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Neem (*Azadrachta indica*): Multipurpose Tree Plant for Doubling Farmers Income in India

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A B S T R A C T

Neem is indigenous to India and used in afforestation programmes. It grows in tropical and subtropical regions across the world. Because of its therapeutic value, Neem oil extract is used to treat type 2 diabetes and neurological diseases such as Alzheimer. Neem, being a multifunctional tree, assists farmers in double their revenue through carbon credit under the clean development mechanism (CDM). Neem provides Fuel wood, timber, and soil fertility enhancement. Farmers in Karnataka profited from the carbon sequestered by the plants they cultivate. Farmers in the state's kolar area are planting mango and tamarind trees with the help of charity women for sustainable development, and they are selling carbon credits for each tone of CO2 absorbed by the plant. As a result, Neem is a source of income for many people. The Indian government's goal to expand agriculture and tree planting should include innovative, profitable agribusiness, as well as sustainable and resilient farming. Inadequate non-farm services, small holding sizes, a challenging rural environment, and general insecurity are all obstacles to agriculture and tree plantation. According to the Environmental Authority Act, every tree must be transplanted, and if this is not possible, 5 new seedlings must be planted. Under this Act, anyone who fells a tree shall pay a fine of Rs.10, 000 or face three months in imprisonment, however the key difficulty with the policy is that Tree Authorities are not present in every city in India, there have been countless cases of corruption when several violators got away by bribing or just paying up the price. It is proposed that a tree authority be dispatched to each state, and that Indians invest in research and development, infrastructure building, and technological implementation. The aim of the review is to shade more light on why the need of multipurpose tree/s, where they are found with respect to agro-climate zones of India with focus to Rajasthan state, their importance, policy details, limitations and future strategy.

Introduction

Azadirachta indica is one of Mother Nature's most outstanding trees. *Azadirachta indica* is a Meliaceae tree that grows in the tropical and subtropical regions of India, Pakistan, and Bangladesh. It may be found from Kerala in southern India to the Himalayan Mountains (Jhariya *et al.*, 2013). Andhra Pradesh is another state in India where the neem tree may be seen growing. includes Andhra Pradesh, Assam, Bihar, Delhi, Gujarat, Haryana, H.P., Kerala, M.P., Maharashtra, Meghalaya, Orissa,

Punjab, and Rajasthan (Fathima *et al.,* 2004). It covers both tropical and subtropical latitudes, and ranges from humid tropical to semi-arid areas, with elevations ranging from sea level to 2,300 feet. It may yield up to 50 kg of fruit each year after it reaches the tenth year (Kumar and Gupta, 2002). Neem is the most adaptable, multifaceted tree with enormous potential and the greatest number of non-wood products (Girish, 2004 and Shankara, 2008). In Sanskrit, neem is known as arista, which means "perfect, complete, and imperishable." It's been utilised in Ayurvedic medicine for a long time. It is known as "The Village Pharmacy" because of its medicinal importance. In addition, it has a high microbiological activity (Imran *et al.,* 2010).

However, the Neem tree is also grown in Africa (Fathima *et al.,* 2004), where it has been utilised in medicinal folklore for centuries. It has been noted that many elements of the Neem tree, including the leaves, bark, fruit, flowers, oil, and gum, are linked to the aforementioned medicinal folklore in the treatment of cancer, hypertension, heart disease, and dialysis. The potential effects of these extracts can undoubtedly be attributed to cellular and molecular mechanisms, which include free radical scavenging, detoxification, DNA repair, cell cycle alteration, programmed cell death mitigation and autophagy, immune surveillance, anti-inflammatory, anti-angiogenic, and anti-metastatic activities, and the ability to modulate a variety of genes (Deye *et al.,* 2016). Trees are typically a source of security for poor rural communities in many African nations, giving food, energy (Koffi *et al.,* 2017), and a source of revenue for the inhabitants (Garrity, 2010). Rural households frequently harvest tree products for personal use and/or resale (Johns *et al.,* 2011).

