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Cultural adaptation to climate change among indigenous people of South India

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Abstract The mainstream discourses on global climate change have tended to focus on mitigation and have neglected the adaptive measures, particularly at the local level, even though the local/indigenous people have been considered to be more vulnerable to such change. However, climate change has a distinct local reality—since the way such change is perceived and addressed is linked with the local people and their practices. Although climate change largely affects the lives of the local poor, certain positive effects may also occur for those marginalized people. In other words, many of the indigenous peoples have an adaptive capacity to deal with climate change. Therefore, climate change adaptation has now increasingly gained prominence. In this context, this paper will investigate the impact of climate change at the local level and explain how an indigenous and vulnerable population, the Konda Reddis, respond to such change through cultural adaptation. The paper will focus on the cultural significance of the *jeelugu* (fishtail palm, *Caryota urens*) and Konda Reddis' shift from the *jeelugu* to the *tati* (palmyra palm, *Borassus flabellifera*). I will argue that such a shift is an indication of an adaptation to climate change. I will also maintain that though climate change plays a dominant role in stimulating such adaptation, certain other factors also interact with climatic factors in the adaptation.

Keywords Caryota urens · Palmyra palm · Traditional knowledge · Adaptive shift · Konda Reddis · Andhra Pradesh

1 Introduction

There is growing concern about the problem of climate change across the globe and a strongly felt imperative for finding speedy and sustainable solutions for dealing with it. The mainstream (policy) discourses on climate change (including the recent COP-21 or the Paris Agreement)

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mainly concentrated on mitigating the effects of the climate change (reduction of emissions of greenhouse gases). However, there is less focus on adaptation to climate change, and the least focus on cultural dimensions of climate change adaptation and adaptation among local communities and indigenous peoples (Ramos-Castillo et al. 2017). Nevertheless, the latter are important in understanding and responding to climate change. The scientific research on climate change has mainly focused on the developed and less vulnerable regions/countries of the world, and is biased against the developing and more vulnerable regions, which contribute less to climate change. Thus, regional disparities exist in research and knowledge on climate change (Pasgaard and Strange 2013; Pasgaard et al. 2015). Lack of research by developing countries on adaptation to climate change (Pasgaard et al. 2015), and underestimation of the local adaptive capacities in the vulnerable regions by the developed countries, for whom engineered and technological options are commonly known adaptive responses (IPCC 2015), results in unequal distribution of knowledge on adaptation strategies (Pasgaard et al. 2015). However, for limiting the climate change risks, non-technological adaptations, particularly by local people, are as important as the reductions in greenhouse gas emissions (IPCC 2015).

Moreover, local understanding of climate change is important because the effects of climate change (increased temperatures, decreased rainfall, droughts, changing seasonal timings, increased weather event uncertainty), which occur from the local to the global level, are experienced by people, and understood by them, based on local contexts (Rudiak-Gould 2014). Although climate change largely affects the lives of poor and vulnerable people through impacts on livelihood, reduction in crop yields, food insecurity and the destruction of homes, certain positive effects also occur for those marginalized people, such as diversification of livelihoods, agricultural practices, and social networks (IPCC 2015). In other words, "poor people are not normally without resources—they have assets and capabilities that can help develop resilience. … For instance, traditional systems of adapting to climate variability include: switching crops, social networks of support and assistance…" (Giddens 2011:182). Therefore, locally generated knowledge by the locally based researchers may help us to understand the local adaptive capacities in the vulnerable regions of the world and provide contextually relevant advice to strengthen these local adaptive capacities (Pasgaard et al. 2015).

Given the significant role being played by the marginalized, local/indigenous peoples in responding to climate change (Ramos-Castillo et al. 2017), researchers now have started focusing on adaptation among indigenous peoples. Indigenous peoples are the least significant contributors to climate change by their "low carbon" to "carbon-neutral" ways of life (Ramos-Castillo et al. 2017:2), characterized by their continuing practice of sustainable traditional livelihoods and low levels of consumption. However, they are more vulnerable to climate change "due to their resource-based livelihoods and the location of their homes in vulnerable environments" (Wildcat 2013:509), and due to their poverty and marginality (Ramos-Castillo et al. 2017). Nevertheless, they "are not simply victims of climate change:… they are repositories of learning and knowledge on successfully coping with local-level climate variability and effectively responding to major environmental changes…" (Ramos-Castillo et al. 2017:2). Of course, they have been forced to adapt more rapidly, using their traditional knowledge, innovations, and practices in adjusting to the increasingly changing conditions.

Such adaptations and sustainable practices of indigenous peoples accentuate the importance of culture in understanding the effects of climate change and adaptation to them. The concept of culture also helps us to explain how the practices and values of consumption and lifestyles in the developed world produce the crisis of climate change (Morris 2015:547; see also Fiske et al. 2014; Crate 2008). Culture shapes the values of the people and therefore affects the adaptive pathways. It helps to explain differences in responses among peoples exposed to the same environmental and climate risks. Of course, cultures also are shaped by environmental and climatic conditions and affected by climate change (Adger et al. 2013). Climate change endangers people's livelihoods and lives (Adger et al. 2013), particularly in the less developed and "low adaptive capacity" countries (IPCC 2012).

