Agriculture development calls for greater attention to be paid to the arid and semi-arid regions. In these regions the success of crop production is by and large associated with climatic, edaphic and hydrological conditions. The potential for agricultural growth in these dry areas is considerable, if the crop farming is effectively and scientifically managed with a good scientific knowledge of agro-climatology of the specific regions. The basic agro-climatic information of dry areas is very essential especially for the farming communities to choose the suitable crop and operations of its cultivation for successful and sustainable crop production system. It is in this perspective, the present research theme "SOME ASPECTS OF AGRO - CLIMATOLOGY AND GROUNDNUT CROP MANAGEMENT IN THE DROUGHT PRONE ANANTAPUR DISTRICT", is attempted with an objective of applied significance. It is hoped
that the present scientific study at micro-level will immensely help to evolve both prophylactic and curative measures and ultimately to improve the suitable and sustainable system of groundnut cultivation and its economy in the district.

From the present study of "Some Aspects of the Agro-climatology and Groundnut Crop Management in the Drought Prone Anantapur District" the following conclusions are made:

1. Anantapur district as a whole has the rainfall of very scanty, irregular, uneven and uncertain. The district has very low number of rainy days (35 days) in the State. A maximum rainfall of 49 mm., has been received during 38th week which comes under the influence of south-west monsoon. It is noticed that the district receives large share of rainfall from south-west monsoon and it followed by north-east monsoon. The rainfall during south-west monsoon is crucial for sustainable agriculture. Comparatively the areas of Kadiri, Hindupur and Madagasira in the south and Gooty in the north receive good rainfall than the other parts of the district. The areas of Rayadurg, Kalyandurg and Uravakonda on the west and north-west receive very low amount of rain fall. It is found that the rainfall decreases from south and south-east to west and north-west.
2. There has been a significant variation in the distribution of rainfall which is evident from the fact that the coefficient of variation of rainfall is high in the district. Even during peak rainy season, the coefficient of variation of rainfall is high which accounted for more than 60 per cent. During the highest rainfall week (38th week) the average coefficient of variation is 105 per cent. Here it is observed that the high rainfall areas of the district are found with high coefficient of variation of rainfall. The active monsoon periods are also found with high variability of rainfall. The less variability of rainfall is found in the non-monsoonal weeks namely, winter, summer pre-monsoonal weeks. It is inferred that with the decrease of rainfall there is a decrease in the coefficient of variation of rainfall; and with the increase of rainfall, there has been an increase in the variation of rainfall. The rainfall ratio values have also indicated that there has been greater instability and anomalies and abnormalities in the occurrence and distribution of rainfall in the district. The high rainfall ratio values are noticed in the low rainfall weeks confining to winter and summer periods. The low rainfall ratio values are found in the weeks of high rainfall during the south-east monsoon.

3. The comparative account of weekly rainfall has revealed that the rainfall is over and above the average is found in 24 weeks in two time schedules. In the first phase, the rainfall above the mean rainfall is found from 20th to 23rd week (May 14 – July 10).
consisting of 4 successive weeks. In the second phase, there has been a long continuous period ranging from 36th week to 44th week which consisting of 20 weeks accounted for higher rainfall than the average rainfall. It speaks that this period is the crucial period for all the agricultural operations i.e., from showing top harvesting. The high amount of rainfall period is noticed from 35th week to 41st week in the district.

4. During the crop period stage i.e., from 26th week to 44th week (July to Mid October) Kadiri has had a better distribution of high amount of rainfall without sharp fluctuations. It is followed by Gooty, Madakasira and Hindupur areas. On the other extreme side, Rayadurg, Uravakonda, Penukonda, Kalyandurg and Anantapur have been experienced with low distribution of rainfall with striking and disturbing fluctuations in the amount of rainfall during the crop period. Dharmavaram, and Tadpatri are found with moderate distribution with significant fluctuations in rainfall during the cropping season.

5. The trend of aridity index has revealed that there are striking fluctuations from the normal aridity index. Kadiri and Dharmavaram stations have been experienced with maximum number of drought years in Gooty. In many parts of Anantapur district the trend of aridity index has been ranging between 27 weeks and 35 weeks in a year above the mean aridity index in contrast to 15 to 25 weeks below the mean aridity index.
6. Maximum severe drought weeks were noticed in Gooty (15 weeks) and whereas minimum severe drought weeks were noticed in Uravakonda (3 weeks). Maximum large drought weeks were noticed in Uravakonda and Kalyandurg (18 weeks each) and minimum in Gooty (5 weeks). The maximum number of moderate weeks of 15 noticed in Kadiri in contrast to the minimum of 7 weeks in Gooty.