Some trees can be intercropped with domestic crops to improve soil fertility (Pokwana *et al.,* 2020). Trees also provide food, medicine, windbreaks, and firewood, among other things. Furthermore, trees play a vital role in the livelihoods of small-scale farmers and rural communities since they serve as a safety net as well as a way of poverty reduction (Shackleton *et al.,* 2005). In fact, rural people are both aware of and reliant on the products and services that trees give (Shackleton *et al.,* 2007). In a research done by (Kisangau *et al.,* 2021) in the central mountainous part of China's Hainan Island, the primary source of family income (74 percent) was generated from tree planting operations, which provided 46 percent of total revenue. It is particularly essential for rural homesteads since it supplies tree products such as fodder, firewood, woodcraft, medicinal plants, and food for animals and humans without requiring people to travel to woods (Alao and Shuaib, 2013). When a multifunctional tree is planted, however, a variety of demands and functions may be met at the same time. They may be utilized as a windbreak as well as a source of food for the owner. They may be used as fence posts in a living fence as well as the owner's primary supply of firewood. They may be intercropped into existing fields to provide nitrogen to the soil while also serving as a food and fuel source. Most trees found on tropical farms should be multifunctional, providing more than just shade and firewood to the farmer. They should, in most circumstances, be nitrogen-fixing legumes or trees that considerably boost a farmer's food security (2009).

Furthermore, the Indian government's plan for boosting agriculture and tree plantation as a whole should incorporate creative, successful agribusiness, as well as sustainable and resilient farming (2016). Inadequate non-farm services, holding size, an unfriendly rural climate, and overall insecurity are all barriers to agriculture and agroforestry. The policy is as follows: Every tree must be transferred, and in circumstances where this is not possible, 5 fresh seedlings must be planted, according to the Environmental Authority Act. This is a more powerful act that ensures that the environment is treated correctly and compensated for destruction. Under this Act a fine of Rs.10,000 must to be paid for any person who felled the tree/trees or three months in jail,but the major challenge in the policy is that Tree Authorities are not present in every city of India and there have been several instances of corruption where many violators get away by either

bribing or just paying up the amount.

The aim of the review is to shade more light on why the need of multipurpose tree/s, where they are found with respect to agro-climate zones of India with focus to Rajasthan state, their importance, policy details, limitations and future strategy.

Advantage of *Azadirachta indica* as Multipurpose Tree

Medicinal uses of Neem Oil Extract in India

When Neem tree extract is used, it can be attributed to cellular and molecular mechanisms such as free radical scavenging, detoxification, DNA repair, cell cycle alteration, programmed cell death mitigation and autophagy, immune surveillance, anti-inflammatory, anti-angiogenic, and anti-metastatic activities, and the ability to modulate various signaling pathways (Deye *et al.*, 2013). Furthermore, traditional use has demonstrated that ingesting Neem offers advantages (Al Akeel *et al.*, 2017), although there is a lack of current knowledge about toxicity levels and thorough characterization of components are not fully understood (Islas, 2020). Neem contained Flavonoids which function as inhibitors of prostag-landin biosynthesis, and endoperoxides and the enzymes like protein kinases and phosphodiesterases, all involved in inflammation (Batista, 2018). The leaf of the Neem tree appears to have generated a specific combination of glycoproteins known as neem leaf glycoprotein (NLGP) that, when tested on mammalian subjects, demonstrated immune-modulatory action, potentially limiting tumor progression by influencing both local and systemic immunity (Saptak Banerjee *et al.*, 2014). Proline is a current therapy for neurological disorders such as Alzheimer's and Parkinson's disease, Type 2 Diabetes Mellitus, and Polycythemia, according to biochemical study of leaf extracts (Dash *et al.*, 2017). Antimicrobial and insecticidal properties of neem-derived extracts have been discovered, however; Azadirachtin is a complex tetranortriterpenoidlimonoid found in Neem seeds that is responsible for the poisonous effects on insects also experiments revealed that an ethanol extract of neem leaves has antibacterial activity in vitro against both *S. aureus* and MRSA (Gupta *et al.*, 2019).