Although cultural dimensions of climate change are important to understanding both the causes (American Anthropological Association 2015) and people's responses to climate change (Adger et al. 2013; Leonard et al. 2013; Naess 2013; Pearce et al. 2015), most of the studies are on adaptation among indigenous peoples within developed countries like the USA, Canada and Australia (Wildcat 2013; Pearce et al. 2015; Leonard et al. 2013). We need further research into adaptations of indigenous peoples in developing countries. "The need for culturally appropriate adaptation strategies have relevance for Indigenous peoples and subsistence-based communities… whose livelihoods are closely associated with traditional lifestyles based on natural resources" (Pearce et al. 2015:235). Though there is growing interest in the potential of local or traditional ecological knowledge in climate change adaptation, most such studies were on Arctic environments (Naess 2013) and developed countries like Canada, Australia, and the USA (Leonard et al. 2013; Pearce et al. 2015; Maldonado et al. 2013). Although local knowledge and local indicators of climate change can contribute to climate change research and growingly attract scientists from the natural sciences, there is scarce primary data on such indicators (Reyes-García et al. 2016), and there is neglect with regard to combining the primary data with the secondary data from scientific research. Thus, there is a lack of attention to the role of local/traditional ecological knowledge in informing the understanding of climate change and its adaptation.

Against this backdrop, this study focuses on the impact of and response to climate-related environmental change, at the local level, among indigenous people, the Konda Reddis, of South India. This case study of the indigenous Konda Reddis discusses climate change adaptation in the context of a shift in socio-cultural and economic dependence of this community from the *jeelugu* palm (fishtail palm, *Caryota urens*) to the *tati* palm (palmyra palm, *Borassus flabellifera*), and the role of local/traditional knowledge in informing this adaptation. The objectives of the study are (a) to understand climate change impacts on the Konda Reddis via impacts on the *jeelugu* palm/*tati* palm population, (b) to examine the Konda Reddis's traditional knowledge and its utilization to adapt to impacts of climate change, and (c) to provide evidence for the occurrence of climate change in that the shift from *jeelugu* to *tati* has been successful in this warming climate but not elsewhere, and to substantiate this data with the information available from the scientific research/studies.

2 Konda Reddis

The Konda Reddis comprise a forest-based tribal/indigenous community in the state of Andhra Pradesh, India. It is also known as a particularly vulnerable tribal group, as has been recognized and categorized by the Government of India (MoTA 2017). The total population of Konda Reddis was 108,160, according to the 2011 census, and most (77,946) inhabit the East Godavari district of Andhra Pradesh (undivided) (Census of India 2011).

Konda Reddis were identified as one of the most vulnerable sections based on certain criteria: "declining or stagnant population, low level of literacy, pre-agricultural level of technology and are economically backward" (MoTA 2017:78; Kodirekkala 2015). They generally inhabit remote localities of hilly and forested areas (Furer-Haimendorf 1945), "having poor infrastructure and administrative support" (MoTA 2017:78). The community adopted a forest-based subsistence. Traditionally, the Konda Reddis depend on shifting cultivation on the hilly-forest slopes; the men practice hunting in the forest and the women gather forest produce (Furer-Haimendorf 1945; Misra 2005; Kodirekkala 2017). The people also collect and sell minor forest produce to supplement their subsistence (Kodirekkala 2015).

3 Methodology

For the present paper, I have used data collected from both primary and secondary sources. The primary data is based on fieldwork carried out in East Godavari district of Andhra Pradesh. The district was selected because a major portion of the Konda Reddis (77,946 out of 108,160 inhabitants) reside in this district (Census of India 2011). Within the district, I have selected the Agency mandals (the Scheduled sub-districts) of Rampachodavaram and Maredumilli.

Rampachodavaram mandal (sub-district) represents the forested and hilly tracts with moderate to hot climatic conditions; it provides space for *tati* palms (palmyra palm, *B. flabellifera*) and modern cashew plantations. The adjacent Maredumilli mandal has high mountain tracts and is a dense forest region with very cold climatic conditions; *jeelugu* palms (fishtail palm, *Caryota urens*) predominate in this area.

In the Rampachodavaram mandal, I have focused on a cluster of half-a-dozen villages on a hilly terrain for a baseline understanding of the dynamics of the *jeelugu* and *tati* palm population. Among those villages, I have chosen one as my base (main) village for the most intensive fieldwork and visited the other neighboring villages for crosschecking the information and collecting additional data. In Maredumilli mandal, where the *jeelugu* palms (fishtail palm, *C. urens*) exist abundantly, I have carried out extensive field trips to a dozen villages. This extensive field survey was not just for understanding the population and growth dynamics of *jeelugu* but also for exploring the state of *tati* palms there.

