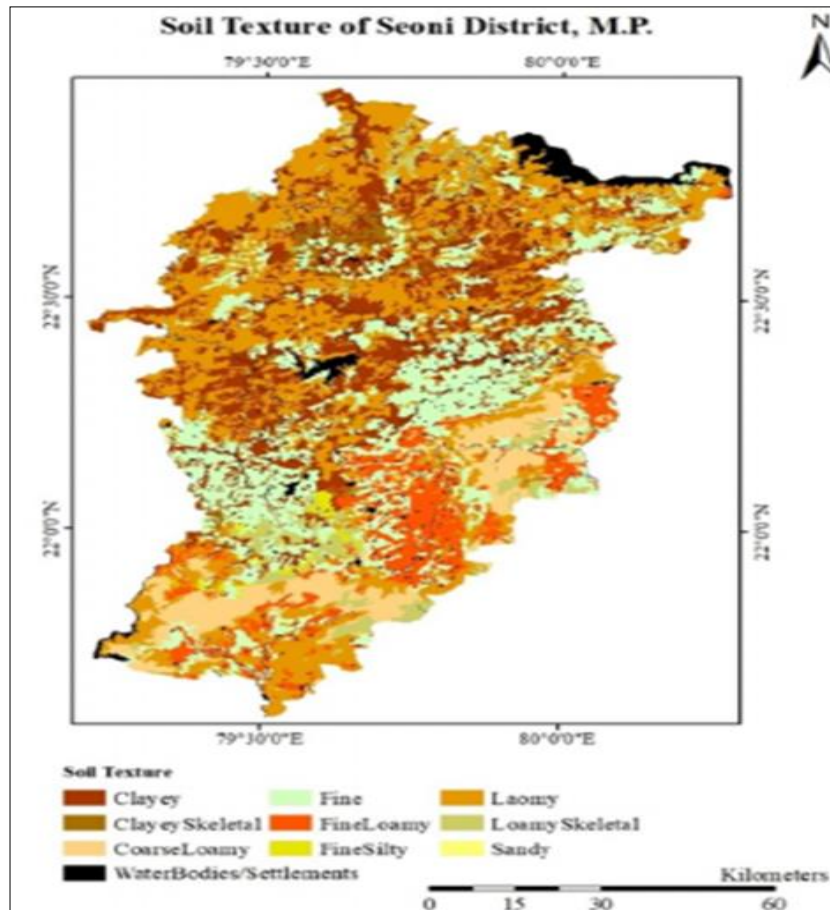
Source: Kumar, Sandeep & Biswas, Utpal & Ahmad, Mobin & Kumari, Sheetal. (2019). Figure 4, 10.22214/ijraset.2019.7106.

Fig 4: Slope of soil distribution of Seoni District



Source: Kumar, Sandeep & Biswas, Utpal & Ahmad, Mobin & Kumari, Sheetal. (2019). Figure 6, 10.22214/ijraset.2019.7106.

Fig 5: Lithology map of Seoni District



Source: Kumar, Sandeep & Biswas, Utpal & Ahmad, Mobin & Kumari, Sheetal. (2019)<sup>[9]</sup>. Figure 5, 10.22214/ijraset.2019.7106.