Economic Uses of Neem Tree

One of the most promising of all plants, for the simple reason that it has the potential to help everyone on the world. No other plant produces as many unusual and diversified goods, nor does it have as many exploitable by-products. India is the world's leading producer of Neem seeds, with roughly 4, 42,300 tons produced yearly, generating 88,400 tonnes of Neem oil and 3, 53,800 tonnes of Neem cake. Apart from a few medical plants acquired from forests, Neem is possibly the only tree that has been theoretically exported among forest products (Nabard, 2011). As a result, several industrialized nations with limited Neem resources, such as the United States, Japan, Germany, France, and the Netherlands, have been importing Neem products mostly from India, Pakistan, and Bangladesh. According to the findings of large-scale field trials done important food crops such as rice, maize, sorghum, banana, and vegetables such as cabbage, cauliflower, cucumber, okra, and potato, etc., have illustrated the value of Neem-based pest management for enhancing crop productivity. The use of Neem and fertilizer mixes can minimize the ammonia volatilization loss produced by nitrifying bacteria in soil, resulting in fertilizer savings. In orchards and household gardens, Neem oil has been used to combat pear slugs in various ways. Neem wood is long-lasting and termite-resistant, making it ideal for building poles, furniture, and other structures. Neem is a good source of fiber in rural India (Anonymous, 2006).

Role of Neem Tree in Carbon Sequestration

Carbon sequestration became popular in the 1980s as a result of the continually rising CO2 levels in the atmosphere. Carbon sequestration (CS) is the process by which plants absorb CO2 from the

atmosphere and store it first in live biomass in its pool, then in dead organic matter (DOM) in the form of litter, dead trees, and harvest residues, or to the carbon pool of wood products (Dao *et al.,* 2021). However, current global greenhouse gas (GHG) emissions are predicted to be 10 Pg (Pg = Petagram, 1 Pg=1015 68 69 g) carbon (C) per year (Nath, 2020), with India ranking third behind China and the United States (Jitendra Ahirwal *et al.,* 2021).

Due to their biomass and diversity, trees are also one of the most important aspects of every landscape. Because 50% of their standing biomass includes carbon, trees are major sinks for atmospheric carbon. Neem is currently grown in practically every part of the nation and is a key component of India's afforestation programs (Chavan *et al.,* 2017). However, In northern Dry zone of Karnataka there was a good amount of Carbon sequestration by the *A. indica* planted in farm lands of ARS Raichur than the Shaktinagar among two places in the Zone, which will create a good long term sink of Carbon and reduces the global warming (Chavan *et al.,* 2017). Forest ecosystems serve as carbon sinks in nature. They store massive amounts of carbon and manage the carbon cycle through CO exchange with the atmosphere. One of the most important carbon sinks in the terrestrial environment is the forest ecosystem. Photosynthesis absorbs carbon dioxide from the atmosphere and stores it in the plant's tissues. Forest ecosystem is one of the most important carbon sinks of the terrestrial ecosystem. Plant uptakes the carbon dioxide by the process of photosynthesis and stores the carbon in the plant tissues. Forest ecosystem plays important role in the global carbon cycle by sequestering a substantial amount of carbon dioxide from the atmosphere. Another study on carbon stock in Neem was done in Niger, and the results showed that Neem is one of the trees that can store carbon (Moussa *et al.,* 2018) Moreover, in determining carbon stocks in tree plants, destructive (Kunhamu *et al.,* 2018) and non-destructive (Bhardwaj and Chandra, 2016) methods are adopted, however, in recent advancement both drones, robot and RS-GIS are parts to determines carbon stocks, but in India tree destruction attracted a penalty of 10,000 rupees or three years impressment as policy by the Indian government unless if permitted by the forestry department or tree authority of India.

Carbon Credit in India

Farmers in Karnataka are reaping the benefits of their labor in a variety of ways. They not only profit from their goods, but they also profit from the carbon dioxide (CO2) trapped by the plants they grow. In the process, they provide a cost-effective way for industrialized countries to cut their greenhouse gas (GHG) emissions. These farmers' carbon credits might be evaluated under the Clean Development Mechanism (CDM), which allows a commercial or governmental organization to engage in afforestation or reforestation projects and sell the stored CO2 to industrialized countries to assist them achieve their Kyoto Protocol emission requirements.

Farmers in the Kolar area of the state are planting mango and tamarind trees with the support of a charity called Women for Sustainable Development (WSD), and selling carbon credits for each tonne of CO2 absorbed by these plants. Plants absorb CO2, a heat-trapping gas whose rising quantity in the atmosphere is contributing to global warming and other environmental problems.