Methods used for data collection include surveys on *jeelugu* and *tati* palm population; interviews (informal and unstructured) with elderly people, and owners and tappers of *jeelugu* and *tati* palms; observation (participant and non-participant) of people's interactions with the palms; and exploration of the local history (specific historical situations) through recording oral histories with elderly people on the *jeelugu* and *tati* palm population dynamics. Field research was conducted during September 2007 and May 2008, and again during March and May 2017 for updating.

Questions posed include: Do the *jeelugu* and/or *tati* palms exist at your village/forest? If yes, their state of availability (abundant or scarce) at present and in the past? How long have *tati* palms existed at your village? What materials do the *jeelugu* and *tati* palms provide (or what are their uses)? When and how long do *jeelugu* and/or *tati* yield toddy? How much toddy does each palm (*jeelugu* and *tati*) give for you? Which toddy you prefer most and why? How have the *jeelugu*/*tati* plants spread? Reasons for the non-existence of *jeelugu/tati*, if any, at your village?

Information collected include: Where were/are the *jeelugu* trees available? What is the cultural significance of the *jeelugu*? How are the *tati* palms useful for Konda Reddis? Where (under what conditions) do the *jeelugu* palms exist? How did the *jeelugu* become extinct in the study area of Rampachodavaram? Where (under what conditions) do the *tati* palms exist? How did the *tati* become relevant for Konda Reddis? How and why did Konda Reddis' shift from *jeelugu* to *tati*?

This study is a mix of exploratory and explanatory, and synchronic and diachronic data. Analysis undertaken to interpret the data is qualitative and comparative. While comparing the data from Rampachodavaram and Maredumilli areas, I have tried to understand why the *jeelugu* palms predominate in the Maredumilli area when compared with the Rampachodavaram area, and tried to explore how and why *tati* palms exist/spread in the Rampachodavaram area and why they do not exist in Maredumilli area.

4 Shift from the *jeelugu* to the *tati*

In this section, the author will suggest an explanation of how the Konda Reddis have responded to climate change, by shifting from the *jeelugu* to the *tati* palms.

4.1 The *jeelugu*

The *jeelugu* or *jeeruka* (*C. urens*) is a semi-wild species (Wijesinghe et al. 2015), which belongs to one of the oldest families of palm plants on earth (Arecaceae). It is variously called fishtail palm (De Zoysa 1992; Everett 1995), sago-like palm (Furer-Haimendorf 1945), toddy palm, jaggery palm (Wijesinghe et al. 2015), and Indian sago palm (Orwa et al. 2009). It is known for the production of sweet sap, which is used for the preparation of both toddy and jaggery (De Zoysa 1992; Everett 1995; Wijesinghe et al. 2015). This palm is indigenous to humid tropical Asia (De Zoysa 1992), particularly to India, Sri Lanka, Malaysia (Verma 1996; Wijesinghe et al. 2015), Myanmar, and Nepal (Orwa et al. 2009). It grows in the wet interior and highland regions (Everett 1995) of humid tropical forests. It prefers moist forests and cool, shady valleys (De Zoysa 1992; Orwa et al. 2009; Verma 1996), and is a slow-growing, shade-tolerant or shade-demanding species (Orwa et al. 2009). In India, it is grown mostly in Andhra Pradesh, Odisha, West Bengal, and Kerala (Verma 1996).

4.2 Cultural significance of the *jeelugu*

The lives of the Konda Reddis are intimately linked with the *jeelugu* trees (see also Furer-Haimendorf 1945; Misra 1998). According to the oldest people of my study village, 76-year-old K.S. Reddi and 74-year-old K.R. Reddi, *tati* or *tadi* trees (the palmyra palm, *B. flabellifera*), which today predominate over the *jeelugu* trees, were not present about "40 years ago" (now 50 years as they informed me in 2007). Earlier, the *jeelugu* trees were abundant in the study area. They provided materials essential for the survival of Konda Reddis, such as (1) giving a milk-like and sugary sap that was used as/for toddy (a beverage), which was considered a cool, appetizing, and revitalizing drink for them, (2) helping as a potential resource in times of famine for preparing food or *jeeruka-ambali* (porridge made of *jeelugu* flour) from its pith (see also Furer-Haimendorf 1945), and (3) providing fibers from the fruit-branches that were very hard, which were helpful and long-lasting in binding, particularly in the preparation of bow and arrows. Because of its perceived benefits, Konda Reddis have preferred to live in close proximity to the *jeelugu* trees on which they have depended for their survival. Since *jeelugu* has been providing abundant water-like sap (ranging from 20 to 40 l per day) in the forest, where the availability of water is unsure (and where that is assured by the *jeelugu*), and revitalizes the energy and strength of Konda Reddis, they have considered such sap as their real milk in their forest habitat. They call it the *pandugulapanta* [crop (milk) of the Pandavas].[1] This drink is shared by all members of the family, including women and children. As a Konda Reddi couple who were sharing the drink with their children informed this author, Konda Reddis consider that this drink would cool down their bodies, particularly during summer, and they give it to their children as it is good for them. The Konda Reddi women said that they take it particularly at times when they are not feeling well. Thus, the *jeelugu* sap is claimed to have several health benefits.