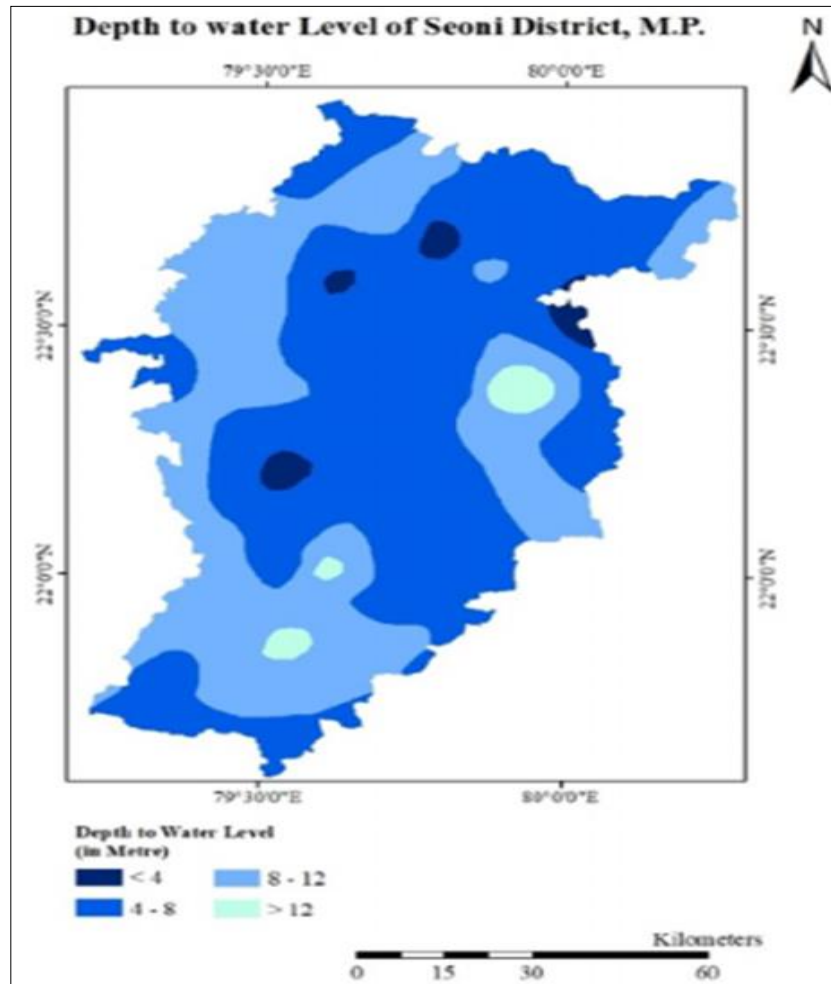
Fig 6: Soil texture distribution map of Seoni district

#### 4. Hydrology and Water Availability

The Satpura landscape provides a rich hydrological network of rivers that sustains both ecological processes and agriculture. This area supports two major river basins: the northern basins, which are the northern tributaries that are tributaries to the Narmada River, and the southern basins: which contain tributaries to the Wainganga River basin (Pant, 2003)<sup>[10]</sup>. With the seasonal flow of the river and its associated streams, these rivers assist with groundwater

recharge and soil conservation as well.

According to a depth-to-water-level evaluation in Seoni District (Fig.7), 58% of the region's groundwater is within 4 to 8 meters from the surface, and 38% is located between 8 and 12 meters; thus making both areas moderate-to-good sources of ground water (Kumar *et al*, 2019)<sup>[9]</sup>. In addition, there was only 1.8% of the area with unproductive water resources. This type of hydrology provides an environment for rainfed horticulture growing, and in particular, fruits that tolerate drought such as custard apple.



Source: Kumar, Sandeep & Biswas, Utpal & Ahmad, Mobin & Kumari, Sheetal. (2019)<sup>[9]</sup>. Figure 5, 10.22214/ijraset.2019.7106.

Fig 7: Depth to water level across the Seoni district

#### 5. Geo-Environmental Significance for Custard Apple Cultivation

The regulating effects of rolling landscape, rich basaltic soils, the weather patterns of monsoons and available groundwater create an ideal environment for custard apple production in the Satpura area, specifically within the Seoni district. The combined impact of these different geographical aspects is the reason custard apples are adapted well to producing successfully and growing their growing areas in the region, necessitating an integrated geographical analysis of custard apple production dynamics.