7. The drought intensity analysis has revealed that the district has a maximum drought intensity of 77 per cent is found in 46th week. While the minimum of 9 per cent is noticed in 40th week. The annual drought intensity has indicated that Kadiri has the maximum drought intensity of 68 per cent whereas the Gooty has the minimum intensity of 54 per cent. In between, Dharmavaram and Rayadurg had 64 per cent; Hindupur and Kalyandurg had 62 per cent of drought intensity; Uravakonda and Anantapur has 58 per cent of drought intensity and Penukonda and Madakasira had 56 per cent of drought intensity. The average district drought intensity is 58 per cent. It is evident from the above facts that the whole of Anantapur district has been experiencing the drought intensity of more than 50 per cent in a year.

8. The weekly and annual water balance analysis has revealed that all the areas of Anantapur district are found with an acute water deficit. On the whole, an average annual water deficit in Anantapur district accounted for 71.2 per cent. A large amount of
water deficit accumulated up to the end of 37th week found over the entire district. But water deficit starts to decrease from 38th week onwards due to the influence of south-west monsoon. Albeit, water deficit continues even after the onset of south-west monsoon. It is only during the 38th, 39th and 40th weeks, water deficit reduces considerably. Here P-PE value is positive. Out of all the stations Uravakonda has maximum of 19 mm., of surplus against the minimum of 3 mm., in Tadpatri during the 38th week. In Anantapur district maximum water deficit is occurred in Rayadurg with 77.0 per cent in contrast to a minimum water deficit in Kadiri with 67.0 per cent.

9. The spread of droughts has indicated that the western and northern parts of the district have been experienced with more number of drought years during the study period. In contrast to this, the eastern and southern parts of the district have been found with less number of drought years. It may be noted that the impact of drought on agriculture is more serious in the western and northern parts of the district which include Kalyandurg, Uravakonda and Rayadurg areas.

10. The pattern and dynamics of landuse analysis in Anantapur district has revealed that, the forest cover is very thin which accounted for only 10.3 per cent of the total geographical area of the district. The nature of the forests in the district may be classified into dry mixed deciduous to thorny open scurb type with
occasional patches of green growth and can be assumed to have reached the climatic climax of the region. Between 1962-65 and 1982-85 the proportion of forest has not shown any increase. The decrease in the forest cover is noticed in the thick vegetative areas of eastern and southern parts of the district. In many parts of the district the moderate to thick forest have been degenerated into open scrubs or thorny bush lands and dry meadows due to several obvious factors like deforestation, over grazing etc., the present distribution of forest cover is too short to maintain the ecological balance in the district. Hence conservation and development of forestry is utmost important on the first and foremost priority scale for many physical, social and economic benefits. The crash programme of "afforestation", "social forestry" and "agro-forestry" etc., are to be treated and implemented as important and significant as that of the "Green Revolution" in agriculture.

11. Non-agricultural land accounted for 18.2 per cent of the total geographical area of the district. It has increased by 2.3 per cent in the 20 year period and much of the increase is due to quarrying, soil erosion, urbanization, industrialisation, communication and irrigation development activities.

12. The area under other uncultivated land accounted for 6.8 per cent. This category of land has decreased by 2.5 per cent in the 20 year period. It is pertinent to state that there has not been
effective utilization of other uncultivated land in the district. In fact, there is no need for reclamation of these lands for cropping because the available arable land itself is more (70 percent) than the requirement. But what is to be done is to make use of these lands for pasture development, and fuel-wood plantations which ultimately solve to some extent the problems of fodder and fuel shortages as well as to safeguard the soils from erosion problem.