4.3 Scientific evidence for traditional knowledge of the *jeelugu*

Recent scientific investigations have also substantiated the claimed health and nutritional benefits of the *jeelugu*. A study reported the potential of *jeelugu* sap as a healthy natural beverage with antioxidant properties, which provides some scientific evidence for indigenous knowledge of traditionally claimed health benefits (Ranasinghe et al. 2012). It is also evident from the scientific research that these trees are a proper source for starch production. Each tree yields about 100–150 kg of starch from the pith of its trunk (Orwa et al. 2009; Wijesinghe et al. 2015). Its flour contains a considerable amount of macrominerals, including calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na) as 70.1, 66.6, 59.5, and 56.7 mg/100 g, respectively, and other nutritionally important trace elements of iron (Fe) and zinc (Zn) content as 14.0 and 3.3 mg/100 g, respectively (Wijesinghe et al. 2015). This information of high starch and mineral contents in *jeelugu* pith/flour provides scientific evidence for "famine food" of *jeeruka-ambali* (porridge with *jeelugu* flour), providing a degree of food security. It is also said that the quality of flour from this tree is equal to the best sago extracted from sago palm (*Metroxylon sagu* Rottboell) (Wijesinghe et al. 2015).

4.4 Climatic and non-climatic factors in the extinction of *jeelugu*

Despite such importance (as mentioned above), particularly for the Konda Reddis, *jeelugu* trees are on the verge of extinction for various reasons. These include (1) *jeelugu* trees are solitary palms that grow in the hilly areas in cooling weather condition and usually in small groups or solitarily (Furer-Haimendorf 1945). However, changing climatic conditions from cool to mildly hot weather, as the villagers indicated, and as also evident from the growth of *tati* trees, restrict the existence or growth of the *jeelugu* trees in the study area of Rampachodavaram. (2) The use of sago pith for the preparation of porridge during times of crop failure and food scarcity due to famine or drought or cyclones necessitated "*jeelugu*-hunting" (searching for and felling down the *jeelugu* trees for food, besides exploiting these for toddy). (3) As the *jeelugu* is traditionally tapped from its inflorescence for sap or toddy, such activity of tapping further restricts its growth and shortens its life span by about 5 years (Wickramasinghe n.d.). (4) *Jeelugu* has a unique pattern of growth of inflorescence unlike that of other palms; Konda Reddis say that flowering begins at the top of the trunk (upper leaf

[1] Pandugulu or Pandu Rajulu (i.e., Pandavas) were the kings and heroes in the epic of the Mahabharata, from whom Konda Reddis trace their origin. Konda Reddis say that the Pandavas had been dependent on the *jeelugu* sap during their forest exile.

axils) and blooms successively downwards to the trunk (i.e., in the reverse order) (see also Everett 1995; Orwa et al. 2009). The tree grows till the time of its first inflorescence and *gela* (bunch of fruits) appear at the terminal region of the tree. After that, it stops growing and starts dying, while producing some more inflorescences and *gelalu* (bunches of fruits) underneath the first *gela* in the downward direction. (5) The germination potential of this plant is low due to the hard seed coat (Rodrigo et al. 2012), and climate change may further delay it. All such conditions have together led to the decrease of *jeelugu* palms in the study area of Rampachodavaram.

On the other hand, the demand for toddy has continued and indeed increased with the growth of population in the area. For instance, my base village of Rampachodavaram had 50 households and a population of 219 in 1961 (Census 1961) but had grown to 76 households and 278 persons during 2007–2008 (source—based on my fieldwork), and to 90 households and 326 persons by 2017 (source—based on my fieldwork). Here, the households along with the population also matter because they are the loci for consumption and production as well.

Such requirements demanded the increase of *jeelugu* palms. However, *jeelugu* palms have limitations, as already mentioned, and it became difficult to "domesticate" this wild species due to varying climatic conditions and environmental and cultural reasons. In other words, as the Konda Reddis state, the *jeelugu* usually grows in a "cooling area" (cold climatic condition) like that of Maredumilli, where its growth is rapid (nearly a twofold increase) when compared with its growth in the hot climatic area of Rampachodavaram. For instance, for the first inflorescence and *gela* (bunch of fruits) of *jeelugu*, it takes about 15 years in the "cooling area" of Maredumilli, whereas it takes about 25 years or more in the hot climate area of Rampachodavaram. The quantity of toddy also varies at two folds from the "cooling area" of Maredumilli (40 l) to the "hot area" of Rampachodavaram (20 l). According to Konda Reddis, if the women come into contact with *jeelugu* tree during their time of menstruation, the *jeelugu* gives little or no toddy.

