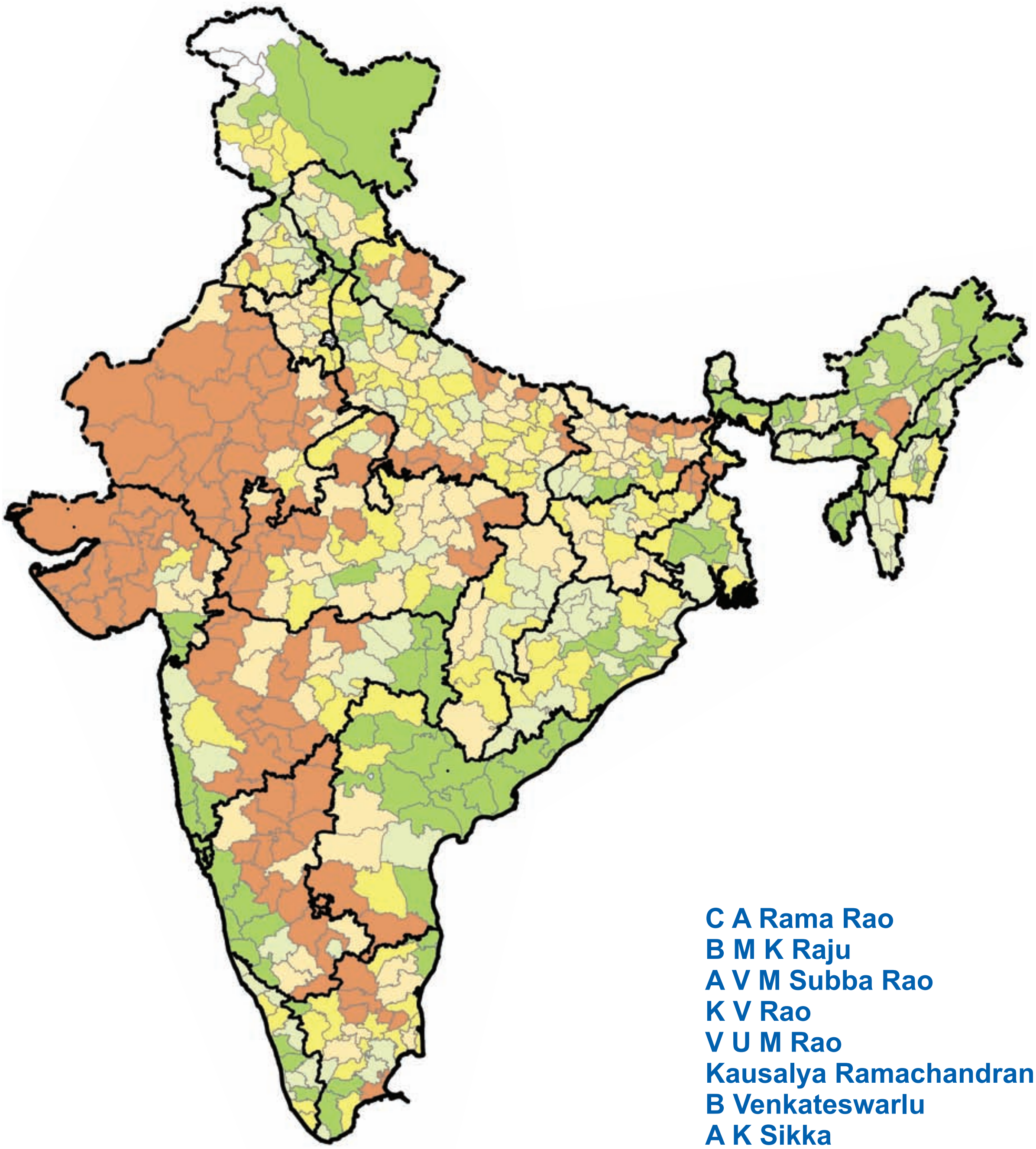
ATLAS on

Vulnerability of Indian Agriculture to Climate Change



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CRIDA

CRIDA is a constituent organization of the Indian Council of Agricultural Research (ICAR), an autonomous body of Ministry of Agriculture, Government of India. Established during 1985 by upgrading the All India Coordinated Research Project for Dryland Agriculture (AICRPDA), Hyderabad, CRIDA works with the mandate of undertaking basic and applied research for a more sustainable rainfed agriculture. It hosts two net work projects viz., All India Coordinated Research Project for Dryland Agriculture and All India Coordinated Research Project on Agrometeorology. It is also coordinating the National Initiative on Climate Resilient Agriculture (NICRA) launched by ICAR with a view to developing technologies and strategies towards a more climate resilient agriculture in India. The Institute works with many national and international organizations in pursuit of its mandate.

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FOREWORD

Changing and increasingly variable climate is among the major challenges to ensuring food and livelihood security of populations world over. Developing countries such as India with a relatively large share of population dependent on agriculture are more prone to the adverse effects of climate change. Historical trends and a number of model based projections point to a noticeable increase in surface temperature in India. This along with the possible changes in spatial and temporal patterns in rainfall poses challenges to sustainable agricultural production. Keeping the need to make Indian agriculture more resilient to changing and increasingly variable climate, the Indian Council of Agricultural Research launched a megaproject "National Initiative on Climate Resilient Agriculture (NICRA)" during February 2011. This initiative, being coordinated by CRIDA, Hyderabad, is a collaborative and participatory effort by a number of institutes addressing the specific sub-sectors within agriculture. In order to develop and target appropriate adaptation measures, it is important to identify regions that are more affected by climate change. This identification process involves assessment of vulnerability of different regions and hence was taken up as an important activity under NICRA.

In the context of climate change and agriculture, the purpose of any vulnerability assessment should be to identify the regions that are likely to be more adversely affected by changing climate and to develop tactics and strategies that help impart resilience to crop and animal production systems and thus to the livelihoods of people dependent on agriculture. This makes it necessary to consider a host of non-climatic factors along with the climatic data for a meaningful and comprehensive vulnerability assessment and this is the trajectory of evolution of such studies in literature.

This publication presents the analysis of vulnerability of agriculture to climate change and variability at the district level considering the fact that most of the development planning and programme implementation is done at district level in India. The output of the analysis is presented in the form of maps representing various dimensions of vulnerability. I am sure, this Atlas is useful in identifying the districts that are relatively more vulnerable to climate change so that the necessary investments can be targeted. It is also useful in identifying sources of vulnerability that are critical to developing appropriate adaptation measures in terms of technologies, investments and policies.

(S. Ayyappan)

Dated the 29th August, 2013
New Delhi

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This document is an output of the work related to assessing vulnerability of Indian agriculture to climate change and variability which is an important activity in the project 'National Initiative on Climate Resilient Agriculture' (NICRA) launched during February 2011 by the Indian Council of Agricultural Research. This effort enjoyed the keen interest and support of Dr. S Ayyapan, Director General, ICAR and Secretary, DARE, Dr. A K Sikka, DDG (NRM) and Dr. A K Singh, Former DDG (NRM) throughout. We profusely thank them for their keen interest, guidance and support. We sincerely acknowledge the support and encouragement received from Director, CRIDA and Dr. M Maheswari, Principal Investigator, NICRA.

The approach and methodology adopted in this study was arrived at after a brain-storming workshop attended by experts from organizations such as IARI, NCAP, IISc, ICRISAT, IWMI, FAO, LNRMI, WOTR. The intermediate outputs were presented to scientists of CRIDA and during the First Annual Workshop of NICRA. The draft output was also shared in a consultation workshop with different stakeholder organizations including Department of Agriculture, Ministry of Environment and Forests, Ministry of Water Resources, NRAA, IARI, ICRISAT, IISc, TERI, GIZ, DFID, AFPRO, MSSRF, IMD, NRSC, NIRD, NAAS etc. The inputs received from all the participants are gratefully acknowledged.

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We place on record our sincere thanks to IITM, Pune for providing the downscaled projections of future climate as related to SRES A1B scenario used in this study. We also acknowledge the help received from NDMA and National Seismic Adviser for readily providing the data related to flood proneness and cyclone proneness.

The hard work of putting the voluminous data together and processing done by Mr. Sudhakar Reddy, Dr. Yella Reddy, Ms. Swapna, Ms. Latha, Dr. Aruna Kumari, Ms. Gayathri, Mr. Satish, Mr. Praveen Kumar and Ms. Thilagavathi deserves our appreciation and acknowledgement. The painstaking effort of word processing done by Smt. Kanaka Durga deserves our thanks.

Authors

List of Abbreviations

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AESR	Agro Ecological Sub Regions
AFPRO	Action For Food Production
AVHRR	Advanced Very High Resolution Radiometer
CGWB	Central Groundwater Board
CMIE	Centre for Monitoring Indian Economy
CRIDA	Central Research Institute for Dryland Agriculture
DAC	Department of Agriculture and Cooperation
DES	Directorate of Economics and Statistics
DFID	Department for International Development
DoLR	Department of Land Resources
FAO	Food and Agriculture Organization
GCM	Global Circulation Model
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GoI	Government of India
HDI	Human Development Index
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
IMD	India Meteorological Department
IPCC	Intergovernmental Panel on Climate Change
IWMI	International Water Management Institute
LNRMI	Livelihoods and Natural Resources Management Institute
MODIS	Moderate Resolution Imaging Spectroradiometer
MoEF	Ministry of Environment and Forests
MSSRF	MS Swaminathan Research Foundation
NAAS	National Academy of Agricultural Sciences
NABARD	National Bank for Agriculture and Rural Development
NCAP	National Centre for Agricultural Economics and Policy Research
NDMA	National Disaster Management Authority
NDVI	Normalized Difference Vegetation Index
NIA	Net Irrigated Area
NIRD	National Institute of Rural Development
NRAA	National Rainfed Area Authority
NRSC	National Remote Sensing Centre
NSA	Net Sown Area
NBSSLUP	National Bureau of Soil Survey and Land Use Planning
PRECIS	Providing Regional Climates for Impacts Studies
RCM	Regional Climate Model
SRES	Special Report on Emission Scenarios
TERI	The Energy and Resources Institute
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WOTR	Watershed Organization Trust

1 Introduction and Background

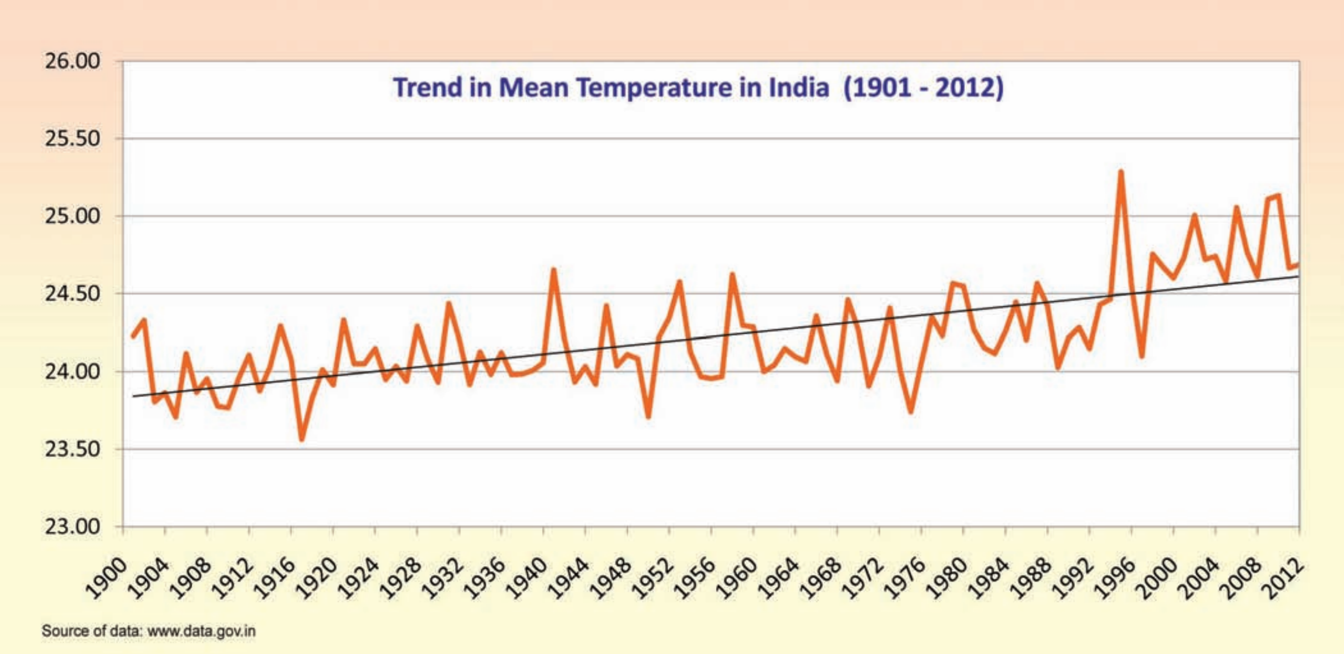
Introduction and Background

There is now adequate evidence about the impending climate change and the consequences thereof. The fourth assessment report of Intergovernmental Panel on Climate Change (IPCC) observed that 'warming of climate system is now unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global sea level' and the atmospheric concentration of carbon dioxide (CO_2) has increased from the pre-industrial levels of 280 to 379 ppm in 2005 (IPCC, 2007) and to around 392.5 ppm during 2012 (Bala, 2013). Climate change is probably the most complex and challenging environmental problem facing the world today (Ojwang' et al., 2010) and is increasingly recognized as a potent threat to agriculture in general and to food security in particular. The IPCC defines climate change as "a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or variability of its properties, and that persists for an extended period, typically decades or longer" (IPCC, 2007). This definition, unlike the one given by the UNFCCC, does not distinguish the change in climate over time due to natural variability or due to anthropogenic activity. Although climate change is global in its occurrence and consequences, it is the developing countries like India that face more adverse consequences. Globally, climate change is seen as a failure of market mechanisms wherein the polluters haven't had to pay for the negative externalities (Stern, 2007).

Climate change projections made for India indicate an overall increase in temperature by 1 to 4^{0}C and precipitation by 9-16% towards 2050s (Krishna Kumar et al., 2011). However, different regions are expected to experience differential change in the amount of rainfall that is likely to be received in the coming decades. Another significant aspect of climate change is the increase in the frequency of occurrence of extreme events such as droughts, floods and cyclones. All of these expected changes will have adverse impacts on climate sensitive sectors such as agriculture, forest and coastal ecosystems and also on availability of water for different uses and on human health. Historical trends also show a noticeable increase in mean temperature in the country though there is no discernible trend in the rainfall during the last several decades. However, regional variation in behaviour of monsoon rainfall was observed over the years.

The international negotiations on climate change have now rightly recognized that adaptation is as important as mitigation in dealing with climate change as the world is already committed to certain extent of climate change and even the fullest possible mitigation efforts will not prevent the projected rise in temperature till 2100. Therefore, adaptation measures to deal with climate variability and change need greater attention in terms of policy, research and institutional interventions. In order to develop and target appropriate adaptation measures, it is important to identify regions that are relatively more affected by climate change. This 'identification process involves assessment of vulnerability of different regions' (Acosta-Michlik et al., 2005).

Keeping the need to make Indian agriculture more resilient to changing and increasingly variable climate, the Indian Council of Agricultural Research (ICAR) launched a megaproject "National Initiative on Climate Resilient Agriculture (NICRA)" during February 2011. This initiative, being coordinated by CRIDA, Hyderabad, is a collaborative and participatory effort by a number of institutes addressing the specific sub-sectors within agriculture. In order to develop and target appropriate adaptation measures, it is important to identify regions that are more affected by climate change. Hence, assessment of vulnerability of different regions was taken up as an important activity under NICRA. This publication presents the analysis of vulnerability of agriculture to climate change and variability at the district level considering the fact that most of the development planning and programme implementation is done at district level in India. Also, most of the non-climatic data that is integral to assessment of vulnerability to climate change and adaptation planning is also available at district level. Thus, this Atlas is useful in identifying the districts that are relatively more vulnerable to climate change so that the necessary investments can be targeted better. It is also useful in identifying sources of vulnerability that are critical to developing appropriate adaptation measures in terms of technologies, investments and policies.