Marginal farmers with 8-2.02 hectares of dry land are now engaging in such programmes because they are struggling to make ends meet on their annual agricultural revenue. "Most of the farmers are planting these trees on.4 hectares of land in the hopes of making money in roughly five years," says WSD director Anandi Sharan. Approximately 70 of these farms have previously sold CO2 that trees on their land will potentially sequester over a full lifetime to Future Forests.WSD assesses a fee of $12-13 per tonne of carbon (tC) stored in trees, with the farmer receiving $10 per tC. On average, 4 hectares of land with around 200 trees (a combination of 120 mango and 20 tamarind trees) can sequester roughly 20 tC, with diverse fuel plants such as Neem and acacia on the boundary. Over the

course of nearly 40 years, this amount is trapped. Farmers are first paid 50 percent of their crop.

Farmers in the state, on the other hand, have been uncertain to support such initiatives because the majority of them are landless. The programme is further hindered by the area's low soil quality and water shortage.

Agro-Climatic Zones in Rajasthan, India

Agro-climatic means land unit uniform in respect of climate and length of growing period (CLGP) which is climatically suitable for a certain range of crops and cultivars (FAO; 1983)

India has been delineated into 126 agro-climatic zones by the Indian Council of Agricultural Research (ICAR). Similarly, Rajasthan has been divided into 10 agro-climatic zones. The Agro-climatic zones of Rajasthan are as follows:

Irrigated North Western Plain

Hyper Arid Partial Irrigated Zone

Transitional Plain of Inland Drainage

Alluvial Plain of Luni Basin

Semi-Arid Eastern Plain

Flood Prone Eastern Plain Arid North Western Sandy Plain

Flood Prone Eastern Plain

Sub Humid Southern Plain and Aravallis

Humid Southern Plain

Humid South Eastern Plain (RAJRAS, 2010).

Breakthrough of Neem Tree in India

Neem which is commonly known to be used as antimicrobial agent is now used to aid biomethanation. In India, many biogas plants process cattle dung (CD). At the same time, an excessive amount of litter of leaves is swept and burnt. However, research investigated that small-scale integration of leaf litter of Neem (LLN) to the operational CD-based biogas plant under mesophilic conditions can be done. The introduction of LLN at the volatile solid ratio of 1:4 (LLN: CD) respectively improved daily biogas production, specific methane yield, and the resultant electrical energy by 13.11, 15.26, and 15.02% and reduced the proportion of CO2 by 5.85%. However, because of the energy required to crush the LLN in CD-LLN–based, the net percentage increase of the electrical energy dropped to 13.59%. CD-LLN–based reactor also produced 56.34% higher electrical energy per organic substrate additional and performed well by 15.0% in terms of CO2 emission compared to CD-based. Digester performance was seriously unaffected during the transition stage (Muhammad *et al.,* 2020).

Strategy towards Improving Farming

The strategy that government needs to adopt to boost farming includes;

Stable, safe and affordable food supplies

Sustainability and resilient farming

Innovative, and profitable agribusiness

Limitations /Challenges

Overcrowding in agriculture

Unhealthy rural atmosphere

Inadequate non-farm services

Size of holding

Insecurity

Investment inadequacy

Poor techniques of production

Inadequate irrigation facility

One of the major barriers to the growth of the cultivation in India is the lack of investments on research & development, infrastructure creation and implementation of technology (Kumar, 2019).

Policy of Tree Felling In India

As per the Environmental Authority Act, every tree must be transplanted and in cases where they cannot be transmigrated, 5 new saplings must be planted. This is a stronger act which ensures that the environment is handled in a responsible way and compensated for destruction.

According to this Act, the penalty for cutting down a tree is Rs.10, 000 or 3 months imprisonment. There are several instances reported in which laymen ended up paying Rs.10, 000 as compounding fee to the forest department for cutting down trees in their premises. Despite the fact of the policy, a lot of challenge may arose such; Tree Authorities are not present in every city of India and there have been several instances of corruption where many violators get away by either bribing or just paying up the amount.

Laws Protecting Trees Plants and Even Bushes from Being Cut Down

The Indian Forest Act 1927.

Preservation of Trees Act 1984.

Forest Conservation Act 1980.

Punjab Land Preservation Act 1900.

Hill Areas (Preservation of Trees) Act 1955.
Assam (Control of felling and removal of Trees from Non Forest land) Rules 2002.