Given the above, Konda Reddis in the study area of Rampachodavaram found the *tati* trees, which were growing in other plain areas, as suitable alternatives for meeting their requirements of not only sweet sap (toddy) but other benefits as well.

4.5 The *tati*—its benefits, spread, and adoption

The palmyra palm, which is also called fan palm [*Flabellifer*—for fan-shaped leaves—is derived from flabellum (in Latin for fan)], toddy palm, and desert palm (Morton 1988), is "a multipurpose tree with great utility" and "referred to as [a] tree of life" (Chaurasiya et al. 2014:768). Although it grows in different parts of India (Chaurasiya et al. 2014; Morton 1988), "[i]t is not indigenous to this country" (Sandhya et al. 2010:86). It is "believed to be a native of tropical Africa" (Chaurasiya et al. 2014:768). It is also found in South and South-East Asia (mainly coastal areas), including Sri Lanka, Myanmar, Bangladesh (Chaurasiya et al. 2014), Pakistan, Malaysia, Indonesia (Bayton 2007), Papua New Guinea (Morton 1988), and Thailand (Barfod et al. 2015). In India, it is widespread in Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Maharashtra, Odisha, Madhya Pradesh, Bihar, and West Bengal (Ramachandran et al. 2004). It is extensively found in the sandy plains and savanna (often near the sea) (Bayton 2007).

The palmyra palm has a great value for the local people (Chaurasiya et al. 2014), as it provides several varieties of products significant for the local economies. Every part of the palm is used, though the sweet sap (toddy) is the most significant product for the local people

(Bayton 2007). Other uses include food, fiber, and timber (trunk) (Chaurasiya et al. 2014), and many products from the leaves (Morton 1988). Edible parts are seeds, fruits, and seedlings. The large seeds, before their shells harden, contain jelly-like kernels (Morton 1988) or immature soft juicy seed nuts (Chaurasiya et al. 2014). Its ripe fruit contains orange-yellow sugary pulp (Chaurasiya et al. 2014). The germinated nuts (seedlings) are also eaten after boiling these (Sandhya et al. 2010).

Knowing these benefits, the Konda Reddis have started planting the *tati* (palmyra palm) trees. They have collected the *tati-tenkalu* (seeds of *tati*) from plains areas and planted these in barren and empty lands around their agricultural fields. Thus, the Konda Reddis have adopted the *tati* plants. Later, these plants spread further by different means (human actions—intentional or unintentional, and natural means). As a result, over the last 50 years, the number of *tati* plants and their density have increased and become the source of livelihood for the Konda Reddis due to the multiple benefits provided by these trees. Thus, over the last 50 years, the *tati* was adopted due to changes in climate and other reasons.

Now, the *tati* is regarded as a plant of immense use for the Konda Reddis because they consider that it is the only tree which can meet many of their survival needs. Its trunk can be used as pillars and beams in house construction; its leaves are used for thatching roofs; its petioles are used as fibers for binding material, rope-making, and for producing *tati peechu* (extraction of a kind of fiber), which has a good market outside; its fruits are edible as already mentioned; and lastly, its toddy is life-saving as it is like a food for them for about 5 to 6 months.

It is also evident/reported in scientific studies that the fresh sap of *tati* is a good source of vitamin B complex (Morton 1988; Sandhya et al. 2010) and has a laxative property (Sandhya et al. 2010). The fruit of this tree is an important semi-arid zone resource with water content, and its ripe fruit is a rich source of sugars, vitamins C and A, and also minerals and fibers (Chaurasiya et al. 2014; Sandhya et al. 2010). Its jaggery, which is extracted from sweet sap, is reported to have more nutritious value than that found in crude cane sugar. This jaggery contains 76.86% sucrose, 1.66% glucose, 1.04% protein, 0.19% fat, 3.15% total minerals, 0.861% calcium, and 0.052% phosphorus, and also iron and copper as 11.01 mg and 0.767 mg/100 g, respectively (Morton 1988).

The Konda Reddis consider the *tati* as a *chiranjeevi* (having everlasting life), when compared with *jeelugu*, which has a unique limitation in its growth. This "tree of life" has been adopted (much like the *jeelugu*) in view of the reasons mentioned above, and cultural practices have evolved to include this tree in the traditional festival of trees (*chetlapanduga*). Now, the Konda Reddis, particularly those belonging to the younger generation, treat this tree like that of *jeelugu*, and it is worshipped on the occasion of *chetlapanduga* (cf. Misra 1998), as it became an important part of their life. Thus, in course of time, the *tati* has been internalized and indigenised (at least for the younger generation), and has become an integral part of Konda Reddi culture.