##### Ecological Requirements of Custard Apple

###### 1. Botanical Characteristics

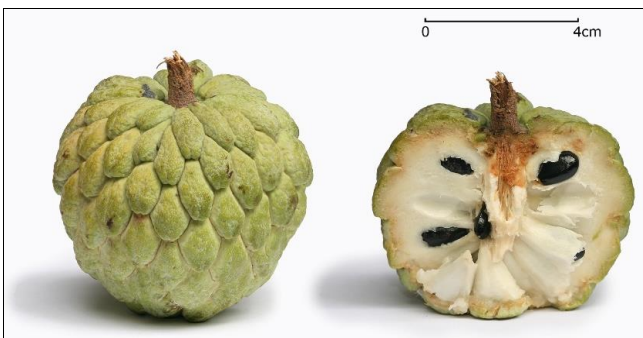
The custard apple (*Annona squamosa* L.), a member of the Annonaceae family, is a small to medium-sized deciduous tree originating from the tropics and subtropics. It can be found at heights between 3 and 8 m, has a wide rounded canopy, and has simple, alternate, glossy leaves 5-17 cm

long and 2-6 cm wide. Flowering occurs as either single flowering or clustered flowering, both have greenish-yellow petals and are pollinated by insects (e.g. mainly beetles). Therefore, the genetic variation of the cultivars is typically quite large in fruit size, shape and quality. The aggregate fruit contains a large (number of) fused carpels producing the creamy (white to yellowish) pulp that forms the basis of the custard apple and contains a large (number of) hard seeds, which can be anywhere from 20 to 40 per fruit (Wikipedia, 2025)<sup>[12]</sup>.

Custard apple exhibits a wide range of genetic differences (intraspecific variation), which have led to the designation of many cultivars or landraces throughout India, including Balanagar, Barbados seedling, British Guiana, Kakarlapahad, and local Sitaphal types (Agropedia 2024)<sup>[11]</sup>. These genetic variations are evidence of the adaptations made by *A. squamosa* to different regions and their ecological flexibility within the environment(s) in which they are grown.



**Fig 8:** *Annona squamosa*, Cross section (Source: Wikipedia)



**Fig 9:** *Annona squamosa* (Source: Wikipedia)

## 2. Growth Requirements: Soil pH, Texture, and Moisture

Ecologically, Custard apples can be grown in many types of soil, but there are types of soil that will grow custard apples the best. Custard apple will have the greatest growth and highest yields when growing in well-drained sandy loam or loam soil, with good aeration and a moderate amount of fertility. The ideal soil pH for custard apples is between 5.5 and 7.5 (slightly acidic to near-neutral), which usually provides the best conditions for root development and availability of nutrients for the plant. Heavy clay soils, or soils that are waterlogged, prevent the roots from breathing and are not good for custard apples because they will be more likely to get root rot and to have less aeration than other types of soil (Agropedia, 2024; Asiafarming, 2016) <sup>[1, 2]</sup>.

The availability of moisture is a key determining factor in the vigour of trees and their reproductive success; the custard apple tree is a moderately drought tolerant species and can withstand relatively short periods of drought once established. However, consistent availability of moisture during the flowering period and early stages of fruit set contributes to improved pollination and greater retention of

fruit (Agropedia, 2024) <sup>[1]</sup>. Excessive rainfall or prolonged waterlogging during the flowering and fruit setting phases can result in reduced fruit set and enhanced flower drop and incidence of physiological disorders. Therefore, while *A. squamosa* can survive in marginal soils, irrigation or mulching to manage moisture may be required when grown in semi-arid growing regions (AgricultureinIndia.net, 2015) <sup>[3]</sup>

## 3. Sensitivity to Climate

The climate in which a custard apple grows determines the area where it can grow and how often it will flower. Custard apples are a tropical/subtropical fruit, which means that their best growing temperatures range approximately from 20° to 35°C (AgricultureinIndia.net, 2015; Agropedia, 2024) <sup>[1, 3]</sup>. This fruit does not handle the cold well enough; frost will kill the foliage of custard apple trees or even sometimes kill the tree itself and frost will greatly reduce a custard apple tree's ability to produce seeds. However, even though custard apples can survive short periods of drought due to their deep roots and drought-resistant characteristics, custard apple trees will lose their flowers and have limited fruit production if the drought continues longer than a few weeks. Also, if the temperature is above 40°C, custard apple trees will lose their flowers and have limited fruiting unless there is adequate moisture in the soil (AgricultureinIndia.net, 2015) <sup>[3]</sup>. When custard apple trees are flowering and setting fruit, moderate humidity will improve the success of pollination. On the contrary, if the custard apple trees receive too much rainfall during these events, they will not produce fruit successfully and will have higher disease rates.