2 Vulnerability– Concept and Approaches to Assessment

'Vulnerability' has emerged as a cross-cutting multidisciplinary theme of research in the current context characterized by rapid changes in the environmental, economic and social systems. Accordingly, vulnerability is viewed differently by different individuals and organizations depending on the context in which they operate. For example, vulnerability is viewed as susceptibility to a natural hazard or refers to the frequency of occurrence of a hazard in the literature related to disaster management. As opposed to this, development economics views vulnerability as the propensity of the entity to face a negative outcome in terms of poverty, food insecurity or loss of welfare and does not always link this negative outcome to a specific risk. In the context of climate change and agriculture, vulnerability refers to the propensity of the entity to face a climate shock and suffer loss in production and/ or income from agriculture, though the latter is not always specified explicitly (Kavi Kumar et al., 2007). Vulnerability is essentially an *ex ante* concept and refers to the possibility of being hit or propensity to be harmed by a stress or shock (Ionescu et al., 2008).

Earlier studies on vulnerability assessment viewed vulnerability more as a biophysical impact of climate change. These impact assessments 'superimpose future climate scenarios on an otherwise constant world to estimate the potential impacts of anthropogenic climate change on a climate-sensitive system' (Fussel and Klein, 2006). The emphasis gradually shifted to derive policy lessons from vulnerability assessment as the purpose of such assessment was to identify strategies that reduce vulnerability of the systems or populations concerned. Recent studies on vulnerability recognize the importance of non-climatic factors in dealing with climate change. Vulnerability in climate change context is generally related to the residual impact of climate change after accounting for the (autonomous) adaptation. There are three major approaches to analysis of vulnerability to climate change:

Socio-economic approach: This mainly focuses on socio-economic and political status of individuals or social groups that vary in terms of education, wealth, health status, access to resources (credit, information, etc), social capital and so on. This approach holds these variations responsible for differential vulnerability levels (e.g. Adger and Kelly, 1999). Here, vulnerability is considered as a 'starting point or state' of the system before it encounters the hazard event.

Biophysical approach: This approach assesses the level of damage that a given environmental stress causes to both social and biological systems and is generally identified with impact assessment or hazard-loss relationship. As opposed to the socio-economic approach, this focuses on the 'end point'. In the context of crop production, this involves simulating or modelling how crop yields change under conditions that characterize climate variability or climate change (e.g. Olsen et al., 2000; Pathak and Wassmann, 2009; Boomiraj et al, 2010; Srivastava et al., 2010, Abdul Harris et al., 2013).

Integrated approach: This combines both socio-economic and biophysical approaches to determine vulnerability. The IPCC definition of vulnerability ("The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is **exposed, its sensitivity, and its adaptive capacity**" (McCarthy et al., 2001)) accommodates this approach to vulnerability analysis. According to this definition, vulnerability has three components – adaptive capacity, sensitivity and exposure.

Sensitivity is defined as "the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli". It is determined by demographic and environmental conditions of the region concerned. Exposure is defined as "the nature and degree to which a system is exposed to significant climatic variations". Thus, exposure relates to climate stress upon a particular unit of analysis (Gbetibouo and Ringler 2009). "A more complete measure of exposure to future climate change would require consideration of projected changes in climate in each analysis unit" (Eriyagama et al., 2012). Adaptive capacity is "the ability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. It is considered to be "a function of wealth, technology, education, information, skills, infrastructure, access to resources, stability and management capabilities" (McCarthy et al., 2001)

In this framework, adaptive capacity is largely consistent with socio-economic approach and sensitivity with biophysical approach and both are internal dimensions. The component of exposure is viewed as an external dimension. While higher exposure and sensitivity mean higher vulnerability, adaptive capacity moderates vulnerability and hence is inversely related to vulnerability. Although lack of standard methods for combining the biophysical and socio-economic indicators is a limitation to this approach, it can be helpful in making policy decisions (Deressa et al., 2008).

Though there are different methods and approaches for assessing the vulnerability, selection of a particular method is determined by the context, purpose and scale of analysis as well as by the availability of appropriate data. We have adopted the 'indicator method' to construct the vulnerability of agriculture to climate change and variability at the district level.

Because of its transparency, this method was followed in many studies that assessed vulnerability. Deressa et al (2008) ranked the seven Ethiopian states based on vulnerability indices constructed following the integrated approach. Eriyagama et al (2012) analysed the relative vulnerability of districts in Sri Lanka using historical data on the indicators related to the three components of vulnerability. Studies on vulnerability to climate change in India are limited (Panda, 2009). O'Brien *et al* (2004) assessed the vulnerability of different districts in India to climate change and to trade globalization following the integrated approach. They identified districts that were relatively more vulnerable to climate change, to globalization of agricultural trade and to both. They have used the climate projections for the period 2071-99 made using the HaDRM 2 climate model output. Palanisami et al (2008) assessed the vulnerability of districts in Tamilnadu to climate change. They used indicators that represent demographic, agricultural and technological development and constructed vulnerability index for different agro-climatic regions and districts in Tamilnadu. This approach broadly classifies the indicators into those related to physical, natural, human and financial resource endowments that determine the livelihood outcomes. Some studies such as Kavi Kumar and Tholkiappan (2006) assessed vulnerability of coastal districts by combining a number of indicators related to adaptive capacity, sensitivity and exposure. Palanisami et al (2010) assessed the vulnerability of districts in the Krishna-Godavari basin based on indicators related to agriculture, demography, etc. Ravindranath et al (2011) assessed the vulnerability of districts in North-Eastern states by constructing separate vulnerability indices for agriculture, forestry and water sectors. They incorporated the data on climate projections into models that predict the forest cover which were then included in the construction of vulnerability index following the IPCC framework.

This study combines, compared to the earlier studies, a richer set of indicators to construct the relative vulnerability index for ranking the districts. Unlike most of the earlier studies, this study incorporates the climate projections. Also, the climatic projections are converted into agriculturally relevant indicators/ variables such as incidence of dry spells, distribution of rainfall, etc. which would be more useful in planning technology development and policy formulation for adaptation. This Atlas will help Government of India and the respective state governments plan for investment in climate resilient agriculture by focussing on the particular components which make the region/ district more vulnerable than others. The study is also more comprehensive as it covers 572 rural districts in the country.

3 Methodology

As mentioned earlier, the definition of vulnerability given by IPCC is adopted in this study. According to this, vulnerability is a function of the extent and degree to which an entity is exposed, the sensitivity of the entity to climate change and the adaptive capacity to adapt to and cope with the changing climate. Considering that vulnerability intends to capture the residual impact of climate change after accounting for autonomous adaptation (Fussel and Klein, 2006) that farmers undertake and the difficulties involved in quantifying the potential and residual impacts at the district level, indicator method[1] was chosen to assess vulnerability of agriculture to climate change at the district level. Indicators are those variables that reflect the underlying phenomenon of interest. It is this 'significance' to the phenomenon/ issue being addressed that makes an indicator out of a variable. Further, the indicators ideally should have a monotonic relationship with the underlying phenomenon over a reasonable range of values that they may take.

3.1. Selection of indicators

In the present context, the three components of vulnerability – sensitivity, exposure and adaptive capacity – are represented through a number of indicators that would reflect these components. These indicators were chosen from a broader list of indicators based on review of literature, discussions with the experts and nature of relationship with the three components of vulnerability. It may be noted here that inclusion of indicators into dimensions of sensitivity or adaptive capacity is relatively more difficult and subjective (Kavi Kumar and Viswanathan, 2006). We have considered those indicators that determine the extent and intensity of the possible effect of climate change and/or variability as reflecting sensitivity. Thus, the variables like net sown area, rural population density (see table 1) determine the 'extent' of the problem while the indicators such as water holding capacity of soils, stage of ground water development, frequency and intensity of occurrence of climate shocks determine the intensity or degree of effect of such shock. Similarly, variables/ indicators that are relatively more responsive to policy measures are included in the adaptive capacity[2]. The determinants of exposure are derived from climate projections as done in previous studies such as O'brien et al (2004), Deressa et al (2008), Ravindranath et al (2011).

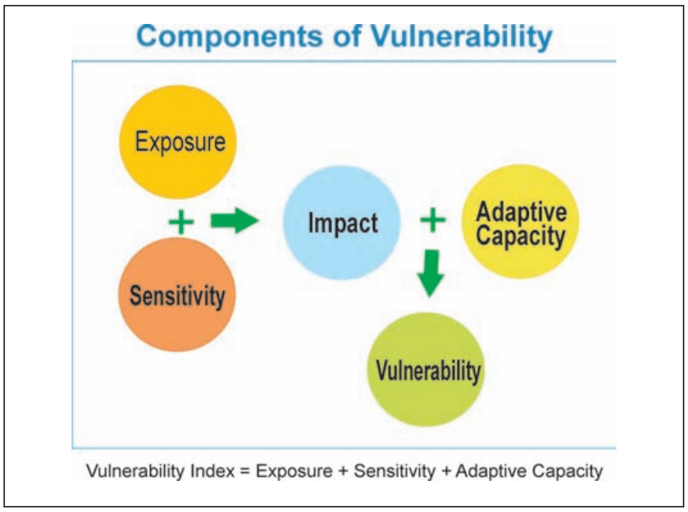


Fig . Schematic representation of vulnerability assessment

The description and computation of different indicators[3] chosen along with the sources of data for these indicators are presented in Tables 1-3.

Table 1 : Indicators of sensitivity included in computation of vulnerability index

Indicator	Measurement (unit)	Rationale	Relationship with sensitivity	Source of data
Net sown area	Net sown area in relation to geographical area (%)	A relatively higher area under cultivation implies higher relative importance of agriculture in the district and also that more area is affected	Direct	Directorate of Economics and Statistics (DES), Department of Agriculture and Cooperation (DAC), Government of India; Agricultural Census, DAC, GoI; DES of different states, Department of Planning of different states
Degraded and waste land	Extent of degraded and waste land in relation to geographical area (%)	Productivity levels would be low and highly risky if crops are grown on degraded and waste lands	Direct	ICAR (2010)
Annual rainfall	Average annual rainfall (mm)	Higher the rainfall, better is for crop growth (over a wide range except in extremely higher levels)	Inverse	IMD
Cyclone proneness	Composite index constructed by combining number of cyclones crossing the district, number of severe cyclones crossing the district, probable maximum precipitation for a day, probable maximum winds in knot, probable maximum storm surge	Higher index of cyclone proneness means more frequent and intense incidence of cyclones and hence more sensitivity of the district	Direct	NDMA website http://ndma.gov.in
Flood proneness	Geographical area prone to flood incidence (%)	Larger area susceptible to flood incidence implies high sensitivity	Direct	National Seismic Advisor, GoI-UNDP
Drought proneness (Drought)	Index computed by combining the probability of occurrence of severe and moderate droughts with weights of 2:1 and expressed as %	Incidence of more frequent droughts implies a more risky agriculture and hence more sensitivity	Direct	Derived from Gore et al (2010)
Available water holding capacity of soil	Amount of water that the soil can hold (mm)	Capacity of soils to hold larger amount of water can save crops during dry spells	Inverse	Computed considering the texture and depth of soil taken from NBSSLUP and Dunne and Wilmott (2000).

contd.....

Indicator	Measurement (unit)	Rationale	Relationship with sensitivity	Source of data
Stage of ground water development	Draft of ground water in relation to availability (%)	Draft of ground water is an indication of further scope to harness ground water resources for irrigation and higher relative draft means less scope for future and hence higher sensitivity	Direct	CGWB (2012)
Rural population density	Number of rural people per sq km of geographical area	Higher density is an indication of population pressure on land resources and since the livelihoods of rural population are heavily dependent on agriculture, it means higher sensitivity	Direct	GoI, Census, 2001
Small and marginal farmers	Area owned by small and marginal farmers in relation to total sown area (%)	Smaller farm size limits marketable surplus and also the opportunity to diversify the cropping pattern and the low investment capacity of farmers make agriculture more sensitive to any climatic shock	Direct	Agricultural Census 2005-06 (DAC, GoI)

Table 2 : Indicators of exposure included in computation of vulnerability index

Indicator	Measurement (unit)	Rationale	Relationship with exposure
Change in annual rainfall	Change (%) in annual rainfall during mid-century (2021-50) or end-century (2071-98) relative to the baseline (1961-90)	Increase in rainfall is favourable to agricultural productivity	Inverse
Change in June rainfall	Change (%) in June rainfall during mid-century (2021-50) or end-century (2071-98) relative to the baseline (1961-90)	An increase in rainfall enables sowing of crops in right time	Inverse
Change in July rainfall	Change (%) in July rainfall during mid-century (2021-50) or end-century (2071-98) relative to the baseline (1961-90)	An increase in July rainfall enables sowing of crops in right time and better establishment of crop stand	Inverse
Change in number of rainy days	Change (%) in number of rainy days during mid-century (2021-50) or end-century (2071-98) relative to the baseline (1961-90)	Increase in number of rainy days implies a better distribution of rainfall	Inverse

contd.....

Indicator	Measurement (unit)	Rationale	Relationship with exposure
Change in maximum temperature	Change in maximum temperature (^{0}C) during mid-century (2021-50) or end-century (2071-98) relative to the baseline (1961-90)	An increase in maximum temperature implies adverse effects on crop yields	Direct
Change in minimum temperature	Change in minimum temperature (^{0}C) during mid-century (2021-50) or end-century (2071-98) relative to the baseline (1961-90)	An increase in minimum temperature implies adverse effects on yields, especially for rabi crops like wheat	Direct
Change in incidence of extremely hot days	Change in frequency of days during March to May when maximum temperature exceeds the normal by 4^{0}C at least during mid-century (2021-50) or end-century (2071-98) relative to the baseline (1961-90)	An increase in frequency will imply adverse yield effects	Direct
Change in incidence of extremely cold days	Change in frequency of days during December to February when minimum temperature falls below the normal by 4^{0}C at least during mid-century (2021-50) or end-century (2071-98) relative to the baseline (1961-90)	An increase in frequency will imply adverse yield effects	Direct
Change in frequency of occurrence of frost days	Change in frequency of occurrence of frost days (during Dec - Feb) during mid-century (2021-50) or end-century (2071-98) relative to the baseline (1961-90)	An increase in frequency will imply adverse yield effects	Direct
Change in drought proneness	Change in drought proneness during mid-century (2021-50) or end-century (2071-98) relative to the baseline (1961-90)	Increase in drought proneness means higher yield risk	Direct
Change in incidence of dry spells of >= 14 days	Change in number of dry spells during June to October during mid-century (2021-50) or end-century (2071-98) relative to the baseline (1961-90)	Higher the number of dry spells, less is productivity	Direct
Extreme rainfall events	These are represented through four different indicators		
Change in 99 percentile rainfall	Change (%) during mid-century (2021-50) or end-century (2071-98) relative to the baseline (1961-90)	An increase indicates the possibility of crop productivity getting affected. Increase in the intensity of such extreme rainfall event also means higher probability of floods with all the attendant problems.	Direct
Change in number of events with >100 mm rainfall in 3 days	Change (%) in the number of events during mid-century (2021-50) or end-century (2071-98) relative to the baseline (1961-90)	These events will adversely affect crop stand and crop productivity. Increased incidence of these events also means higher probability of floods with all the attendant problems	Direct

contd.....