The older people of the base village said in 2007 that there were no *tati* trees in the region of Kakawada Gandi[2] about "40 years back" (50 years by now in 2017), except in a couple of villages (Dabbavalasa and Sokulagudem and a few plants in the neighboring Rakota village). This is plausibly because of varying geo-climatic conditions.[3] Some Konda Reddis from the

[2] Kakawada Gandi refers to the hilly terrain of the Kakawada village/region in Rampachodavaram mandal. It covers about 20 villages, including my base (study) village.

[3] Kakawada *Gandi* is a place in the mixed geo-climatic zone. It is within Rampachodavaram mandal and is bounded by the mandals of Maredumilli and Devipatnam. Since the Dabbavalasa and Sokulagudem villages are located close to the plains and to the Devipatnam area (that covers the riverside settlements and adjacent areas with hot climate), and experience a relatively hotter climatic condition than the study area, this may explain why *tati* trees are growing there.

neighboring Tunnuru village told me (in 2007) that the *tati* trees do not grow in their village even "today" (by that time of 2007), despite several efforts by the villagers. But now, *tati* plants have started growing there, as I have seen a few small plants recently in 2017. This change might be a result of climate change.

5 A trend of rise in temperatures: evidence from meteorological data

I would present some further evidence to support my proposition about climate change (rise in temperature) in the study area. In Table 1 below, month-wise maximum and minimum temperatures recorded in East Godavari district (where the study area/village is located) for periods of 10 years from 2000 to 2009 are given (Census of India 2011).

In the charts below (Column and Line) 1, 2, 3, and 4, the variation of temperatures based on the month-wise maximum and month-wise minimum temperatures for the years 2000 and 2009 are indicated. The data in Table 1 reveals a trend of a rise in temperatures (both maximum and minimum) from 2000 to 2009 and the charts clearly show this trend of rise in temperatures, which is an indication of climate change.

Temperatures in the region reach a maximum of 48 °C nowadays. For instance, on 26th May 2015, the temperature in Rajahmundry, the nearest town/city to the study area, reached 48.3 °C, the highest in Andhra Pradesh (The New Indian Express 2015). Though the above data is at the regional level, this would also reflect the climatic change at the village level since the village is a part of the region/district. The data is also significant in the context of the non-availability of village-specific climatic data.

Table 1 Temperatures (month-wise maximum and minimum) for a decade (2000–2009) in East Godavari district (study region)

Sample number	Year/ month	Maximum/ minimum	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2000	Maximum	29.5	30.2	33.2	36	38.1	34.1	32.5	31	32.9	33.5	31.2	29.4
		Minimum	20	22.5	23.3	26.6	27.9	26.5	26.1	25.5	26	24.9	22.6	19.3
2	2001	Maximum	29.3	32.1	33.8	34.8	38.3	33.9	33.5	31.7	33.3	32	30.4	29.3
		Minimum	19.9	21.9	24.3	26.1	28.2	26.7	26.6	25.7	26.1	25.3	23.5	19.7
3	2002	Maximum	29.4	31.6	34	36.2	39.5	35.9	37.2	31.8	34.2	31.9	30.7	29.9
		Minimum	20.6	21.3	23.6	26.3	28.6	27.5	28.1	25.7	26.3	24.8	21.7	19.9
4	2003	Maximum	29.1	30.7	33.2	36.8	38.2	37.3	31.5	32.1	33.3	30.7	30.7	28.1
		Minimum	19.7	22.6	24.2	26.6	28.7	27.8	26	26.4	26.3	25.1	22	20
5	2004	Maximum	28	30.7	34.5	36.3	35.9	35.6	32.7	32.8	32.6	31.4	30.9	30.2
		Minimum	19.7	21.1	24	26.9	27.8	27.3	26	26	25.9	24.6	21.1	19.4
6	2005	Maximum	30.4	32.4	34.2	36.1	37.3	38.1	32	33.1	31.1	30.7	30.3	29.1
		Minimum	21.3	21.4	24	26.5	27.7	27.7	26.1	26.2	25.7	25.4	21.5	20.1
7	2006	Maximum	30.1	32.7	34	35.5	35.9	36.5	33.6	31.8	32.4	33.6	30.1	30.1
		Minimum	19.5	20.2	24.1	26	27.5	27.6	26.9	25.8	25.7	25.2	22.9	20.8
8	2007	Maximum	29.9	31.2	33.2	35.9	38.6	35.3	33.5	32.3	31.6	31.7	31.7	30.2
		Minimum	20.3	20.7	23.8	25.8	28.5	27.3	26.4	26.2	26.1	24.5	22	21.2
9	2008	Maximum	30.6	30.9	33.3	35.5	39.6	34.1	33	31.6	32.3	33.5	32	30.9
		Minimum	19.3	22.4	22.7	26	28.2	26.6	26.2	25.7	25.9	24.6	22.8	20.9
10	2009	Maximum	31	32.5	34	36.5	37.7	38.5	33.2	34.5	33.9	33.6	31.6	30.5
		Minimum	20.7	22.2	23.8	26.5	27.8	28.2	26.3	26.9	26.6	24.9	23.9	20.2