The average yearly precipitation range of 500 to 800 mm is typically suitable for the area, as it matches with the monsoon precipitation pattern found in Central India. Having an adequate supply of water at the time of reproduction will allow for a sufficient water supply without causing the plant to be stressed due to excessive water (Agropedia 2024; Asiafarming 2016) <sup>[1, 2]</sup>. The ecological plasticity of custard apples allows for the fruiting of the tree to occur from near sea level to approximately 1000 meters in elevation, so long as the water and temperature at that elevation remain within acceptable limits (AgricultureinIndia.net 2015) <sup>[3]</sup>.

## 4. Phenology: Flowering and Fruiting Cycle

The phenological cycle of *A. squamosa* relates growth patterns and the environment together through reproductive output. Flowering generally occurs during the pre-monsoon (late spring to early summer). The time it takes for a custard apple to develop fruit is approximately 3–4 months. Warm and moderately humid weather conditions determine success with pollination which results in fruit being set and yield capability. Fertilization and maturation of fruit occur at the end of the monsoon or post-monsoon and coincide with peak demand for custard apples in many areas where they are consumed.

Every environmental stressor (e.g., soil moisture deficit, high temperature, and extreme precipitation) has the potential to disrupt phenological progression, either through flower or immature fruit abscission, delayed fruit maturation, or inducing physiological disorders (e.g., fruit mummification & woodiness) (Agropedia, 2024) <sup>[1]</sup>. These disruptions demonstrate the necessity of managing climate stress through appropriate site selection and adaptive cultural practice.

## Geo-Environmental Influences on Growth

### 1. Soil Effects

Soil types in Seoni District greatly influence how well custard apple trees will grow and produce (Seoni District Profile). Black cotton soils come from basalt and there are also sandy loams, loamy soils and clay soil zones represented in the area - indicative of geological diversity. Soil texture can greatly impact a tree's ability to obtain oxygen, retain water or hold nutrients - all very important factors in promoting healthy tree growth and producing quality fruit. Loamy and sandy loam soils normally have a good balance between water-holding capacity and aeration, which allows roots to obtain oxygen and absorb nutrients very effectively, thus improving vegetative growth and reproductive performance (Agropedia, 2024) <sup>[1]</sup>. However, soils with very poor drainage or have an excessive amount of clay will create low dissolved oxygen levels in the soil, which will restrict the ability of roots to function properly and subsequently reduce fruit production. Recent studies conducted regarding fruit crops indicate that proper fertilizer management (especially nitrogen, phosphorus and potassium) will greatly improve both the yield and quality of custard apples by enhancing tree physiological functions like photosynthesis and the movement of materials to fruit (Kumar *et al.*, 2006) <sup>[11]</sup>.

### 2. Climate Effects

Climate is an important factor that affects the phenology and productivity of custard apple. Custard apples perform best when grown in a tropical to warm subtropical climate with an average temperature of about 20 to 35° C. However, when exposed to temperatures above 40° C for a short period of time, this crops' flowering can be adversely affected, resulting in flower drop and lower fruit production due to increased rates of evapotranspiration and moisture stress (AgricultureinIndia.net 2015; Agropedia, 2024) <sup>[1, 3]</sup>. The tree's growth and flowering requirements regarding rainfall are between 600-800 mm of rainfall per year, which aligns extremely well with the monsoon pattern of Seoni district where the average annual rainfall is approximately 1,200 mm (District Profile). Custard apple trees are moderately tolerant to drought conditions, but drought stress during flowering can impede successful pollination and reduce the total yield; heavy rainfall at flowering time creates high humidity, which enhances successful pollination and fruit set, while prolonged heavy rainfall results in fungal diseases and/or premature dropping of fruit (Hiwale, S, 2015) <sup>[7]</sup>. Since custard apple trees have such climatic sensitivities, it is critical to carefully time the implementation of cultural practices according to the season.