Indicator	Measurement (unit)	Rationale	Relationship with exposure
Change in mean maximun rainfall in a single day as % to annual normal	Change during mid-century (2021-50) or end-century (2071-98) relative to the baseline (1961-90)	An increase indicates the possibility of crop productivity getting affected. Increase in the intensity of such extreme rainfall event also means higher probability of floods with all the attendant problems. It is also an indicator of uneven distribution of rainfall.	Direct
Change in mean maximun rainfall in 3 consecutive days as % to annual normal	Change during mid-century (2021-50) or end-century (2071-98) relative to the baseline (1961-90)	These events will adversely affect crop stand and crop productivity. Increased incidence of these events also means higher probability of floods with all the attendant problems.	Direct

All these indicators are computed using the daily data on rainfall, maximum temperature and minimum temperature as obtained from PRECIS for SRES A1B[4,5]. These data are available for 0.44 X 0.44^0 grids. Using these grid data the district level estimates are arrived at by taking a simple average of all the grids falling in any given district in case of temperature and by taking a weighted average of the same with the area under each grid passing through the district as weight in case of rainfall.

Table 3 : Indicators of adaptive capacity included in computation of vulnerability index

Indicator	Measurement (unit)	Rationale	Relationship with adaptive capacity	Source of data
Rural poor	Proportion of rural population that is below poverty line (%)	Higher the poor, lower will be the capacity to adapt to climate change and variability.	Inverse	Chaudhary and Gupta (2009)
SC/ST Population	Proportion of population belonging to SC/ST (%)	SC/ST population is, in addition to being relatively poor, also less educated, poorly integrated with main-stream economy and heavily-dependent on natural resources for their livelihoods	Inverse	GoI, Census, 2001
Agricultural Workers	Number of workers engaged in agriculture in relation to total workers (%)	This indicates a relatively higher importance of agriculture in the livelihoods of population compared to other sectors.	Inverse	GoI, Census, 2001
Total Literacy	Percent people who are literate	Higher literacy enables people to adapt better and also enhances their ability to diversify livelihoods	Direct	GoI, Census, 2011

contd.....

Indicator	Measurement (unit)	Rationale	Relationship with adaptive capacity	Source of data
Gender gap	Difference between total literacy and female literacy	A lower gap indicates better gender equity	Inverse	GoI, Census, 2011
Access to markets	Number of agricultural markets per one lakh farm holdings[6]	Better access to markets helps farmers receive better prices and thus higher incomes. Better market access was also shown to be positively related to technology adoption.	Direct	Website http://agmarknet.nic.in
Road connectivity	Villages that have paved roads (%)	This is indicator of market access as well as of better integration with the economy and the associated spread effects of development.	Direct	GoI, Census, 2001
Rural electrification	Number of villages with electricity supply in relation to total number of villages (%)	This is an indicator of overall development in the village which positively influences the ability to adapt.	Direct	GoI, Census, 2001
Net irrigated area	Per cent of net sown area having access to irrigation	Irrigation is an important adaptation-enabler as it enables farmers save crops during dry spells or droughts. It is also strongly related to technology adoption	Direct	DES, DAC, GoI, Agricultural Census-2005-06, DAC
Livestock population	Number of livestock (small and large ruminants) expressed in terms of Adult Cattle Units per sq km of geographical area	This is an indicator of diversification of agriculture and livelihoods and hence enhances the ability to cope with climatic aberrations	Direct	Livestock census 2007
Fertilizer consumption	Consumption of fertilizer nutrients (N+P+K) per ha of gross sown area	Higher use of fertilizers is an indicator of adoption of improved technologies	Direct	CMIE
Groundwater availability	Availability of groundwater (ha m/sqkm)	This reflects the scope to exploit groundwater resources for irrigation	Direct	CGWB (2012)
Share of agriculture in district domestic product	Proportion of district domestic product contributed by agriculture (%). Computed by multiplying the state level GDP from agriculture by share of the district in the gross sown area in the state	Higher share indicates relatively less developed secondary and tertiary sectors in the district	Inverse	Computed from state level data obtained from www.rbi.org.in

3.2. Computation of Vulnerability Index

A database of all the indicators chosen for 572 rural districts, as appearing in 2001 census was created. The data on the indicators chosen were then normalized and combined into an index following the methodology followed in computation of Human Development Index[7] (UNDP, 1999, 2006). However, it differs from it in that the minimum and maximum of the indicator values are taken from the data set rather than fixing the minimum and maximum values on *a priori* considerations. In case of rainfall, the maximum value is fixed at 1500 mm as most crops do not respond positively to rainfall above this. Similarly, maximum values were defined for fertilizer consumption (400 kg/ha) and number of markets (40).

The process of construction of vulnerability index involves normalization of all the indicators and then averaging these resultant normalized values. The following formulae were used to normalize different indicators depending on the relationship of the indicator with the dimension:

$$Z_i = \frac{X_i - X_{\min}}{X_{\max} - X_{\min}}$$

When the indicator is positively related to the index

$$Z_i = \frac{X_{\max} - X_i}{X_{\max} - X_{\min}}$$

When the indicator is negatively related to the index

Where

Z_i is normalized value of i^{th} district w.r.t. the indicator X

X_i is the value of indicator in original units for i^{th} district

X_{min} is the minimum value of the indicator in original units across the districts

X_{max} is the maximum value of the indicator in original units across the districts (unless specified on *a priori* basis)

Three indices for sensitivity, exposure and adaptive capacity were constructed by obtaining a weighted mean of the indicators identified. These three indices were then averaged (with differential weights) to obtain the vulnerability index, higher values of which indicate higher vulnerability and lower values lower vulnerability. It is to be noted that this index is not an absolute measure of damage or risk due to climate change and it is only a relative measure of risk between the districts. It is however helpful in targeting and prioritization of investments for adaptation.

The weights given to each of the indicators were arrived at based on review of literature and a series of discussions with a group of experts actively involved in research for developing appropriate adaptation and mitigation measures and strategies to deal with climate change. Table 4 presents the weighting scheme followed in the computation of vulnerability index.

These results were also found in agreement with the results obtained using the weights derived by subjecting the data to principal components analysis. The findings were presented to relevant stakeholders before finalizing the output[8]. All 572 districts were categorized into five equal quintiles of 114 districts each and one district at the margin was added to the two more vulnerable categories. Thus, five categories of districts with – Very High Vulnerability (115), High Vulnerability (115), Medium Vulnerability (114), Low Vulnerability (114) and Very Low Vulnerability (114) were identified. Further, the most important factors contributing to vulnerability were identified based on the normalized values of all the indicators and weights from each of the three dimensions given in case of districts with high and very high vulnerability so that appropriate interventions can be planned to minimize the vulnerability.

Table 4 : Weighting scheme followed in construction of vulnerability index

Exposure (25)	Weight (%)	Sensitivity (40)	Weight (%)	Adaptive Capacity (35)	Weight (%)
Change in Annual rainfall	10	Net sown area as % GA	15	Rural poor	10
Change in June rainfall	5	Degraded land as % GA	5	SC/ST Population	5
Change in July rainfall	15	Annual rainfall (normal)	20	Agricultural Workers	5
Change in number of rainy days	5	Cyclone proneness	5	Total Literacy	5
Change in MaxT	8	Area prone to flood incidence	10	Gender gap	5
Change in MinT	10	Drought proneness	20	Acces to Markets	5
Change in extreme hot day frequency	5	AWC of soil	5	Road Connectivity	5
Change in extreme cold day frequency	3	Stage of Groundwater development	10	Rural Electrification	5
Change in frost occurrence	2	Rural Population density	5	Irrigation	20
Change in drought proneness	12	Area operated by small and marginal farmers	5	Livestock population	8
Change in incidence of dry spells of >= 14 days	5			Fertiliser consumption	8
99 percentile rainfall	5			Groundwater availability	15
Change in number of events with >100 mm rainfall in 3 days	5			Share of agriculture in district domestic product	4
Change in maximum rainfall in a single day as % to annual normal	5				
Change in maximum rainfall in 3 consecutive days as % to annual normal	5				

GA - Geographical Area

3.3. Variants of Vulnerability Index Computed

Considering the uncertainty associated with climate projections, it may not be entirely desirable to derive the relative vulnerability based on the output of any single climate projection model. It is useful to construct the vulnerability index sans the climate projections so that one can obtain an idea as to how different districts are predisposed to climate change and variability. Thus, vulnerability index was also constructed by including only those indicators related to sensitivity and adaptive capacity. Thus, three variants of vulnerability index were constructed:

1. Vulnerability based on the indicators for sensitivity and adaptive capacity
2. Vulnerability based on the indicators related to sensitivity, adaptive capacity and exposure with the latter capturing the projected changes in climate for the period 2021-50 relative to the baseline (1961-90)

3. Vulnerability based on the indicators related to sensitivity, adaptive capacity and exposure with the latter capturing the projected changes in climate for the period 2071-98 relative to the baseline (1961-90)

These three variants are referred to as vulnerability, vulnerability (mid-century) and vulnerability (end-century), respectively in the remaining part of this publication. State-wise distribution of districts with different levels of vulnerability, identification of important sources of vulnerability and possible interventions are, however, done based on the relative vulnerability (mid-century).

3.4. Other Indicators

In addition to providing a measure of relative vulnerability index as explained above, it is considered useful to present some other variables that are relevant to planning adaptation. Thus, information on the following variables/ indicators is also presented:

Rainfall per rainy day

Measured in terms of millimetres of rain per rainy day, it is an indicator of rainfall intensity as well as of distribution of rainfall, especially when considered along with total rainfall. A higher value without a corresponding increase in the total rainfall indicates unfavourable distribution of rainfall. It is presented in terms of change during 2021-50 and 2071-98 relative to 1961-90.

Normalized Difference Vegetation Index

The status of vegetation in a given locality is influenced by the climatic features of that location. NDVI is a measure of biomass or vegetation status computed using the remotely sensed data. The variations in NDVI over time are known to be related to variability in climate especially with temperature and rainfall. Therefore, the temporal variability in NDVI was captured to understand the variability of climate during the recent past in the country[9].

NDVI (AVHRR)

To identify vulnerable regions in the country, temporal analysis of dynamics of weather aberrations was carried out for each year. First, a layer of annual Max NDVI for each year was prepared from AVHRR (8-km) NDVI data product using 24 images for each of the 25 years (1982-2006). Next, they were stacked to estimate CV of Max NDVI which was then used to plot a variability map using pixel-level data at State and AESR-levels

NDVI (MODIS)

In addition to AVHRR data, MODIS (16-day 250m) NDVI data product was used to downscale vulnerability analysis to district-level so that it can help in implementing mitigation and adaptation strategies at the administrative-level.

4 Scope and limitations

Scope and limitations

As mentioned, the analysis was done for the 572 rural districts as appearing in the 2001 Census of India. Each Union Territory included in the analysis was considered as a single district. Since the vulnerability index constructed is relative in nature, considering all the districts that vary widely with respect to the indicators chosen together will mean that the indicator is linearly related to the underlying phenomenon which may not be the case in reality. For example, the annual rainfall ranges from about 155 mm in Jaisalmer (Rajasthan) to about 12000 mm in Jantia Hills (Meghalaya). A significant positive deviation in rainfall may mean less vulnerability in a district with low mean rainfall and a similar deviation may lead to increased vulnerability in regions with very high mean annual rainfall. However, wherever appropriate, we have imposed the upper and lower limits so that the non-linearity issue is addressed to some extent and the bias reduced to that extent. Climate projections for the country vary with the corresponding GCM/ RCMs and with different emission scenarios assumed. We have used only one model projection (A1B SRES scenario). This scenario was used as it showed 'reasonable skill in simulating the monsoon climate over India' (Krishna Kumar et al., 2011) and was considered as 'the most appropriate scenario as it represents high technological development, with the infusion of renewable energy technologies following a sustainable growth trajectory' (MoEF, 2012). Further, for a study of this scale, obtaining data on all the variables/ indicators for a uniform reference period is extremely difficult. For most of the status variables like irrigation, net sown area, electrification, district domestic product, etc. we have used the most recent data available for each unit of analysis unless specified otherwise. The missing data were computed following appropriate methods such as using nearest neighbourhood value, average value of respective state, etc. The country has witnessed reorganization of districts several times and we have limited our analysis for the districts as appearing in 2001 and those districts that have been formed since then could not be explicitly included in this analysis as some of the indicators chosen were derived based on the time series data.

5 Findings

This section presents the data on indicators of different dimensions of vulnerability, the indices of sensitivity, exposure and adaptive capacity and the vulnerability index. An analysis of variability in the climate in the recent past in terms of the variability in NDVI is also presented here. The relative rankings of districts based on the vulnerability index and on the indices of the three components are given in Annexure.

5.1 Sensitivity indicators

Net sown area as proportion of geographical area (Fig. S1): NSA is relatively less in the hill states of Jammu & Kashmir, North Eastern states and in a few districts in Rajasthan and Gujarat. It is relatively high in the Indo-Gangetic Plains, Maharashtra and a few districts in Gujarat. Districts with more of area under agriculture are more sensitive as it indicates that more area is subjected to changing climate and variability.

Degraded and waste lands (Fig. S2): It indicates the extent of land degraded due to different forms of erosion, salinity and alkalinity etc. Because of their poor status in terms of physical, chemical, biological and hydrological attributes, they render crop production highly sensitive to the changing climate. Large tracts of degraded land are present in Rajasthan, Uttar Pradesh, Madhya Pradesh, and North Eastern States. The problem is relatively low in Bihar, Gujarat, Punjab, Haryana, Uttarakhand etc.

Annual rainfall (Fig. S3): Higher rainfall is generally considered as favourable to higher agricultural productivity and production. However, a very high rainfall may as well lead to more erosion and to higher incidence of floods. Rainfall is typically higher in Western Ghats, Eastern and North Eastern India and low in Gujarat and Rajasthan where the climate is arid. The tracts comprising states of Maharashtra, Madhya Pradesh, Karnataka, Tamilnadu and Andhra Pradesh represent a semi-arid climate with rainfall ranging from 700 to 1300 mm.

Cyclone proneness (Fig. S4): It is an index computed based on five attributes viz., number of cyclones crossing the district, number of severe cyclones crossing the district, probable maximum rainfall for a day, probable maximum winds in knot, and probable maximum storm surge. The index is computed for all the districts on the sea coast. The districts along the west coast, except those in Gujarat, are relatively less cyclone-prone compared to those on the east coast.

Area prone to flood incidence (Fig. S5): More than 20 per cent of geographical area is prone to incidence of floods in a majority of districts in Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal and in a few districts in North-Eastern states, Gujarat, Andhra Pradesh, Kerala and Orissa.

Drought incidence (Fig. S6): Very high incidence of drought (> 20%) is observed in a few districts in Rajasthan and Gujarat. The incidence is relatively low in the Western Ghats, Eastern and North-Eastern India.

Available water holding capacity of soil (Fig. S7): A low capacity of soil to hold water that the plants can take means higher sensitivity of crop yields to variable and changing climate. It is more than 100 mm in most of the districts and is relatively low (< 60 mm) in Jammu & Kashmir, Uttarakhand, Himachal Pradesh, North-Eastern states and a few districts in Rajasthan.

Stage of groundwater development (Fig. S8): This indicates the draft of groundwater relative to availability. The situation with respect to ground water is precarious in a majority of districts in Rajasthan, Punjab, Haryana and in a few districts in Gujarat, Uttar Pradesh, Karnataka, Tamilnadu and Madhya Pradesh where more than 100 per cent of available groundwater is already being used.

Rural population density (Fig. S9): This indicates the degree of dependence of population on agriculture and hence higher the density more is the sensitivity. A higher density also means higher man-land ratio indicating the low per capita availability of land. Districts in eastern part of Uttar Pradesh, Bihar, West Bengal and Kerala have rural population density of more than 600/km^2. In a majority of the districts in the country, the rural population density is less than 400/km^2.

Small and marginal farmers (Fig. S10): This is closely related to rural population density and is also an indicator of distribution of land. More than 60 per cent of land is owned by small and marginal farmers in Jammu & Kashmir, Uttar Pradesh, Uttrakhand, Bihar, Jharkhand, West Bengal, Kerala, Tamilnadu, Orissa and in a few districts in Andhra Pradesh and North-Eastern states.