Source: Indian Meteorological Department, Hyderabad, tabled in Census of India 2011:22

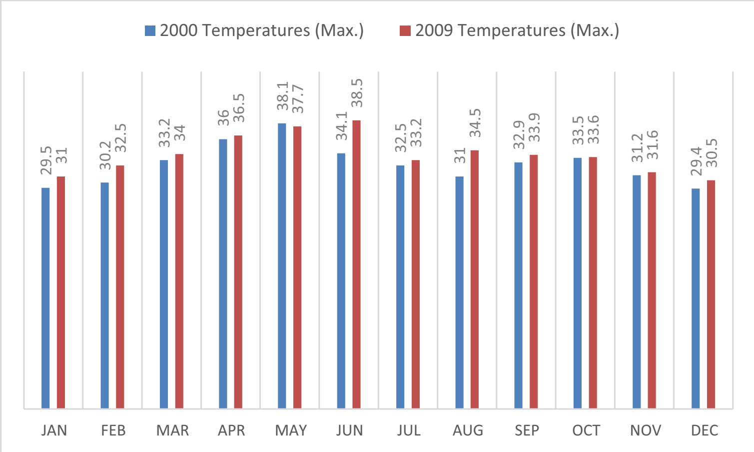

Chart (Column) 1 Variation of temperatures (month-wise maximum) between 2000 and 2009 in East Godavari district (study region)

6 Discussion and conclusion

Given the context of the politics of global climate change, this paper has addressed the impact of, and response to, climate change at the local level among the indigenous and vulnerable population, with reference to the Konda Reddis. Though the mainstream discourse projected the local people as more vulnerable to climate change and undervalued the local knowledge, it is found that the Konda Reddis have a profound knowledge of their local environment and effective adaptive capacities, which are important for their survival and for limiting the risks of climate change.

Konda Reddis traditionally grow different varieties of crops in order to minimize the risk of crop failure caused by varying climatic reasons. In times of harvest failure and food scarcity due to extreme weather events or climatic conditions (cyclones or drought and famine), Konda

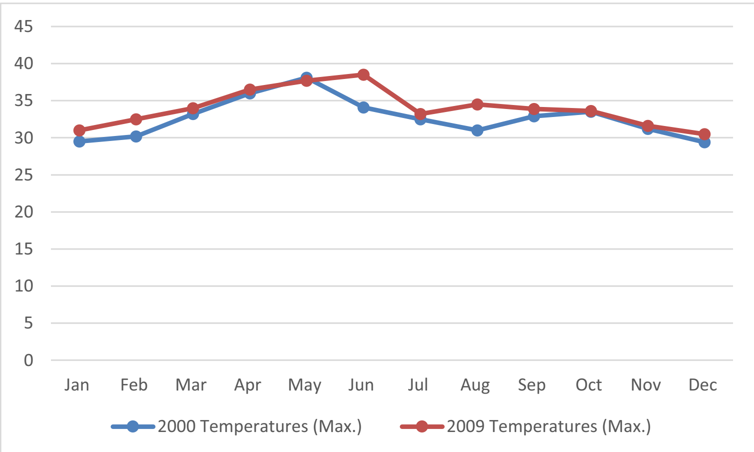

Chart (Line) 2 Variation of temperatures (month-wise maximum) between 2000 and 2009 in East Godavari district (study region)

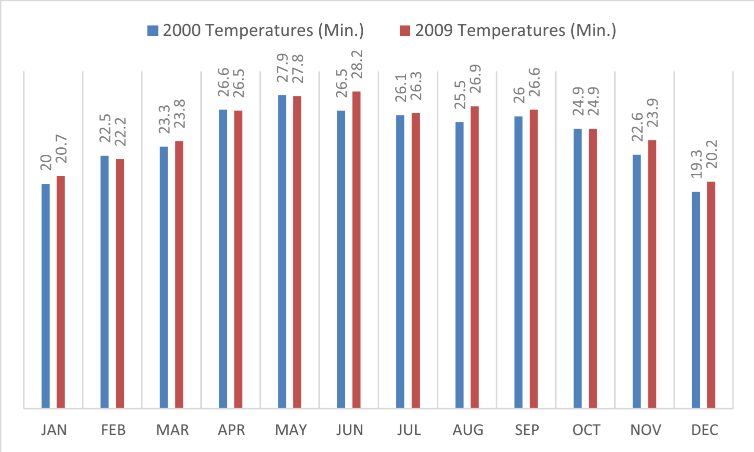

Chart (Column) 3 Variation of temperatures (month-wise minimum) between 2000 and 2009 in East Godavari district (study region)

Reddis used to switch from their dependence on shifting cultivation to reliance on alternative food sources in the forest, such as the *jeelugu*, from which they extract starch and prepare porridge.