### 3. Topography & Aspect

Seoni's topographic differences create variations in surface runoff and soil moisture distribution, affecting microclimate conditions. The majority of Seoni has gently sloping terrain (1–8% slopes), causing less runoff and maintaining soil moisture, both of which are positive for custard apple growth on farms (Kumar *et al.*, 2019) <sup>[9]</sup>. In a small area with steeper slopes, increased runoff and greater soil erosion reduce available moisture and depth of soil, which inhibits root growth and stability of crops. Elevation has an influence on temperature regimes; however, Seoni's moderate elevation (~600–700 m above mean sea level)

provides thermal conditions that are favourable for *A. squamosa* with no risk of frost damage.

### 4. Human and Land-Use Factors

Anthropogenic factors including traditional commercial farming methods, irrigation methods, fertiliser application methods and land use change impact on custard apple yield. In the Seoni district a majority of smallholder farmers practice traditional cultivation techniques and have very little irrigation infrastructure, resulting in their dependence on rainwater supplied by the monsoon (District Profile). The use of improved fertiliser techniques (e.g., balanced NPK) can be shown to increase the growth rate of the trees and improve tree fruit quality as demonstrated through nutrient management trials. Deforestation and land fragmentation due to the expansion of agricultural land and settlement areas can also have an indirect negative impact on orchards by altering the hydrology of the area, increasing the rate of soil erosion and degrading the connections between the various ecosystems. By implementing agroforestry systems in conjunction with custard apple farming it may be possible to mitigate some of the negative impacts of land use while supporting ongoing ecological sustainability (Berry, N., Dilraj, I., Dubey, S., & Rai, N., 2023) <sup>[4]</sup>

### Conclusion

This review-based study examined the environmental factors, especially geographical and ecological characteristics, affecting the growth and productivity of Jambu Sitafal (Custard Apple, *Annona squamosa* L.) in the Satpura area, particularly in Seoni district of Madhya Pradesh. After reviewing geographical, ecological and horticultural literature, the results of this work highlight that the successful and ongoing agriculture of custard apple in this area is based on the synergistic relationship between natural environmental conditions and human agricultural practices.

According to this study, the geo-environmental conditions found in Seoni District provide an ideal habitation for the custard apple due to its combination of gently rolling plateaus, basalt-derived loamy and clayey soils, moderate elevation (400 – 700m), and tropical monsoonal climate. The combination of well-drained, loamy soils which are moderately deep and of good fertility, as well as having a gentle slope on the soil surface, makes them conducive to root establishment, moisture retention, and nutrient uptake, all of which have a direct effect on plant physiology, flowering behaviour, and fruit quality. The fact that there is a predominance of gentle slopes also helps to reduce the amount of surface runoff and soil erosion, which enhances the availability of soil moisture during critical stages of the plant's life cycle (phenology).

The climate of the Satpura region is highly compatible with the ecological needs of *A. squamosa* (custard apple): moderate temperatures, separate rain and dry seasons, and annual precipitation above the minimum required for custard apple production allows for sustained vegetative growth and production of fruit. The review indicates that while climatic factors do allow for the production of custard apples, novel climatic uncertainties would have a greater impact on flowering, successful pollination, and fruit retention; these include; intra-seasonal variation of rainfall, infrequent periods of drought, and increasing extremes in temperature. Therefore, as a result of these new climatic

uncertainties it is critical to implement water and orchard management strategies that allow for adaptive practices for a crop that has historically been classified as a drought tolerant species.

Human and land use factors are two areas that have both benefited and affected custard apple production. One way that they have benefited custard apple production is through the use of traditional low input farming systems and reliance on rainfed conditions, allowing farmers to use custard apples as a sustainable livelihood crop for smallholder farmer producers. Conversely, the long-term challenges to the sustainability of custard apple production are lack of irrigation infrastructure, poor management of nutrient inputs, fragmentation of land, and deforestation. Recommendations made in the literature suggest increased custard production through improved agronomic practices (eg, adding compost to produce larger custard fruits), better management of soil fertility, and use of agroforestry-based land use planning approaches that will preserve the fragile Satpura ecosystem.