Sensitivity Index (Fig. S11): Most of the districts in north-west India have very high sensitivity and those in the Indo-Gangetic plains of Uttar Pradesh, Bihar and West Bengal exhibit high sensitivity. Similarly, a number of districts in peninsular semi-arid regions are also highly sensitive. Sensitivity is found to be relatively low in the eastern, north-eastern, northern parts and along the west coast of the country.

5.2 Exposure indicators

5.2.1. Exposure (Mid-century relative to baseline)

Change in annual rainfall (Fig. EM1): Rainfall is projected to increase or to remain constant in a majority of districts except in a few districts in Bihar, Jharkhand, West Bengal, Arunachal Pradesh, Andhra Pradesh, Karnataka and Tamilnadu.

Change in rainfall during June (Fig. EM2): Rainfall during June is critical to sowing of most of rainy season crops and hence as such is a key determinant of cropping pattern. This is projected to decrease in majority of districts in Rajasthan, Gujarat, Punjab, Haryana, Jammu & Kashmir, Karnataka, Tamilnadu and in a few districts in Maharashtra, Andhra Pradesh and North-Eastern states.

Change in rainfall during July (Fig. EM3): Rainfall during July is projected to increase or remain the same in a majority of districts, Some districts in Rajasthan, Karnataka, Tamilnadu, Andhra Pradesh, Bihar, West Bengal and North-Eastern states are, however, expected to receive less rainfall during July.

Change in number of rainy days (Fig. EM4): Number of rainy days is an indicator of distribution of rainfall when seen with the amount of rainfall during a year. No considerable change in the number of rainy days is likely in a majority of districts. The rainfall is expected to be received in fewer days in some districts of Bihar, Jharkhand, West Bengal, North-Eastern states, Karnataka, Andhra Pradesh, southern Maharashtra and Tamilnadu. A few districts in north-western parts of the country, Andhra Pradesh and Orissa are likely to experience more rainy days.

Change in maximum temperature (Fig. EM5): Except for Punjab, Haryana and a few districts in Rajasthan, maximum temperature is likely to rise by more than 1.5^0C in rest of the country. A few districts in Bihar, West Bengal, Jharkhand, North-Eastern states, Himachal Pradesh, Uttrakhand and Karnataka are likely to experience much hotter days with the rise in maximum temperature exceeding 2^0C.

Change in minimum temperature (Fig. EM6): The minimum temperature is expected to increase by 2 – 2.5^0C in most districts with the rise being somewhat moderate (1.5 – 2.0^0C) in the eastern and north-eastern states. The nights are projected to be much warmer (by >2.5^0C) in Jammu & Kashmir.

Change in incidence of extremely hot days (Fig. EM7): A day is considered extremely hot when the maximum temperature on any given day exceeds the normal by at least 4^0C during March to May. A few districts in Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana, Uttar Pradesh, Uttarakhand, Madhya Pradesh and North-Eastern states are likely to experience more frequent hot days compared to the base line.

Change in incidence of extremely cold days (Fig. EM8): Defined as the number of days when the minimum temperature is at least 4^0 C below normal during December to February, its occurrence is expected to increase in whole of Gujarat, in a large number of districts in Rajasthan, and in some districts in Madhya Pradesh, Maharashtra, Karnataka, Tamilnadu, Chhattisgarh, West Bengal and North-Eastern states. In rest of the country, the number of days with cold wave conditions is expected to decrease.

Change in occurrence of frost (Fig. EM9): The number of days when the minimum temperature falls below zero is projected to decrease by more than five days in a few districts in Jammu & Kashmir, Himachal Pradesh, Rajasthan, Punjab, Haryana, Uttarakhand and Arunachal Pradesh. Frost occurrence is expected to decrease by a maximum of five days in most parts of central and northern India.

Change in occurrence of drought (Fig. EM10): The incidence of drought, measured in terms of occurrence of number of severe droughts per 100 years, increases in a few districts in Rajasthan, Madhya Pradesh, Chhattisgarh, Maharashtra, Bihar, eastern Uttar Pradesh, North-Eastern States, Karnataka, Tamilnadu, Jammu & Kashmir and in a majority of districts in Kerala. Some districts in eastern Rajasthan, Punjab, Uttar Pradesh, Andhra Pradesh, and Karnataka are projected to experience drought less frequently.

Change in incidence of dry spells (Fig. EM11): Expressed as number of dry spells of 14 days at least, it is expected to increase in some districts in eastern Madhya Pradesh, Maharashtra, Karnataka, Tamilnadu, Chhattisgarh, Orissa, Bihar, Jharkhand, and Kerala.

99 percentile rainfall (Fig. EM12): Taken as an indicator triggering the incidence of floods, this is expected to increase by more than five per cent in most districts in the country, except in a number of districts in Andhra Pradesh and Tamilnadu and in a few districts in Karnataka, West Bengal and North-Eastern states.

Change in number of events with more than 100 mm rainfall in three consecutive days (Fig. EM13): This is another indicator related to extreme rainfall whose incidence is expected to increase in majority of districts. It is projected to decline in some districts in Andhra Pradesh, Tamilnadu, Karnataka, West Bengal, Rajasthan and North-Eastern states.

Change in mean maximum rainfall in a single event (Fig. EM14): The amount of rainfall received in a single event is projected to increase in a few districts in states such as Gujarat, Madhya Pradesh, Maharashtra, Karnataka, Tamilnadu, Andhra Pradesh, Uttar Pradesh and Jharkhand. In most part of the country, it is expected to remain about the same as in the baseline and to decrease in a few districts.

Change in mean maximum rainfall in three consecutive days (Fig. EM15): Compared to the baseline, a much higher proportion of annual rainfall is projected to be received in a few districts in Gujarat, Madhya Pradesh, Tamilnadu, Maharashtra, Karnataka, and in north-eastern states. The intensity of such extreme rainfall events is projected to decrease in most districts of Andhra Pradesh and in some districts in the states such as Karnataka, Tamilnadu, Chhattisgarh, Rajasthan, Jharkhand, Orissa and north-eastern states.

Exposure Index (Fig. EM16): High to very high exposure is observed in districts of Madhya Pradesh, Karnataka, Rajasthan, Gujarat, Maharashtra, Bihar, Tamilnadu, North-Eastern states and in Jammu & Kashmir. Districts with low and very low exposure are seen in Andhra Pradesh, Orissa, West Bengal, parts of Punjab, Haryana, Rajasthan and Uttar Pradesh.

5.2.2. Exposure (End-century relative to baseline)

Change in annual rainfall (Fig. EE1): Rainfall is projected to increase by more than five per cent in a majority of districts except in a few districts in Rajasthan and Tamilnadu where it is projected to decrease by more than five per cent. In a few districts in Karnataka, Andhra Pradesh, Maharashtra, Tamilnadu and Arunachal Pradesh, the change in rainfall is expected to between -5 to +5 per cent compared to the baseline period.

Change in rainfall during June (Fig. EE2): This is projected to decrease in majority of districts in Rajasthan, Gujarat, Maharashtra, Karnataka, Andhra Pradesh, much of Tamilnadu, Southern parts of Chhattisgarh and Orissa, parts of Punjab, Himachal Pradesh and Jammu Kashmir. In northern and north-eastern states and in a few districts in Kerala, it is expected to increase by more than five per cent.

Change in rainfall during July (Fig. EE3): Rainfall during July is projected to increase in most parts of central and northern India and is expected to decrease by more than five per cent in many districts in Andhra Pradesh, Karnataka, Rajasthan and in a few districts in Arunachal Pradesh, Jammu and Kashmir, Maharashtra and Tamilnadu.

Change in number of rainy days (Fig. EE4): The rainfall is expected to be received in fewer days in some districts of Rajasthan, Maharashtra, Karnataka, Tamilnadu and north-eastern states. The number of rainy days is expected to increase in a majority of districts in southern India and to remain about the same in the states of Uttar Pradesh, Madhya Pradesh, West Bengal, Bihar, Jharkhand and North-eastern states.

Change in maximum temperature (Fig. EE5): Northern India is likely to experience much hotter days with a rise in maximum temperature of 4^0C. Even in southern and central India, the maximum temperature is expeted to increase by more than 3^0C except in a few districts on the west coast.

Change in minimum temperature (Fig. EE6): Except for the districts in Kerala and a few districts in Tamilnadu, Karnataka, Maharashtra, Rajasthan and in North-eastern states, the minimum temperature is expected to rise at least by 4^{0}C in most part of the country. Some districts in hill states of Jammu & Kashmir Himachal Pradesh, Uttarakhand as well as some in Rajasthan and Sikkim are likely to experience much warmer nights as the minimum temperature is projected to rise by 5 to 5.5^{0}C.

Change in incidence of extremely hot days (Fig. EE7): The number of days when the maximum temperature exceeds the normal temperature for the day by at least 4^{0}C is projected to increase in a majority of districts in eastern, southern and northern states and decrease in Gujarat and in a number of districts in Rajasthan, Maharashtra, Bihar, West Bengal, Jharkhand and Jammu & Kashmir.

Change in incidence of extremely cold days (Fig. EE8): The frequency of occurrence of cold days, when the minimum temperature falls below the normal temperature by at least 4^{0}C is projected to increase in a majority of districts in central and western parts of the country, in the states of Maharashtra, Gujarat, Rajasthan, Madhya Pradesh, Orissa and Karnataka. The frequency of occurrence of such colder nights is expected to decrease in most parts of northern and north-east India and Tamilnadu.

Change in occurrence of frost (Fig. EE9): The number of days when the minimum temperature falls below zero is projected to increase marginally in a few districts in Jammu & Kashmir, Himachal Pradesh, Uttarakhand and Sikkim. Frost occurrence is expected to decrease in most parts of central and northern India, with the decrease being more conspicuous in districts of Rajasthan, Punjab, Haryana, Jammu & Kashmir, Uttarakhand and Arunachal Pradesh.

Change in occurrence of drought (Fig. EE10): The incidence of drought, measured in terms of occurrence of number of severe droughts per 100 years, is projected to increase by more than one in many districts in Rajasthan, Madhya Pradesh, Chhattisgarh, Maharashtra, Punjab, Eastern Uttar Pradesh and in a few districts in Bihar and North-Eastern States. Some districts in eastern Rajasthan, Uttar Pradesh, Andhra Pradesh, Orissa, Tamilnadu, West Bengal and North Eastern states are projected to experience drought less frequently.

Change in incidence of dry spells (Fig. EE11): Expressed as number of dry spells of 14 days at least, it is expected to increase in some districts in eastern Madhya Pradesh, eastern Uttar Pradesh, Chhattisgarh, Jharkhand , Bihar, Orissa, Maharashtra, Karnataka and Tamilnadu. Dry spells are projected to be less frequent in many districts of Rajasthan, Gujarat, Andhra Pradesh, districts along the west coast, Maharashtra, Madhya Pradesh and north-eastern states.

99 percentile rainfall (Fig. EE12): Taken as an indicator triggering the incidence of floods, this is expected to increase by more than five per cent in most districts in the country, except in a number of districts in Andhra Pradesh and Tamilnadu and in a few districts in Karnataka, Rajasthan and North-Eastern states.

Change in number of events with more than 100 mm rainfall in three consecutive days (Fig. EE13): This is another indicator related to extreme rainfall whose incidence is expected to increase in majority of districts. It is projected to decline in some districts in Andhra Pradesh, Tamilnadu, Karnataka, Rajasthan, Uttar Pradesh and Arunachal Pradesh.

Change in mean maximum rainfall in a single event (Fig. EE14): The amount of rainfall received in a single event is projected to increase in a few districts in Rajasthan, Gujarat, Maharashtra, Punjab, Jammu & Kashmir, Uttar Pradesh, Madhya Pradesh and West Bengal. In most parts of the country, it is expected to remain about the same as in the baseline.

Change in mean maximum rainfall in three consecutive days (Fig. EE15): Compared to the baseline, a much higher proportion of annual rainfall is projected to be received in a few districts in Rajasthan, Gujarat, Punjab and Maharashtra. The intensity of such extreme rainfall events is projected to decrease in most districts of Andhra Pradesh and in some districts in the states such as Karnataka, Tamilnadu, Maharashtra, Chhattisgarh, Uttar Pradesh, Jharkhand, Orissa and north-eastern states.

Exposure Index (Fig. EE16): High to very high exposure to climate change is observed in districts of Rajasthan, Madhya Pradesh, Uttar Pradesh, Punjab, Jammu & Kashmir, Uttrakhand, Chhattisgarh, Karnataka, Maharashtra and north-eastern states. Districts with low and very low exposure are seen along the west and east coasts of the country as well as in Andhra Pradesh, Haryana, western Uttar Pradesh, southern Madhya Pradesh, northern Maharashtra, Jharkhand and north-eastern states.

5.3 Adaptive Capacity indicators

Rural poverty (Fig. A1): Incidence of rural poverty is relatively higher (>40%) in some districts in Bihar, Orissa, Jharkhand, eastern Uttar Pradesh, Maharashtra. Poverty is relatively low in Punjab, Haryana, Rajasthan, Andhra Pradesh and Kerala.

SC/ST Population (Fig. A2): More than 80 per cent of population belongs to SC/ST in a few districts in Jammu & Kashmir, North-Eastern states and in Chhattisgarh. In most of the districts, it varies between 20 to 40 per cent.

Agricultural workers (Fig. A3): A higher proportion of main workers dependent on agriculture indicates a higher importance of agriculture and inadequate access to livelihoods in non-agricultural sector and hence a higher value means lower adaptive capacity. In a majority of districts, the dependency on agriculture is more than 60 per cent. The proportion of main workers engaged in agriculture is less than 20 per cent in a few districts in Kerala, Gujarat and Karnataka.

Literacy (Fig. A4): Sixty to eighty per cent of population is literate in a majority of districts in the country. Whereas as the literacy rate exceeds 80 per cent in the districts along the west coast and in a few districts in J &K, Punjab, Himachal Pradesh, Haryana, Uttarakhand, Tamilnadu, West Bengal, Madhya Pradesh and North-Eastern states, less than 60 per cent of population is literate in some pockets throughout the country.

Gender gap (Fig. A5): Expressed as the difference between the general literacy rate and female literacy rate, this is an indicator of gender equity. Districts with lower gap are better placed with respect to adaptive capacity. The gender gap is found to be more conspicuous (15-20%) in a few districts in Rajasthan and Jammu & Kashmir and is found to vary between 10 to 15 per cent in a majority of districts in central and northern parts of the country.

Access to agricultural markets (Fig. A6): A well developed market infrastructure is a source of development as they can help farmers get better prices and better access to inputs. In most of the districts, there are less than five markets per lakh holdings.

Road connectivity (Fig. A7): A better transport infrastructure enables an improved integration of the rural economy with the rest of the economy and thus helps diversify livelihoods. There are a few districts in Madhya Pradesh, Uttarakhand, Jharkhand, Orissa and North-Eastern states where less than 25 per cent of villages are connected with roads. In many of districts in these states as well as in Uttar Pradesh, Karnataka, Jammu & Kashmir and North-Eastern states, less than 75 per cent of villages are approachable by paved roads.

Rural Electrification (Fig. A8): All the villages in many states are electrified. However, electrification of villages is incomplete in districts of Bihar, Jharkhand, Arunachal Pradesh, Uttar Pradesh and in a few districts in Rajasthan, Orissa and Chhattisgarh. Lack of electric supply is an indicator of underdevelopment and hence of relatively less adaptive capacity.

Per cent Irrigated area (Fig. A9): Access to irrigation is an important source of adaptation to climate variability and change. Less than 30 per cent of net sown area is irrigated in a majority of districts. Districts in Punjab, Haryana, Uttar Pradesh, Bihar and a majority of districts on the eastern coast have more than 60 per cent of sown area under irrigation.

Density of livestock population (Fig. A10): Livestock rearing provides an important avenue for diversification of income and hence is positively related to adaptive capacity. In a majority districts, the livestock density is less than 200 adult cattle units/km^2. Relatively higher densities (>300ACU/km^2) are observed in a few districts in Uttar Pradesh, Bihar, West Bengal and Tamilnadu.