Konda Reddis have extended their useful adaptive strategy to further respond to climate change by shifting from *jeelugu* to an alternative species of *tati* (like switching of crops). The climate-induced change from cool to relatively hot weather, as some Konda Reddis indicated, and also as evident from the growth of *tati* trees, restricts the growth of the *jeelugu* trees in the study area. The succession and increasing importance of *tati* over *jeelugu* reveals the coping strategies of the Konda Reddis to the changing climatic conditions.

Unlike the *jeelugu*, the *tati* is found in tropical and dry climatic regions (Chaurasiya et al. 2014; Morton 1988; Sandhya et al. 2010). Hot and sunny conditions are suitable for this plant to grow. It is drought tolerant, but cold sensitive (Sandhya et al. 2010). It grows wild (Morton 1988) and is

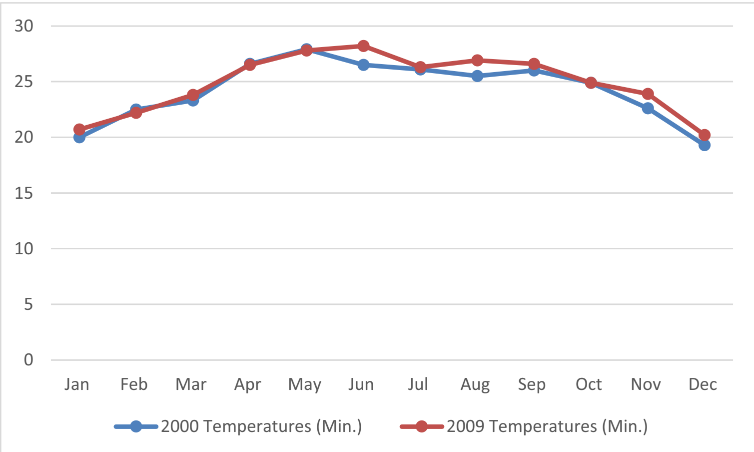

Chart (Line) 4 Variation of temperatures (month-wise minimum) between 2000 and 2009 in East Godavari district (study region) cultivated in open lands, with well-drained conditions (Sandhya et al. 2010). It is well adapted to agroforestry systems and home gardens (Barfod et al. 2015). The *tati*, with such characteristics, emerged as a viable alternative to the *jeelugu*. With this, the supplementary subsistence base of the Konda Reddis has shifted from the traditional *jeelugu* sap and starch extracted from its pith (during times of crop failure) to the products of the *tati*.

It is also important to note here that though climate change plays a significant role in stimulating adaptation, multiple other stimuli can also trigger such adaptive responses. In other words, there are also some non-climatic factors that have motivated the Konda Reddis to shift from the *jeelugu* to the *tati* palm. They include (1) increased pressure on the *jeelugu* from the increased population; (2) *jeelugu*'s unique nature of growth unlike other palms (as it grows till the time of its first inflorescence at the terminal region of the tree and then it starts dying); (3) increased demand for toddy and the activity of tapping (that is reported to further restrict the growth/lifespan of *jeelugu*); (4) scarcity of *jeelugu* due to the above and following reasons: increased pressure on the forestlands owing to growing population demand for slash and burn cultivation with shortened fallow periods, the change from shifting cultivation to cashew plantation that in turn causes more pressure on the forestlands for want of more lands for such cultivation (see Kodirekkala 2017), the conditions of which subsequently lead to reduction and loss of plant diversity including the *jeelugu*, which is a slow-growing and shade-demanding species; and (5) relative ease of cultivating of the *tati* palm—as it is well adapted to home gardens, barren lands, agroforestry systems, or empty lands around the agricultural fields, and hot climate. All such factors together or in combination with one another led to the decrease of *jeelugu* palms in the study area. Thus, there is a relative contribution of climatic vis-à-vis non-climatic factors in the spread and adoption of *tati* palms by the Konda Reddis.

6.1 To conclude

The Konda Reddis have adapted to climate change by shifting from *jeelugu* and increasingly adopting *tati*, which seems to have been a positive opportunity for them. This adaptive shift helps them to (1) cope with the problem of degradation and extinction of the *jeelugu* trees, (2) increase their knowledge base regarding the use of local resources without having to depend on the market, and (3) combat climate change, as the trees absorb carbon dioxide (CO_2) from the atmosphere. Since the trees have the ability to absorb emissions and withstand high temperatures or water stress (during times of drought or flood), India plans to increase its forest cover from 24 to 33% as part of its national action plan to counter climate change (to absorb CO_2 of 2.5 to 3 billion tons by 2030) (HuffPost India 2015). Unlike the solitary *jeelugu*, the large stands of *tati* can contribute to increasing the agroforestry cover that would minimize the adverse impacts of climate change.

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