This study concludes custard apple farming in Seoni District is an optimal example of crop-environment compatibility in a dryland plateau ecosystem. However, there exists some information deficiency in site-specific yield calculations, climate impact predictions, and evaluation of post-harvest infrastructure. Future research should use geospatial methods, prolonged-time climate data sets and land-based productivity studies to fortify evidence-based planning. Integrated geographic research will promote sustainable horticultural development, enhance farmer income, and maximize the exporting capacity of custard apples grown in the Satpura region.

## References

1. Agropedia. Custard apple: Climate and soil requirements, 2024. Retrieved from <https://theagropedia.com/fruit-science/crops/custard-apple/>
2. Asiafarming.com. Custard apple cultivation guide, 2016. Retrieved from <https://www.asiafarming.com/custard-apple-cultivation-sugar-apple-guide/>
3. AgricultureinIndia.net. Custard apple crop information, 2015. Retrieved from <https://www.agricultureinindia.net/grow/custard-apple-grow/how-to-grow-custard-apples-agriculture/17235>
4. Berry N, Dilraj I, Dubey S, Rai N. Prominent Agroforestry Systems Adopted by Farmers in Seoni District of Madhya Pradesh. *Indian Forester*,2023;149(8):819–826. <https://doi.org/10.36808/if/2023/v149i8/166316>
5. Government of Madhya Pradesh. One District One Product — District Export Action Plan (DEAP): Seoni District. Directorate of Economics and Statistics, Government of Madhya Pradesh. , (Year). Retrieved from [https://sws.invest.mp.gov.in/api/media-file/ODOP-DEAP/Seoni\\_DEAP.pdf](https://sws.invest.mp.gov.in/api/media-file/ODOP-DEAP/Seoni_DEAP.pdf)
6. Goutam K, Sharma TR, Verma BK, Chanderia UK, Pandey SK. Genetic variability in custard apple landraces of Madhya Pradesh, India. *International Journal of Current Microbiology and Applied Sciences*,2019;8(10):2201–2209. <https://doi.org/10.20546/ijcmas.2019.810.256>

7. Hiwale S. Custard Apple (*Annona squamosa* L.). In: *Sustainable Horticulture in Semiarid Dry Lands*. Springer, New Delhi, 2015. [https://doi.org/10.1007/978-81-322-2244-6\\_9](https://doi.org/10.1007/978-81-322-2244-6_9)
8. Horticulture Crops: Fruits: Custard Apple: Madhya Pradesh. CEIC Data. Data reported by the Ministry of Agriculture & Farmers Welfare, India. Available at: <https://www.ceicdata.com/en/india/area-of-horticulture-crops-in-major-states-fruits-custard-apple/area-horticulture-crops-fruits-custard-apple-madhya-pradesh>
9. Kumar S, Biswas U, Ahmad M, Kumari S. An Integrated Approach for Land Suitability Analysis for Agriculture through Remote Sensing and GIS - A Case Study of Seoni District (Madhya Pradesh), India. *International Journal for Research in Applied Science and Engineering Technology*,2019;7:661-674. [10.22214/ijraset.2019.7106](https://doi.org/10.22214/ijraset.2019.7106).
10. Pant A. Ecological analysis of the Satpura conservation area Landscape through stratified field sampling and Remotely Sensed data, 2003.
11. Kumar TS, Girwani A, Reddy GS, Bhagwan A. Studies on nutrient management in custard apple 'Balaganar'. *International Society for Horticultural Science*, 2006. <https://doi.org/10.17660/ActaHortic.2011.890.54>
12. Wikipedia. *Annona squamosa*, 2025. Retrieved from [https://en.wikipedia.org/wiki/Annona\\_squamosa](https://en.wikipedia.org/wiki/Annona_squamosa)