Consumption of Fertilizer nutrients (Fig. A11): It is taken as a proxy to adoption of improved technologies and hence districts with higher rates of nutrient consumption are better placed with respect to adaptive capacity. Nutrient consumption exceeded 200 kg/ha in a considerable number of districts in Andhra Pradesh, Punjab, Haryana, Uttar Pradesh and Tamilnadu and in a few districts in Karnataka, Maharashtra, Gujarat, West Bengal and Jharkhand. It is low (<100 kg/ha) in a majority of districts in Rajasthan, Madhya Pradesh, Orissa, Chhattisgarh and in North-Eastern states.

Groundwater availability (Fig. A12): Higher availability of groundwater can enable adaptation to climate change and variability. Less than 20 ha m of ground water is available per square kilometre of land in a majority of districts in the country except in the states of Indo-Gangetic plains and in a number of districts in North-Eastern states.

Contribution of agriculture to district domestic product (Fig. A13): Higher share of agriculture in the total district domestic product indicates that other sectors are relatively underdeveloped and hence low adaptive capacity. There are very few districts where agriculture contributes to more than 45 per cent of DDP and these are located in Madhya Pradesh, Rajasthan, Jammu & Kashmir and North-Eastern states. Less than 15 per cent of domestic product comes from agriculture in a number of districts in Tamilnadu, Maharashtra, Kerala and in a few districts in Karnataka, Madhya Pradesh, Himachal Pradesh, Uttarakhand, Bihar, Jharkhand, West Bengal etc.

Adaptive capacity Index (Fig. A14): Adaptive capacity is found to be very low in the eastern and north-eastern states, Rajasthan, Madhya Pradesh, peninsular and hill regions. Adaptive capacity is high in Punjab, Haryana, western Uttar Pradesh, many districts along the east coast and in Tamilnadu.

5.4. Vulnerability index

Vulnerability Index (Fig. V1): Many districts in Rajasthan, Gujarat, Maharashtra, Karnataka and some districts in Andhra Pradesh, Uttar Pradesh, Bihar, Uttrakhand and Jharkhand exhibit high and very high vulnerability. Most districts along the eastern and western coast, north-eastern states are less vulnerable.

Vulnerability Index (mid-century) (Fig. V2): Districts in Rajasthan, Gujarat, Madhya Pradesh, Karnataka, Maharashtra, Andhra Pradesh, Tamilnadu, eastern Uttar Pradesh and Bihar exhibit very high and high vulnerability. Districts along the west coast, northern Andhra Pradesh, North-Eastern states are relatively less vulnerable.

Vulnerability Index (end-century) (Fig. V3): Almost all districts in Rajasthan and many districts in Gujarat, Maharashtra, Karnataka and a few districts most all in Madhya Pradesh, Uttar Pradesh, Bihar, Punjab, Haryana, Himachal Pradesh, Uttarakhand and Andhra Pradesh exhibit very high vulnerability. A majority of districts with low and very low vulnerability are located along the west coast, southern and eastern parts of the country.

5.5. Other Indicators

Change in Rainfall per rainy day (mid-century) (Fig. O1): Defined as the total rainfall received to during the year divided by the total number of rainy days during the year, the rainfall per rainy day is projected to increase during the mid-century period compared to the baseline in a majority of districts in Maharashtra, Madhya Pradesh, Tripura, Nagaland, Manipur, Jharkhand, Himachal Pradesh and Gujarat and in a few districts in Punjab, Jammu and Kashmir, Uttrakhand, Kerala and Karnataka. In a majority of northern and western districts, it is projected to increase by less than 1 mm and whereas in distri cts of Andhra Pradesh, Tamilnadu, West Bengal, Bihar, Jharkhand, Arunachal Pradesh it is projected to decrease.

Change in Rainfall per rainy day (end-century) (Fig. O2): Rainfall intensity in terms of rainfall per rainy day is projected to increase in a majority of districts except in southern India and a few districts in Rajasthan, Maharashtra, Arunachal Pradesh, Orissa and Jammu and Kashmir. It is expected to decrease by more than 1mm per day in a few districts in northern Andhra Pradesh.

NDVI (AVHRR) (Fig. O3): There is a clear north - south axis to spatial distribution of agricultural vulnerability, represent as variability in NDVI in the country. High variability in NDVI is observed in arid, semi-arid and dry-sub-humid regions in the country. Map revealed that over 210 M ha in the country may be marginally affected by climate change due to rainfall variability while 76.56 M ha would be moderately and 2.85 M ha severely affected. These regions are essentially located in arid and semi-arid tracts in Rajasthan and Gujarat. Thus, while livestock in western Rajasthan may be critically vulnerable, prosperous farmers from cotton and groundnut growing belt in Gujarat may also face severe economic hardships and losses due to climate change in future.

Geo-statistical analysis indicated that instead of 210 M ha as estimated using AVHRR 8-km NDVI data, over 239.14 M ha may be marginally affected by climate change - induced vulnerability. Over 55 M ha may be moderately vulnerable while over 8 M ha may be severely affected. Relatively higher coefficient of variation in max NDVI is observed in districts of Rajasthan and Gujarat.

MODIS-NDVI (Fig. O4): The climate variability as indicated by the variation in the maximum NDVI (MODIS) is relatively more in the western parts and along the Deccan plateau of the country. Most of the regions in the eastern and northern parts and along the west coast have low variation indicating a more stable climate/ rainfall. The districts exhibiting relatively higher variation in the NDVI are located in arid and semi-arid regions, which include a transition belt between semi-arid and dry sub-humid zones. Districts with high variability in maximum NDVI are located in Rajasthan and Gujarat (Table 5).

Table 5 : State-wise distribution of districts based on variability in maximum MODIS-NDVI (2001-11)

State	Districts
	CV of Max NDVI (10-20%)
Andhra Pradesh	Anantapur, Kurnool, Mahabubnagar, Prakasam
Bihar	Gaya, Jahanabad, Nawada
Gujarat	Ahmadabad, Jamnagar, Rajkot, Surendranagar
Karnataka	Belgaum, Bijapur, Chitradurga, Dharwad, Gadag, Gulbarga, Haveri, Koppal, Raichur
Madhya Pradesh	Barwani, Bhind, Dhar, Guna, Ratlam, Sheopur, West Nimar
Maharashtra	Ahmednagar, Aurangabad, Pune, Sangli, Satara, Solapur
Rajasthan	Ajmer, Alwar, Bhilwara, Ganganagar, Jaipur, Jhunjunu, Karauli, Sawai Madhopur, Tonk
Uttar Pradesh	Jhansi
	CV of Max NDVI (20-30%)
Gujarat	Kacchh
Rajasthan	Barmer, Bikaner, Churu, Hanumangarh, Jodhpur, Nagaur
	CV of Max NDVI (30 – 40 %)
Rajasthan	Jaisalmer
	CV of Max NDVI (40 – 50 %)
Rajasthan & Gujarat	Parts of Jaisalmer, Barmer and Kacchh
	CV of Max NDVI (>50 %)
Rajasthan & Gujarat	Parts of Jaisalmer, Barmer and Kacchh

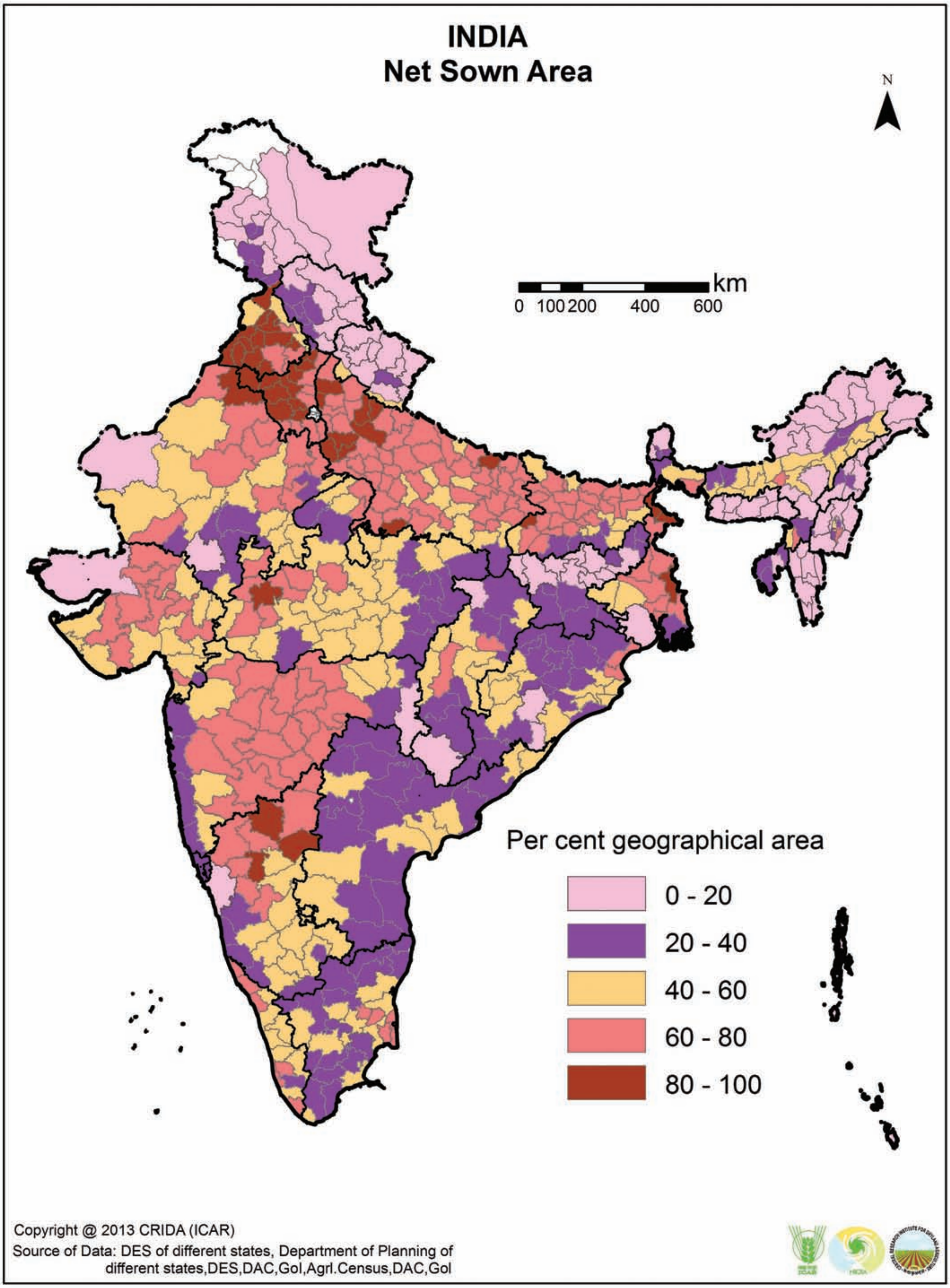

INDIA
Net Sown Area
N
km
0 100 200 400 600
Per cent geographical area
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Copyright @ 2013 CRIDA (ICAR)
Source of Data: DES of different states, Department of Planning of different states,DES,DAC,GoI,Agrl.Census,DAC,GoI

Fig. S1

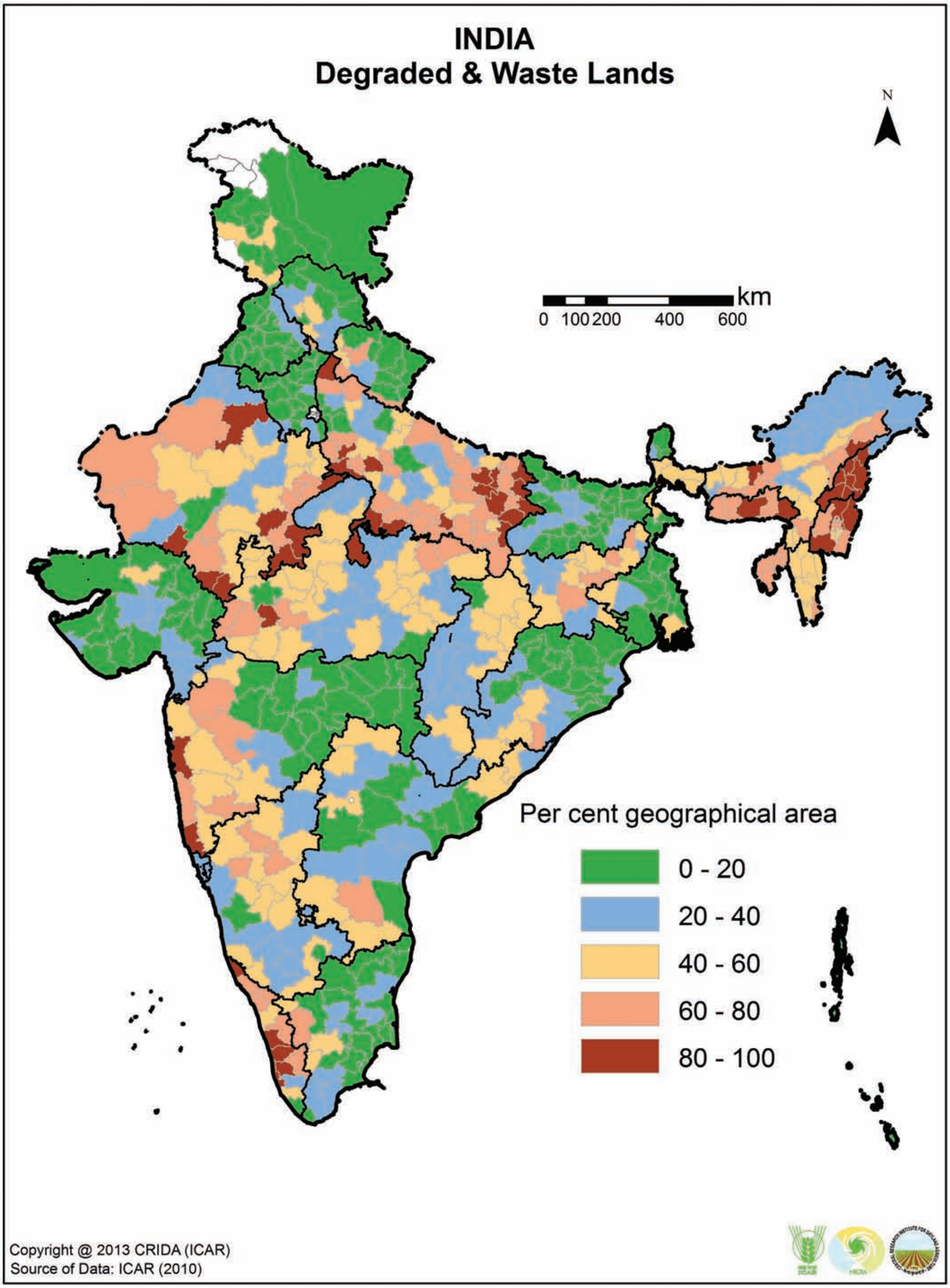

INDIA
Degraded & Waste Lands
N
km
0 100 200 400 600
Per cent geographical area
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Copyright @ 2013 CRIDA (ICAR)
Source of Data: ICAR (2010)