13. The land under fallows accounted for 20.1 percent which indeed a high proportion. However, due to precarious rainfall conditions, low density of population and less competition for cropland purpose in the district, the land under follows is a common phenomenon in the drought prone areas. In the 20 year period the concentration of fallow lands has increased by 5.5 percent which is amounting to 105 thousand hectares. The increasing trend of fallow lands is also due to denudational processes. Besides restrictive environmental conditions, the lack of curiosity about dry farming technology and poor socio-economic conditions of farmers are also caused for increase of fallow lands. The correlation analysis about the impact of the rainfall and the distribution of fallow lands in the district has revealed that a significant negative correlation is found with a coefficient value of -0.65. It showed that these two variables are inversely correlated. It is found that the low rainfall conditions with high variability, scanty irrigation facilities, poor red soils,
undulating terrain with rocky exposures and low dry farming technology as well as poor socio-economic conditions of the people are restricted to effective utilisation of large proportion of fallow lands. To circumvent some of these problems long term plans are to be prepared based on agro-climatic information for better utilisation of fallow lands with multi-tier, sylvi-agri-pastoral-vegetative systems.

14. The net area sown accounted for 44.6 per cent but it has shown a considerable decrease of 5.6 per cent in its concentration between 1962-65 and 1982-85. The regression trend analysis has also indicated the trend of decrease in net area sown in the district, but the trend is highly fluctuating and disturbing which is due to erratic behavior of the rainfall pattern. Since the crop farming is predominantly rainfed (83 per cent) there was a significant positive correlation between rainfall and the extent of agricultural land and the correlation-coefficient is 0.55. It is rather perplexing and intriguing to state that there has been greater instability in the use of agricultural land which is mainly due to an account of rainfed farming. The stable pattern and optimum use of agricultural land through scientific use of land use managed system like dry farming technology, conjunctive use of surface and sub-surface water resources, watershed and soil conservation methods are the need of the hour for the sustainable use of agriculture; land resources of this district.
15. It is significant to state that groundnut cultivation is predominant in the crop scenario of Anml gnp district with as much as 68 per cent (1987 - 90) of the gross sown area of the district. It is found that the groundnut is the most preferable crop of this district due to favourable agro-climatic, edaphic, terrain and socio-economic conditions. The crop is cultivated both in Kharif and rabi seasons both under irrigation and rainfed conditions. Overwhelmingly, groundnut is essentially a kharif crop cultivated mostly as a rainfed crop.

16. It is pertinent to state that there has been a spectacular spatial extension in the concentration of groundnut cultivation between 1962-65 and 1987-90 increased by 47.5 per cent in the district. In terms of hectarage, more than a three times increase is observed i.e., from 210 thousand hectares in 1962-65 to 620 thousand hectares in 1987-90 showing a net areal gain of 410 thousand hectares.

17. The regression trend analysis has revealed that there has been a high positive trend of increase in the area under groundnut cultivation in the 22 year period i.e., from 1963-64 to 1984-85. This positive trend of increase is very significantly accounted for by 95 per cent of coefficient of determination. It suggests that there has been a steady and continuous regular increase of the area under groundnut cultivation through time. The trend of
increase of the area under groundnut cultivation is found in all talks of the district except Anantapur taluk.

18. The area under irrigated groundnut cultivation has shown a positive trend in the district from 1963-64 to 1984-85. This trend of increase is highly significant and is accounted by a very high value of 91 per cent coefficient of determination. It has revealed that absolute increase of irrigated groundnut area has been continuous in the time progression. A similar trend of increase in the area under irrigated groundnut is found in all taluks of the district except Kadiri taluk. It is obvious to state that the recent hybridisation of groundnut farming has been alarmingly increased the irrigated groundnut cultivation in the district.

19. The study has revealed that the spectacular spatial spread of groundnut cultivation in Anantapur district is due to the following reasons (i) it is the most sustainable crop of red sandy and loamy soils under low to moderate rainfall conditions in the district, (ii) it gives higher net returns than the other dry subsistence or commercial crops even during drought conditions, (iii) it is a cash crop of all sections of farming community, (iv) it is a crop of short growing period, (v) the farming operations of the crop are easy and involve less labour input, (vi) it is a less disease prone than the other commercial crops due to seasonal fallowing of the cropped land, (vii) it is
the most useful crop for rotation, (viii) the haulms (plant stalks) of the groundnut are by and large the only source and supply of fodder for the livestock in the district, (xi) it has a higher price value and good market, and (x) the cost of cultivation is moderate.