Bihar Kashth& other Forest Produce Transit Regulations 1973.

ChhattisgarhAdimJanjatiKaSarankshan (Vrikshon Me Hit) Adhinium 1999 Chhattisgarh Transit (Forest produce) Rule 2001.

Delhi Tree Preservation Act 1994.

Saurashtra Felling of Trees (Infliction of Punishment) Act 1951.

Himachal Pradesh Land Preservation Act 1978

Rajasthan Forest Produce Transit Rules 1957

Tamil Nadu Preservation of Private Forest Act 1949.

Recommendation

The review used secondary data obtained from Google, Google scholar, Springer, Elsevier, Taylor and Francis, IEEE and concluded the following information, that Neem is indigenous to India and is used in afforestation programmes. It grows in tropical and subtropical regions across the world.

Because of its therapeutic value, Neem oil extract is used to treat type 2 diabetes and neurological diseases such as Alzheimer. Neem, being a multifunctional tree, assists farmers in double their revenue through carbon credit under the clean development mechanism (CDM). Fuel wood, timber, and soil fertility enhancement were also witnessed from Neem. The tree is so crucial to life in India that the Hindu villagers described how they worship it as a God, and told the story of Lord Krishna comparing himself as a God amongst men as the Neem tree is a God amongst trees.

Table.1 Number of Neem based industries worldwide

Country	Number of Products
India	100
Kenya	8
Germany	5
USA	5
Australia	2
Canada	1
China	1

Shinde and Biswas, 2011

Table.2 Volume, biomass and amount of carbon sequestered by Aindica at different ages of growth

Different site	Parameters	Initial (5YAP)	6 YAP	7 YAP	8 YAP	9 YAP
RTPS	Volume (m^3)	0.018	0.024	0.037	0.048	0.065
Shaktingar Biomass	(ton ha^{-1})	8.00	10.57	16.50	21.44	29.14
Carbon sequestration	(ton ha^{-1})	3.84	5.07	7.92	10.29	13.99
ARS Ratchur	Volume (m^{-3})	0.021	0.028	0.039	0.049	0.073
Biomass	(ton ha^{-1})	9.39	12.69	17.40	22.02	32.55
Carbon sequestration	(ton ha^{-1})	4.51	6.09	8.35	10.57	15.68

Where RTPS = Ratchur Thermal Power Shaktingar, ARS – Agricultural Research Statio, YAP – Years after planting.

(Chavan *et al.*, 2017)

Table.3 Carbon sequestration from selected forestry projects in India

	SevaMndir	FES	Total
Area under post -1990 plantation (ha)	7878	33415	41293
Annual above-ground biomass growth (tons)	8950	42096	51046
Carbon sequestration (C02/year)	16468	77457	93925
Potential annual market (C02/year)	US$ 65872	US$309828	US$375700

Table.4 Carbon sequestration potential of TIST-India

Total number of live trees	**>600.000**
Carbon sequestration- (C02/year	15000
Potential annual market value (C02/year) at CCX AT US$ 4/tco2	US$60,000

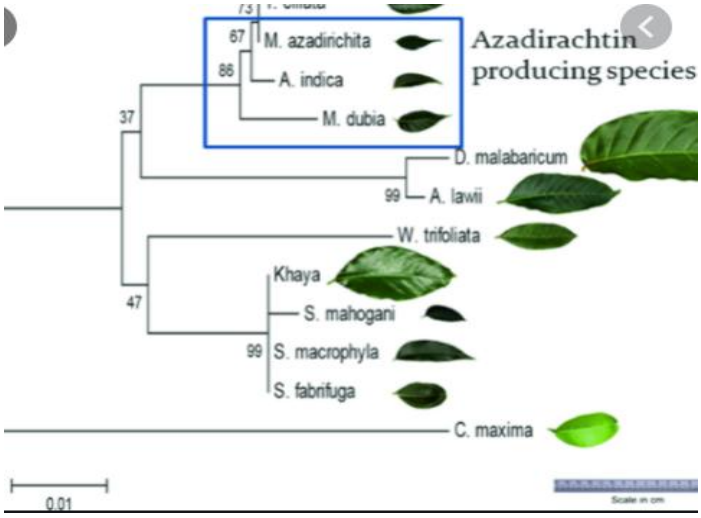
(Chavan *et al.*, 2017)