Fig. S2

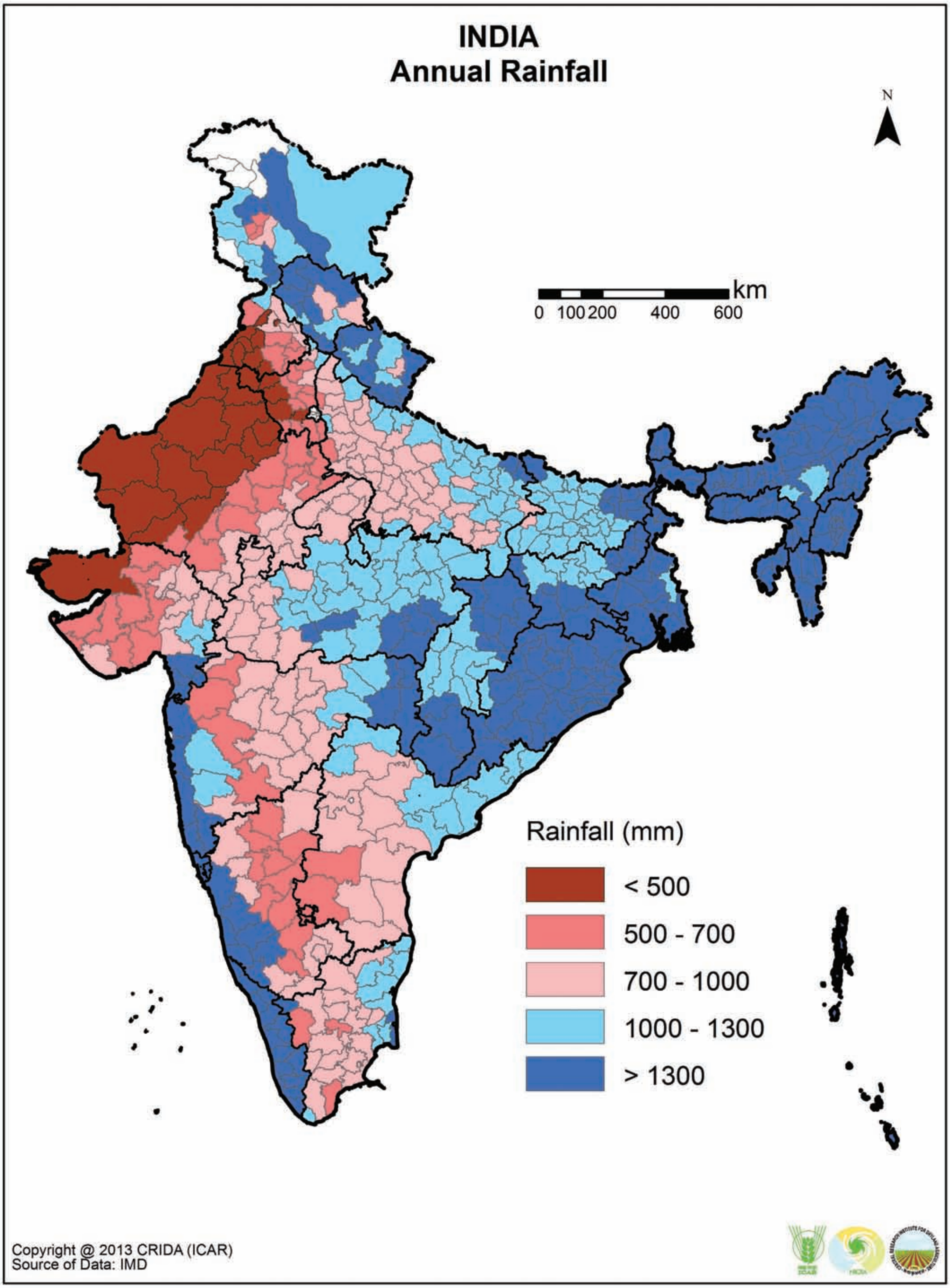

INDIA
Annual Rainfall
N
km
0 100 200 400 600
Rainfall (mm)
< 500
500 - 700
700 - 1000
1000 - 1300
> 1300
Copyright @ 2013 CRIDA (ICAR)
Source of Data: IMD

Fig. S3

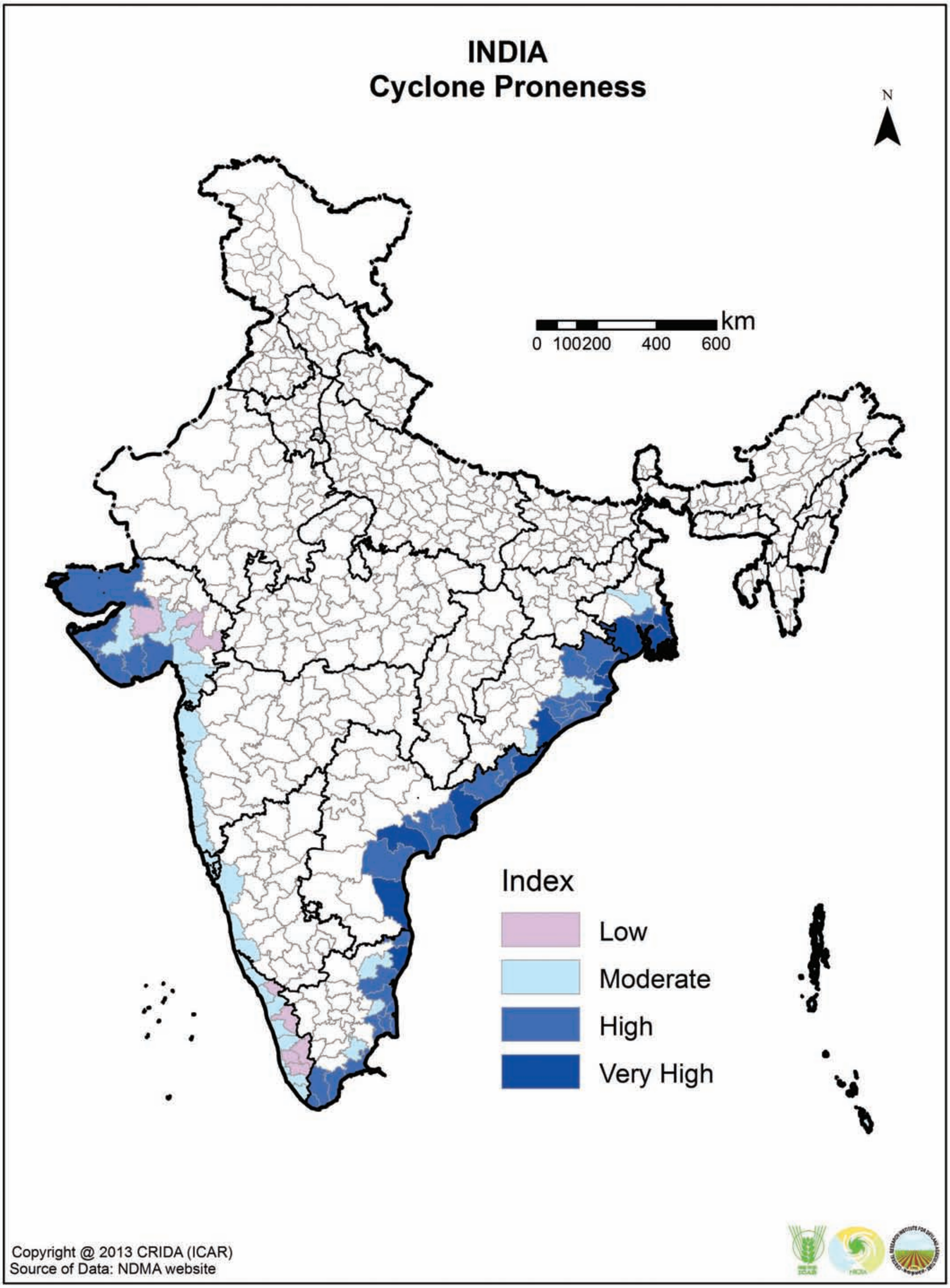

INDIA
Cyclone Proneness
N
km
0 100200 400 600
Index
Low
Moderate
High
Very High
Copyright @ 2013 CRIDA (ICAR)
Source of Data: NDMA website

Fig. S4

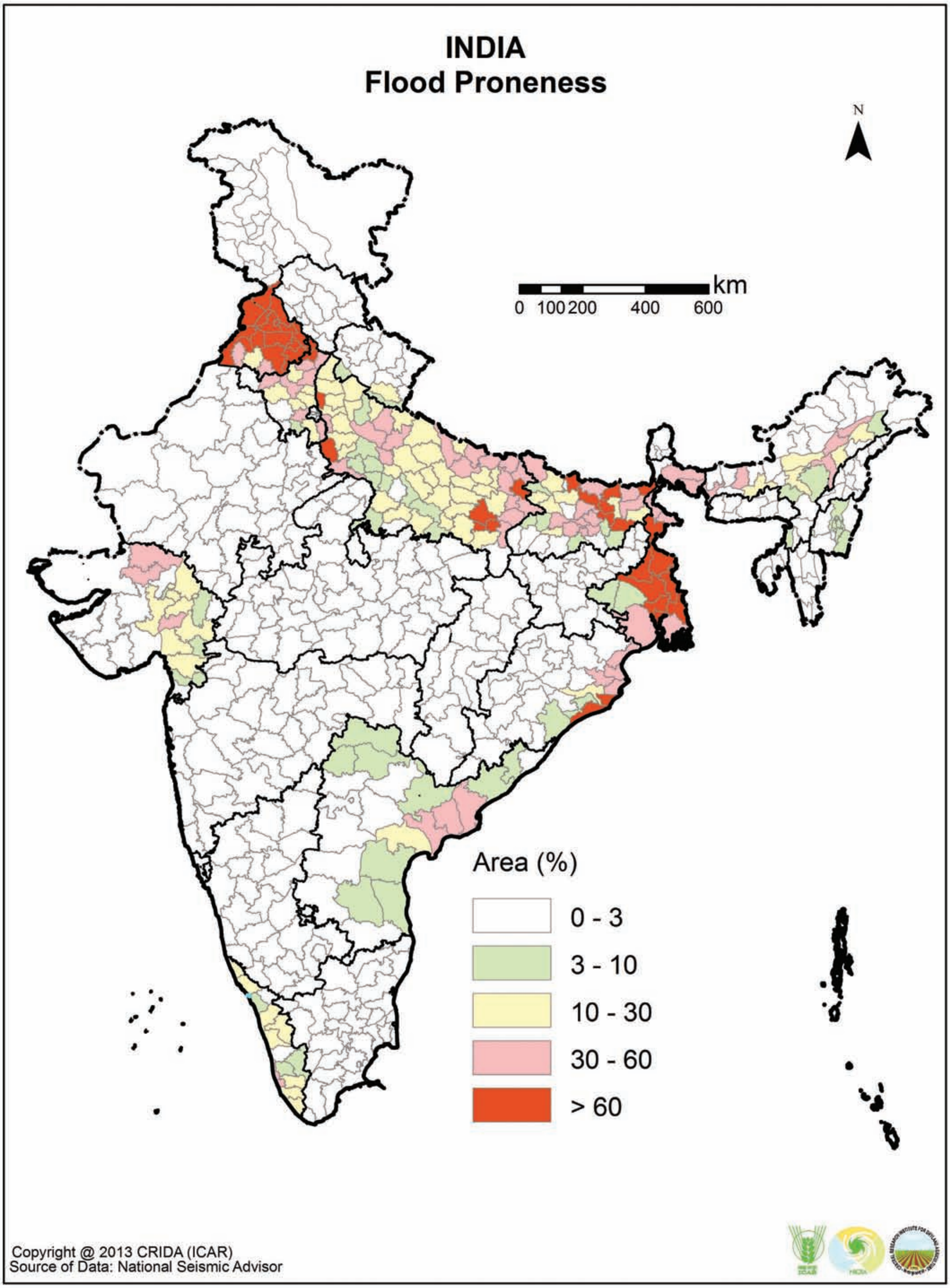

INDIA
Flood Proneness
N
km
0 100 200 400 600
Area (%)
0 - 3
3 - 10
10 - 30
30 - 60
> 60
Copyright @ 2013 CRIDA (ICAR)
Source of Data: National Seismic Advisor

Fig. S5

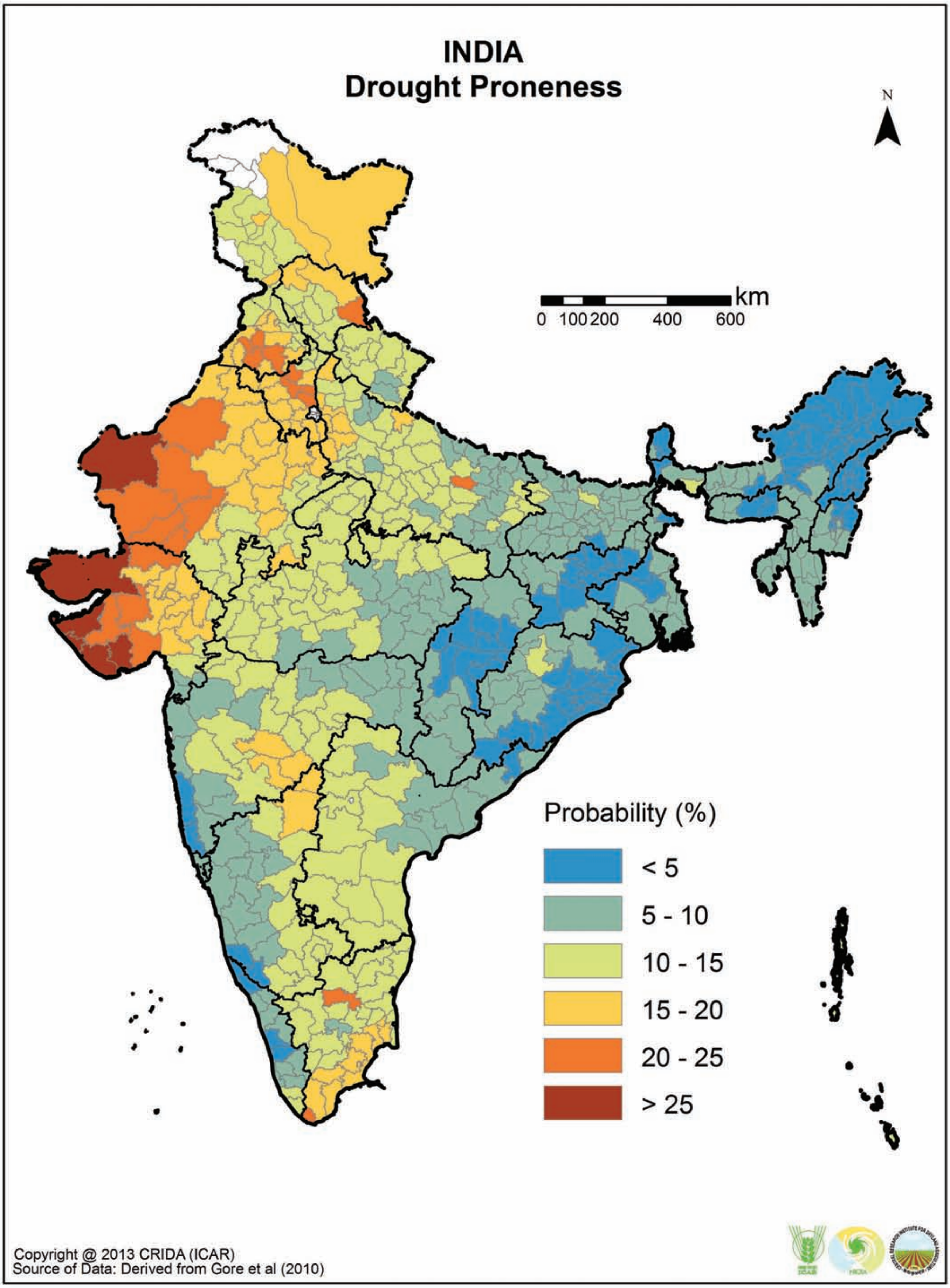

INDIA
Drought Proneness
N
km
0 100 200 400 600
Probability (%)
< 5
5 - 10
10 - 15
15 - 20
20 - 25
> 25
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Derived from Gore et al (2010)