20. In the field study, the farmers belonged to different sections of farming community from different parts of the district have expressed the following opinions about the areal expansion of groundnut cultivation in Anantapur district. The dietary habits of the farmers have been substantially changed from eating small and major millets like korra, bajra, ragi and jowar to rice and wheat. The Government welfare scheme Rs.2/- per kg. rice to all weaker sections and small and marginal farmers has had a marked influence on the change of dietary aspect from millets to rice. This has resulted the replacement of millet fields with groundnut on a large scale in the district. Some farmers have opined that the groundnut crop can be taken with a high degree of success under low rainfall conditions in the favourable soil conditions. After one month of sowing the crop, if one or two rains are received, groundnut yield is much better than the other dry crops. Besides the yield, the fodder is very important from the point of livestock feed. This is also one of the main reasons for the increase of area under groundnut cultivation. Many farmers have felt that the groundnut has a high commercial value than the other dry crops in the recent years. The price value of the groundnut
and marketing conditions are very attracting and encouraging the all sections of the farming community. In their view the net returns are high in the case of groundnut than the millets and pulses. Instead of cultivating millets and pulses, if groundnut is cultivated, more income can be obtained per unit of land and with that income the farmer can go far superior variety of foodgrains for the diet and also to fulfill other family needs.

Since groundnut is a cash crop of all sections of farmers in the district and the cumulative effect of all favourable agro-geographical conditions, the spatial expansion of groundnut cultivation has gradually tended to replace millets, pulses and cotton. In the extreme form, some of the minor millets like korra, varagu and samai are getting eliminated from the cropping pattern in the process of crop transformation.

21. From the groundnut productivity analysis, it is found that the groundnut crop productivity in the drought prone area of Anantapur district has not only been suffering from low per hectare yield levels but also experiencing with high fluctuations from time to time. The reasons for such a state of erratic crop productivity in this chronic drought district are not far to seek. The frequent occurrences of drought, prolonged dry spells, presence of low moisture holding red soils, scanty irrigation facilities and a low level of agro-technification have had a debilitating effect on the crop productivity. The first and foremost effort which should be taken is to reduce the yearly fluctuations in the
yield levels of crop and next to enhance the present yield level by employing dry farming technology in order to reduce the yield gaps between the areas and the districts.

22. The coefficient of correlation between rainfall and area under groundnut in the district is significant to the tune of 0.6 coefficient value. It shows that there has been a considerable degree of impact of rainfall on the spatial spread of groundnut cultivation. It is also found that there is a high correlation between rainfall and the yield pattern of groundnut which is to the tune of 0.78 coefficient value. From the correlation analysis it is inferred that both the area and yield pattern of groundnut are mostly depending upon the distribution of south-west monsoonal rainfall. If there is a failure of the monsoon, especially the yield level of groundnut will be the worst affected. Hence, necessary scientific measures like soil and water conservation methods, suitable dry farming technology, and agricultural extension measures stressing and canvassing upon agro-climatic information about groundnut cultivation are to be taken at massive scale to improve the performances of groundnut cultivation in Anantapur district.

23. The repeated experiments which are conducted by Andhra Pradesh Agricultural University have revealed that the fertilizer application for dry land crops under the present rainfall conditions showed good response in the increase of groundnut yield
level. It is recommended that where 20 Kg. Nitrogen, 40 Kg. Phosphorous and 20 kg. Potassium is applied, the crop will give maximum yield in the normal rainfall conditions in the district.

24. For the entire cropping system consisting of groundnut and pulses the recommended fertilizer dose was 20 Kg. Nitrogen, and 40 Kg. Phosphorus which is good enough for getting good results. It is found that the Phosphorus application to groundnut has shown maximum effect. It is also noticed that response to Potash application was marginal in the inter-cropping system.

25. The response of groundnut varieties to foliar application of iron compounds has shown that spraying of Annabedhi and ferrous sulphate is also effective in the increase of groundnut yield level, especially in the TMV2 variety by 11 per cent increase.

26. The application of Calcium, Sulphur and to some extent Magnesium are responsible for increasing yields in groundnut pods.

It is also noticed that, the requirement of Gypsum is very essential to red soils of this district. But timely application of Gypsum is very essential. The results have indicated that the yields are reduced by the delayed application of Gypsum. The application of Gypsum during the growth stage of groundnut crop has shown significant increase in pod yields.
27. The weed management in groundnut study has revealed that highest pod yields with greater monetary returns will be obtained if the weed management treatment is given in combination of Metlaguntaka in rows, with hand weeding in intra rows for weed control with pre-emergence herbicides Metlaguntaka with hand weeding is adopted.