Table.5 Trees Grown with respect to agro-climatic zones in Rajasthan, India

S.No	Scientific name	Local name	Family name	Place name	Plant parts used for medicine	Climatic zone
1	Prosepsiscineria	khejarli	Arecaceae	Jaisalmer, Barmer, Bikaner and Jodhpur districts	Leaves and pods (leprosy, dysentery, asthma, leucoderma, dyspepsia and earache)	1. Arid North Western Sandy Plain
2	*Mangifera indica*	Aam	Anacardiaceae	Ganganagar, Hanumangarh and north western part of Bikaner district.	leaves helps in keeping body energetic	Irrigated north western plain
3	*Cenchrus americanus*	Bajrasajje	Poaceae	Bikaner, Jaisalmer and parts of Churu	Seeds use to maintain blood high sugar due high fibre content	Hyper arid partial irrigated zone
4	Acacia nilotica	Babool	Fabaceae	Eastern and northern part of Nagaur and entire Sikar, Churu and Jhunjhunu districts.	Seeds used as topical treatment to help wound healing	Transitional plain of island drainage
5	Ziziphussp	Jujube	Rhamnaceae	Pali, Jalore, part of Nagaur, Jodhpur and Barmer districts.	Seeds helps to Stimulate appetite and wound healing	Alluvial plain of luni basin
6	Azadirachtaindica	margosa	Maliaceae	Jaipur, Ajmer, Dausa and Tonk districts. The plain is sandy plain.	Both leaves and used as anti-malaria, stem used for carbonsequestration	Semi-arid eastern plain
7	Citrus limon	apnkheti	Rutaceae	Alwar, Bharatpur and Dholpur districts	Juice and peels are used to treat scurvy	Flood Prone Eastern Plain

8	*Gossypium* spp	Cotton	Malvaceae	Bhilwara, Rajsamand, Sirohi, Udaipur and Chittorgarh districts.	Bark of the tree to treat nausea, fever, headache, diarrhea, dysentery, nerve pain, and bleeding, Women use cotton for menstrual disorders and symptoms of menopause.	1. Sub Humid Southern Plain and Aravallis
9	*Mangifera indica*	Aam	Anacardiaceae	Dungarpur, Banswara and Pratapgarh districts.	leaves helps in keeping body energetic	1.Humid Southern Plain
10	*Psidium guajava*	Guava	Myritales	SawaiMadhopur, Karauli, Jhalawar, Baran, Kota and Bundi districts.	leaf use for stomach and intestinal conditions, pain, diabetes, and wound healing. The fruit is used for high blood pressure too	1.Humid South Eastern Plain

Fig.1 Phylogeny of Neem and Related Species



[18]

Fig.2

Forests can sell carbon through CCX
(Photo credits: Rohit Jindal)

Farmers in Karnataka profited from the carbon sequestered by the plants they cultivate. Farmers in the state's kolar area are planting mango and tamarind trees with the help of charity women for sustainable development, and they are selling carbon credits for each tone of CO2 absorbed by the plant. As a result, Neem is a source of income for many people. The Indian government's goal to expand agriculture and tree planting should include innovative, profitable agribusiness, as well as sustainable and resilient farming. Inadequate non-farm services, small holding sizes, a challenging rural environment, and general insecurity are all obstacles to agriculture and tree plantation. According to the Environmental Authority Act, every tree must be transplanted, and if this is not possible, 5 new seedlings must be planted. Under this Act, any anyone who fells a tree shall pay a fine of Rs.10, 000 or face three months in imprisonment, however the key difficulty with the policy is that Tree Authorities are not present in every city in India, there have been countless cases of corruption when several violators got away by bribing or just paying up the price. It is proposed that a tree authority be dispatched to each state, toxicity of Neem should not be overlooked, weather modification using lessers (cloud seeding with silver iodide), solar radiation project and carbon dioxide removal projects which will change the dimension of the world in terms of ecosystems, monsoon pattern and neighboring countries would face a serious hazardsall the projects are china conspiracy should totally be avoid worldwide, plant destruction approach should be avoided, non-destructive methods such asRS-GIS should be considered and that Indians invest in research and development, infrastructure building, and technological implementation.

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