Fig. S6

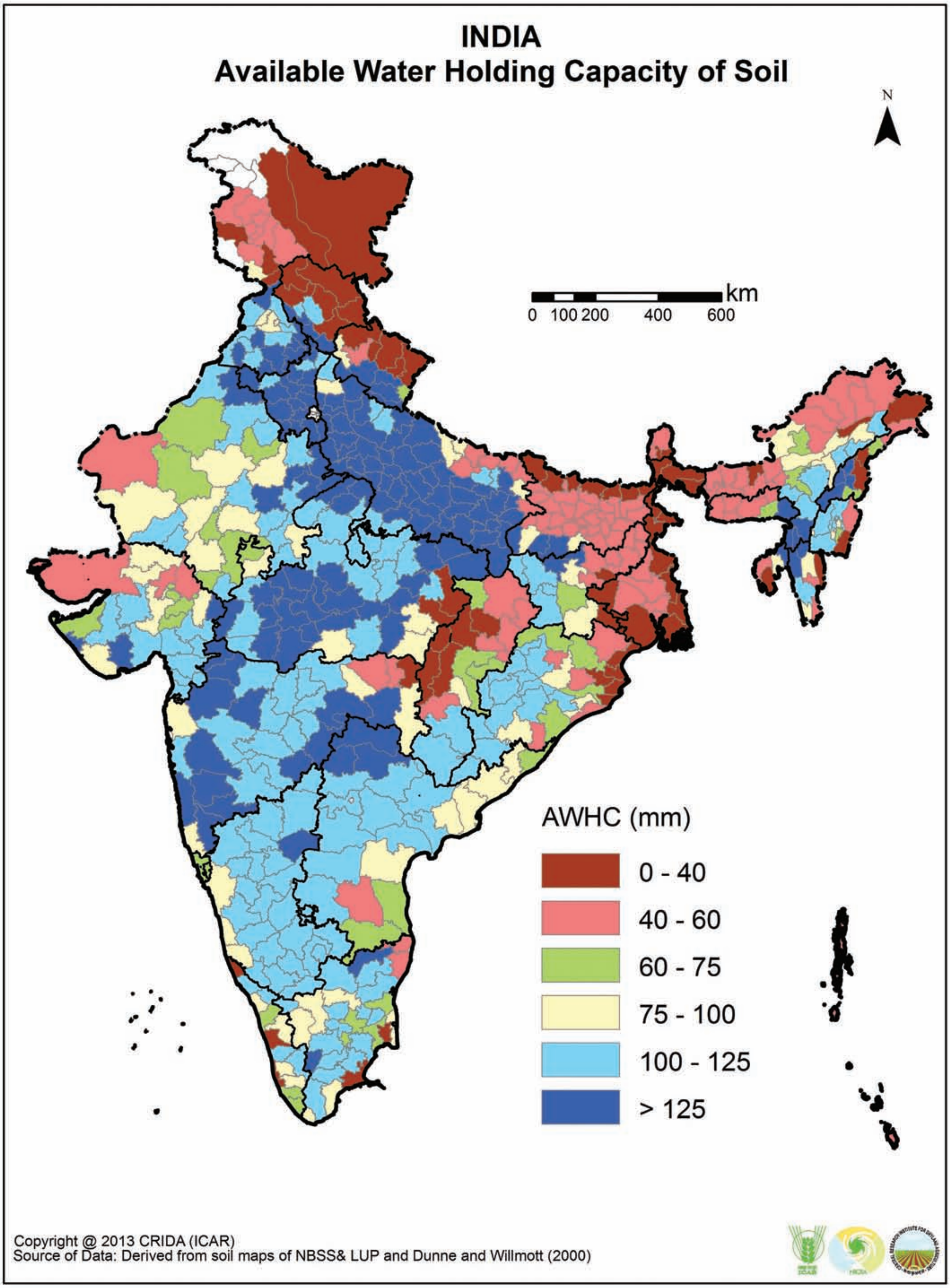

INDIA
Available Water Holding Capacity of Soil
N
km
0 100 200 400 600
AWHC (mm)
0 - 40
40 - 60
60 - 75
75 - 100
100 - 125
> 125
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Derived from soil maps of NBSS& LUP and Dunne and Willmott (2000)

Fig. S7

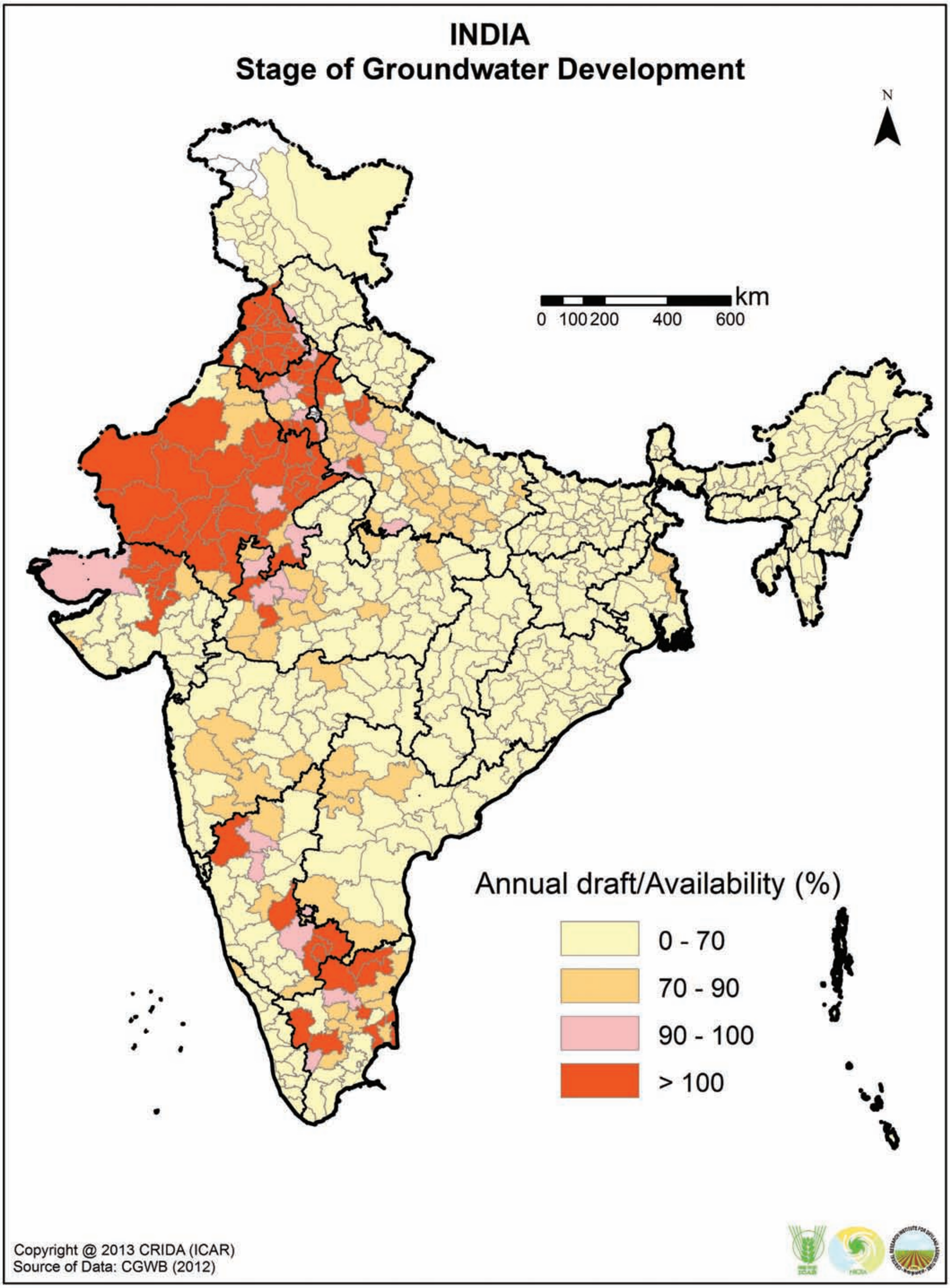

INDIA
Stage of Groundwater Development
N
km
0 100 200 400 600
Annual draft/Availability (%)
0 - 70
70 - 90
90 - 100
> 100
Copyright @ 2013 CRIDA (ICAR)
Source of Data: CGWB (2012)

Fig. S8

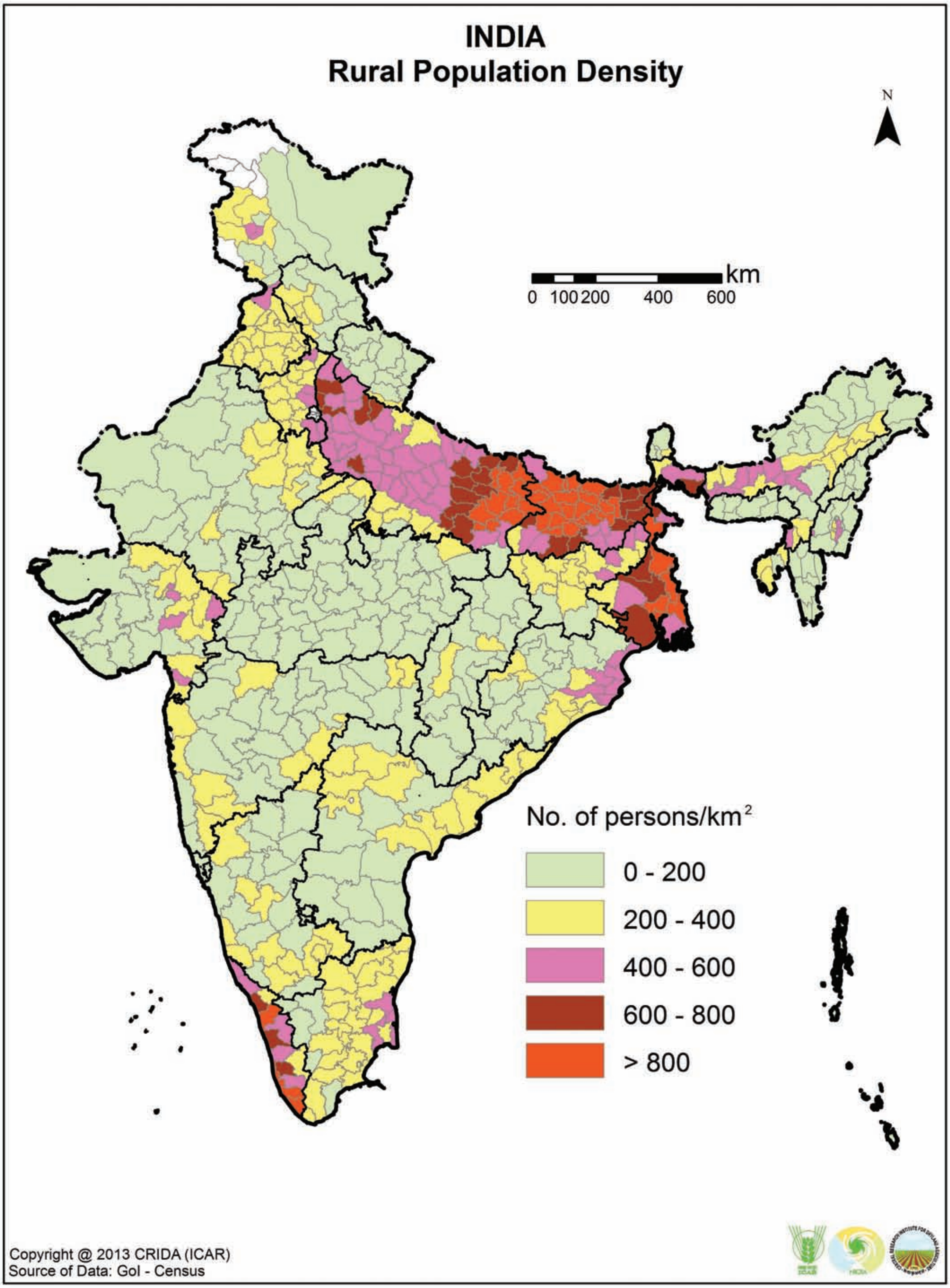

INDIA
Rural Population Density
N
km
0 100 200 400 600
No. of persons/km²
0 - 200
200 - 400
400 - 600
600 - 800
> 800
Copyright @ 2013 CRIDA (ICAR)
Source of Data: GoI - Census

Fig. S9

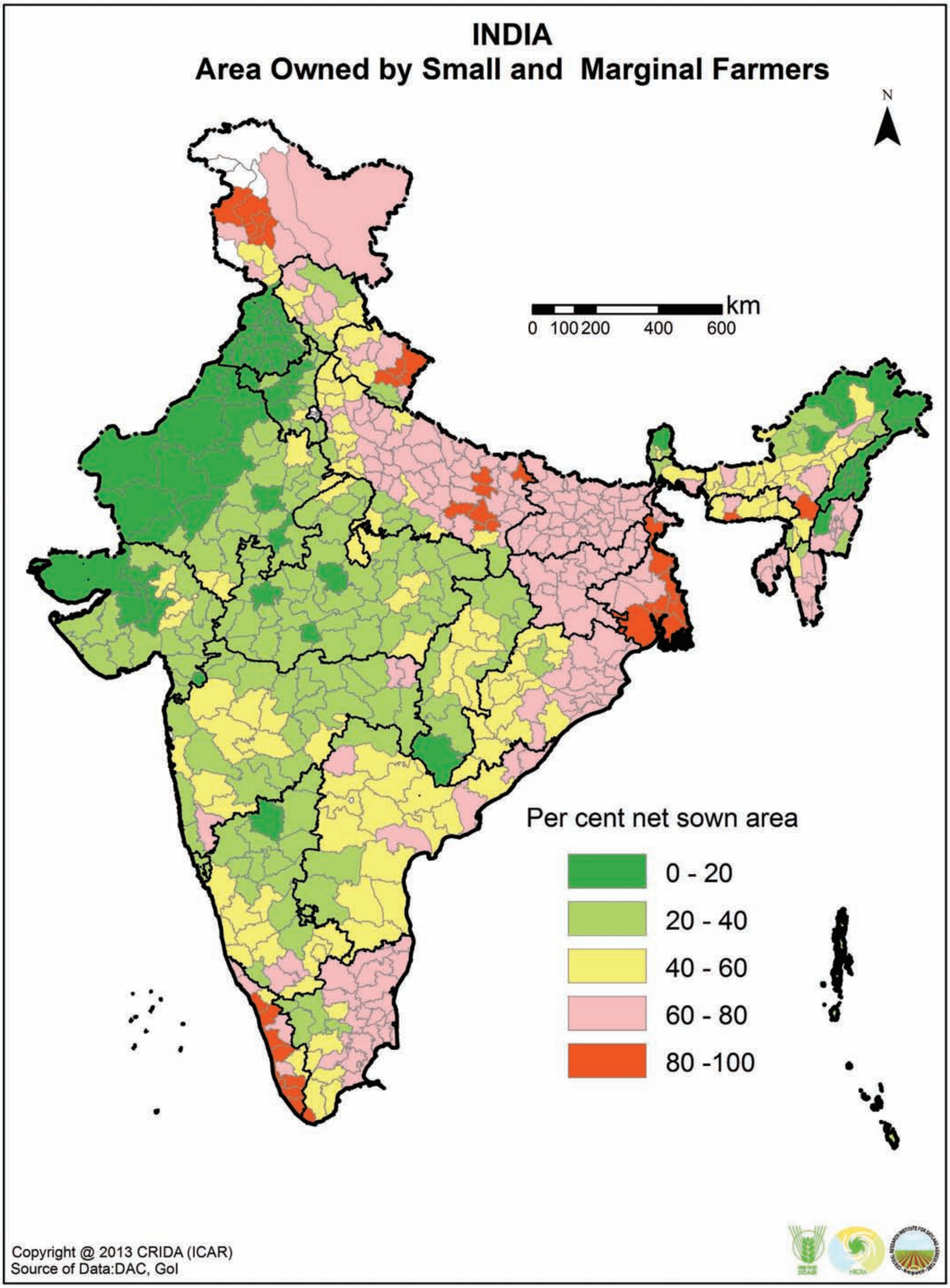

INDIA
Area Owned by Small and Marginal Farmers
N
km
0 100 200 400 600
Per cent net sown area
0 - 20
20 - 40
40 - 60
60 - 80
80 -100
Copyright @ 2013 CRIDA (ICAR)
Source of Data:DAC, GoI