28. The study in response to mechanised groundnut cultivation and traditional method has revealed that the mechanical operation of groundnut cultivation gives 50 per cent increase over traditional method. Hence, it is suggested that simple mechanisation could lead to easy operation in sowing, weeding, harvesting along with reduction in labour demand over to this the yield per hectare would be more.

29. The fertilizer use has to play a key role in rainfed agriculture but its consumption till now is low. The farmer is using some locally available organic manures, because of his poverty, but the efficiency of his system is so low that the soil productivity is seriously impaired. The fertilizer is costly and for making efficient use of this input, the integrated nutrient system should form an integrate part of the farming system to improve productivity per unit fertiliser applied by mobilising all the available quantities of organic manures, scheduling optimum doses of fertilisers in crop sequence in relation to water supply, suitable cropping patterns, other management practices including
placement of fertiliser with effective follow up of moisture conservation practices. The following aspects should receive thrust while developing an integrated farming system in the drought prone areas.

a) Suitable water-shed treatment for in situ water conservation and surface drainage needs to be taken up before introducing any input of improved technology.

b) The response to fertiliser use is variable and the fertiliser dose must be decided in relation to available water supplies.

c) The general fertiliser recommendations need to be modified on the basis of soil test so as to economise the use of Phosphorous and Potassium fertiliser.

d) Fertiliser schedules for different crops need to be worked out in a cropping sequence.

e) The quality of organic manures used, in general, is poor and needs to be improved through suitable conservation measures.

f) Growing of green manure crops/pulse crops will be significant in the extensive fallow areas in the rainy season to check soil loss and improve native soil fertility.

g) Role of green manure/crop residues needs further elucidation for their specific role in nutrient economy and improvement in physical properties of soil.
h) For maximum fertiliser use efficiency the fertiliser should be always placed in the moist soil zone. A low cost seed-cum-fertiliser drill is needed.

30. It is very well recognised that application of chemical fertilisers or organic manures increases the productivity of dryland crops. Sometimes it has also been said that applied in small quantities but adequate to meet the needs of a crop, the response to fertilisers is higher in drylands than in irrigated areas. This is because of the nutrient depletion, continuous cropping over years in the irrigated areas and which the practice has not been in the drylands. The nutrient status of a soil besides being determined by the rate of application of manures or fertilisers, is governed by the crops grown. Also soil and water conservation methods adopted in these areas determine not only the productivity of the crops but also the response to the added manures or fertilisers.

31. The probability of weekly rainfall performance for groundnut cultivation has revealed that in the entire district the rainy season has short wet spells and long dry spells. In the entire district only 2 taluks namely Gooty and Kadiri have favourable rainfall conditions with 16 rainy weeks (67 per cent) exceeding the 50 per cent threshold limit at 10mm. rainfall probability. It is followed by Madakasira with 6 weeks: Rayadurg, Uravakonda, Dharmavaram and Anantapur with 5 weeks; Tadipatri,
Penukonda and Hindupur with 4 weeks and Kalyanadurg with 3 weeks possessing rainfall more than the threshold limit of 50 per cent at 10mm. mean rainfall probability. It obviously reveals that many parts of the district except Kadiri and Gooty have been suffering from the occurrence of large number dry spells/dry weeks which made the groundnut cultivation highly precarious and low productive.

32. The wet week followed by another wet week once again proves the nature of good rainfall pattern in any area. But in Anantapur district, it is found that this pattern of rainfall is very uncommon, unexpeptable and unpredictable. At 10mm. rainfall probability level, the maximum number of wet weeks (w/w) exceeding the threshold limit is found in Gooty and Kadiri (3 weeks) and it followed by Madakasira, Uravakonda, Rayadurg (2 weeks), Anantapur, Tadpatri and Hindupur (one week) while the rest of stations namely, Kalyanadurg, Dharmavaram and Penukonda were not found with any wet week exceeding the threshold limit.

33. The wet week followed by dry week represents the random nature of the rainfall. The entire district invariably is found under high percentage of probability of occurring dry spells after every wet spell. Kadiri has maximum of 23 weeks exceeding the 30 per cent threshold limit while Kalyanadurg, Penukonda and Gooty have second highest of 21 weeks, Madakasira, Dharmavaram, Anantapur have 17 weeks exceeding 30 per cent threshold limit. Tadpatri and
Hindupur have 14 and 16 weeks respectively exceeding the threshold limit while Uravakonda and Rayadurg have 11 weeks exceeding the threshold limit. It has revealed that during rainy season almost all the areas of the district have more number of dry weeks rather than wet weeks. It suggests that the dry land farming techniques as well as soil and water management methods are pre-requisite for sustainable groundnut crop production in all over the district where farming is rainfed.

34. The crop calendar and planning for groundnut cultivation in Anantapur district has revealed the following facts:

i) On the basis of weekly rainfall probabilities there are 4 models specifying the timely operations of groundnut cultivation for different areas of the district suggested. ii) From the suggested models it is found that for the whole of Anantapur district in general, the sowing operations can be taken place from 29th standard week which has the 25 per cent accumulated rainfall of the season before sowing stage. iii) During the stage-1 invariably low percentage of 10mm. is found. iv) During the stage-5, it is also recorded that there is high percentage of 10mm. rainfall probability. Therefore it is suggested that groundnut crop in Anantapur district can be cultivated between the standard week 29 (June 16th onwards) and standard week 42 (October 14th onwards) which takes 14 weeks.
35. The suggested crop calendar models help to resolve the unscientific and unplanned groundnut crop operations in the risks of erratic behaviour of monsoonal rainfall pattern in different parts of the district.

36. Based on the probability analysis and as per the crop calendar it is found that sowing of groundnut seeds can be done when the 25 per cent of accumulated rainfall of the rainy season is occurred. By and large it is found that this is the 29th standard week and it is the suitable week to start the sowing of groundnut TWV2 variety crop in Anantapur district. On the basis of scientific results and suggested models the crop calendar of all the rainguage stations in the district is prepared which indicate the timely operations of successful groundnut crop cultivation at higher probability.

In view of the recent developments made in ago-technology for modernisation of agriculture and production increase; it is high time to provide scientific information about agro-climatology, fertilizer application to rainfed corps, dry land crop management techniques, watershed management and soil conservation etc., to the farming community of arid and semi-arid regions like Anantapur district. One of the important ways of improving groundnut crop production in the district is by adjusting crop cycle in tune with the expected probable moist period of a place as suggested by the crop calendars. The farmer should be provided and trained, with
an alternative strategy to be adopted in the event of late arrival of rains, so that loss can be minimised. In this regard special attention should be taken by the Government to diffuse the agro-climatological and agro-technological information concerning to crop calendar, construction of percolation tanks, check dams, and soil conservation measures, so as to enable proper harvesting of the scarce rainwater as well as recharge of ground water through intensive agricultural extension measures.

In general, the farmers of Anantapur district especially, the small and marginal farmers are afraid of using chemical fertilizer to groundnut crop for yield increase. In their opinion i) it is due to from the point of expenditure the cost of chemical fertiliser is high, and ii) there is no certainty in receiving responsive yield levels due to frequent occurrence of droughts and prolonged dry spells. But as per the scientific results conducted by Agricultural scientists it is found that even under low rainfall conditions there is a good response to fertiliser application in groundnut yield levels. In this regard it may be noted that this information has not been properly reached and convinced the traditional farming community. So what is more required is research programmes are to be taken up in different locations by involving the participation of uneducated and traditional farmers in practicing the dry farming technology, tackling the problems of soil erosion, and moisture deficiency and convincing the farmers to follow the scientific methods of
cultivation to control the drought impact and so as to improve the productivity of agriculture in general and groundnut in particular.

In the initial stage to encourage the scientific methods of groundnut cultivation for sustainable development, the Government has to provide necessary infrastructural facilities in the form of subsidies on fertilisers, hybrid seeds and modern agricultural machinery as well as credit loans in the feasible and compatible manner. Agricultural planning, monitoring and evaluation cells are to be set up at different places in the district to perform the groundnut crop cycling system and the scientific activities of the concerned on sound lines. The groundnut cultivation in Anantapur district has a bright future for achieving good yield levels and sustainable crop development at higher probability on the lines of agro-climatological and agro-technological information system.

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