Fig. S10

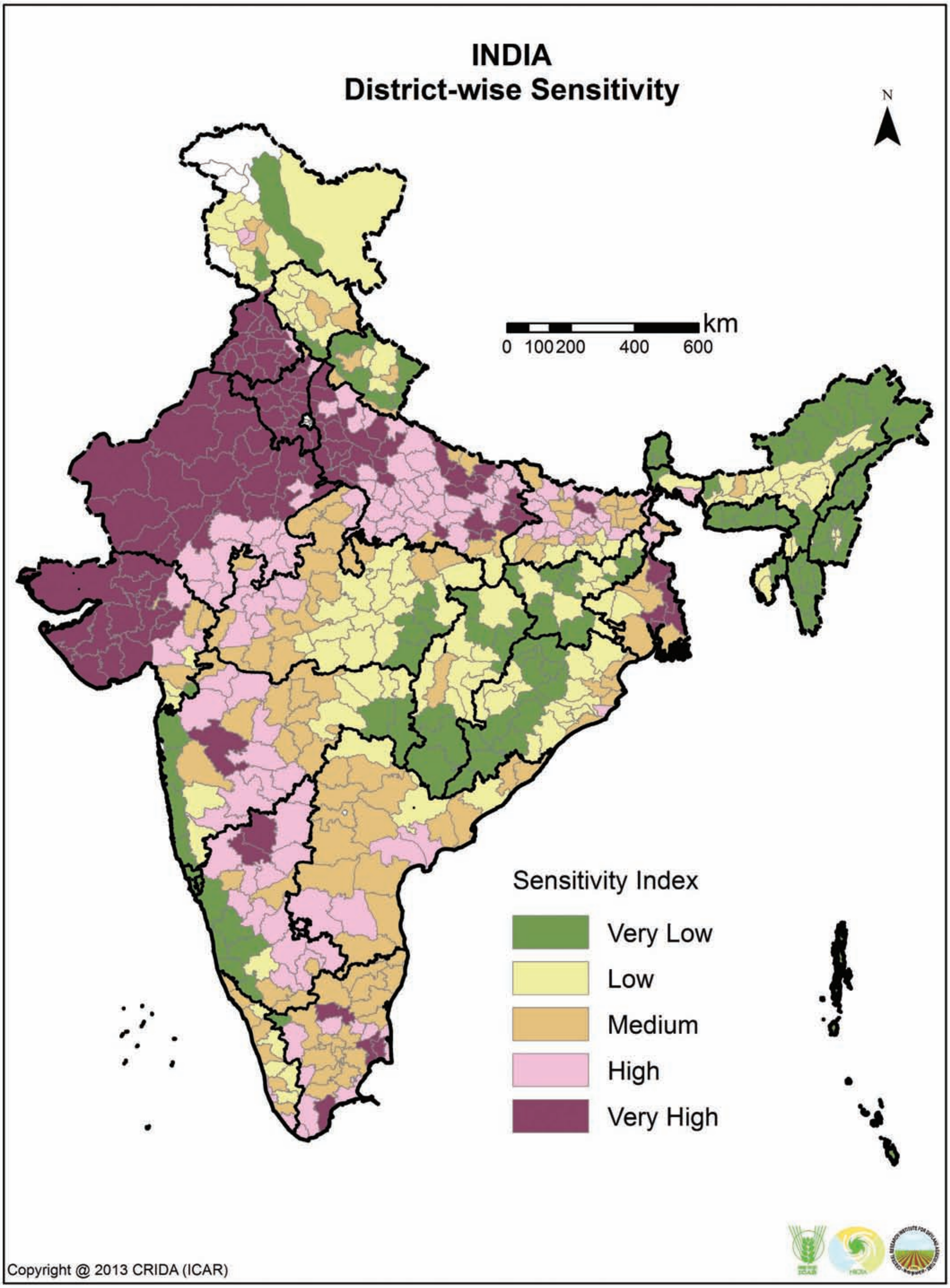

INDIA
District-wise Sensitivity
N
km
0 100 200 400 600
Sensitivity Index
Very Low
Low
Medium
High
Very High
Copyright @ 2013 CRIDA (ICAR)

Fig. S11

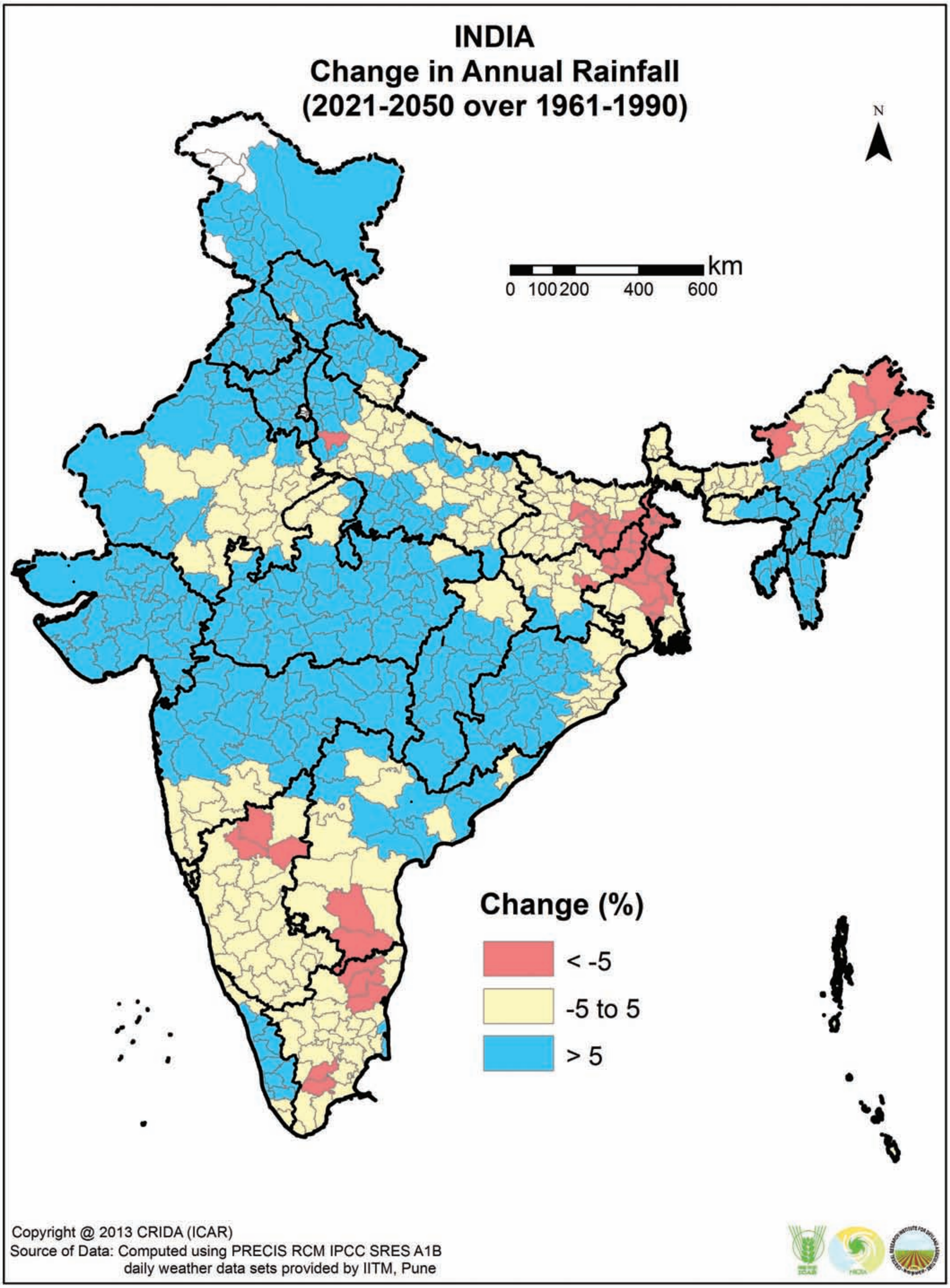

INDIA
Change in Annual Rainfall
(2021-2050 over 1961-1990)
N
km
0 100 200 400 600
Change (%)
< -5
-5 to 5
> 5
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EM1

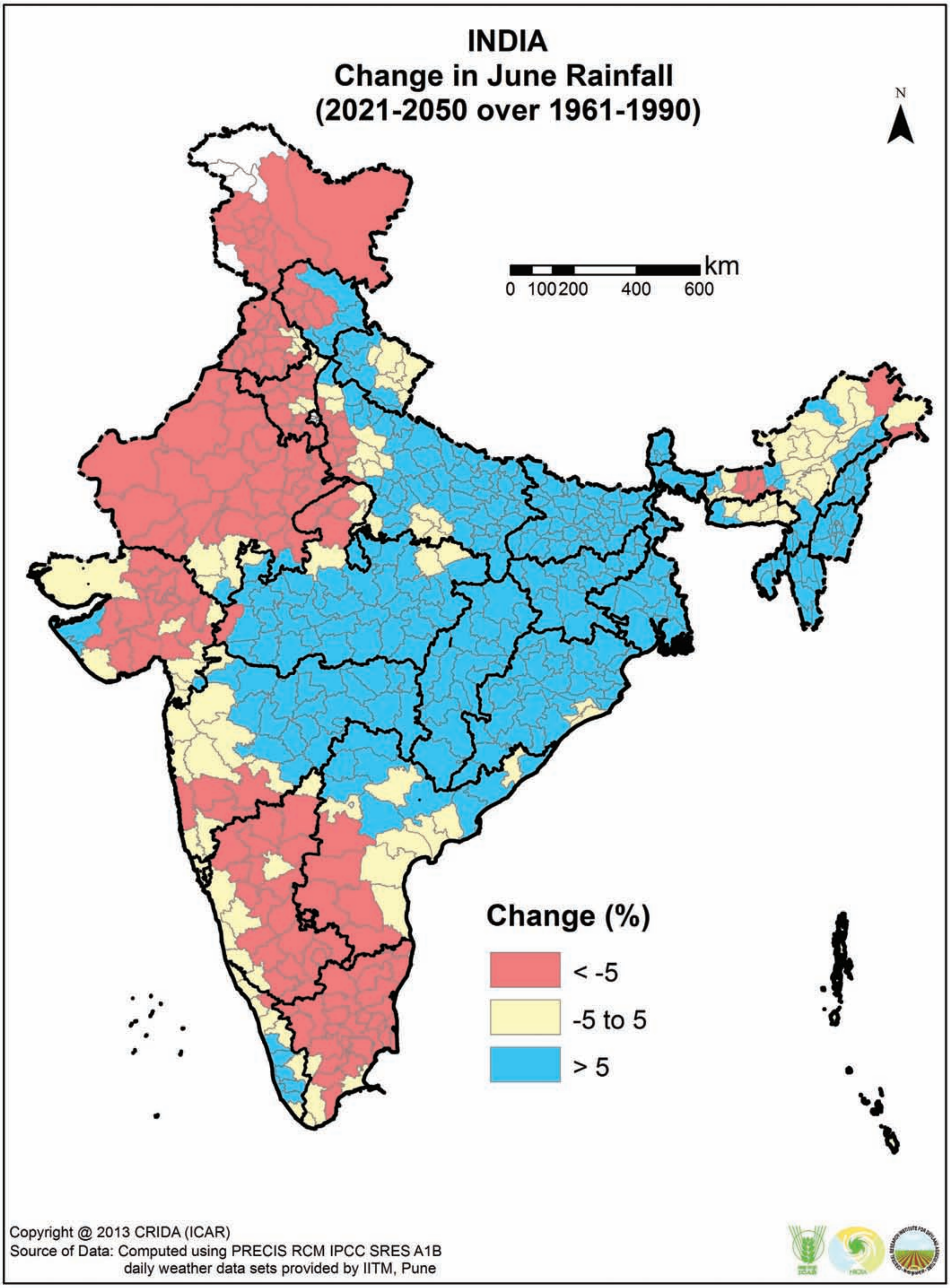

INDIA
Change in June Rainfall
(2021-2050 over 1961-1990)
N
km
0 100200 400 600
Change (%)
< -5
-5 to 5
> 5
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EM2

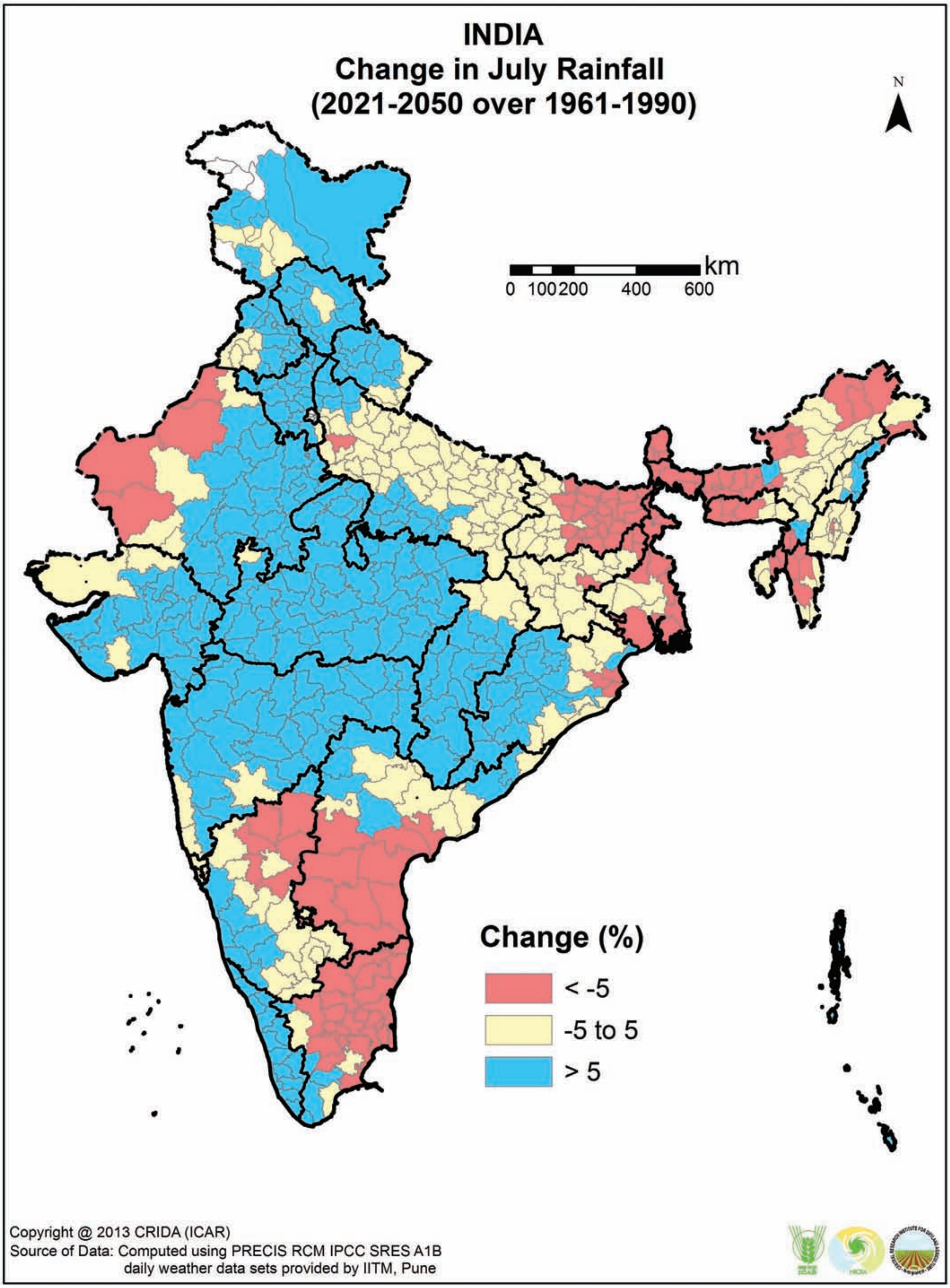

INDIA
Change in July Rainfall
(2021-2050 over 1961-1990)
N
km
0 100200 400 600
Change (%)
< -5
-5 to 5
> 5
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EM3

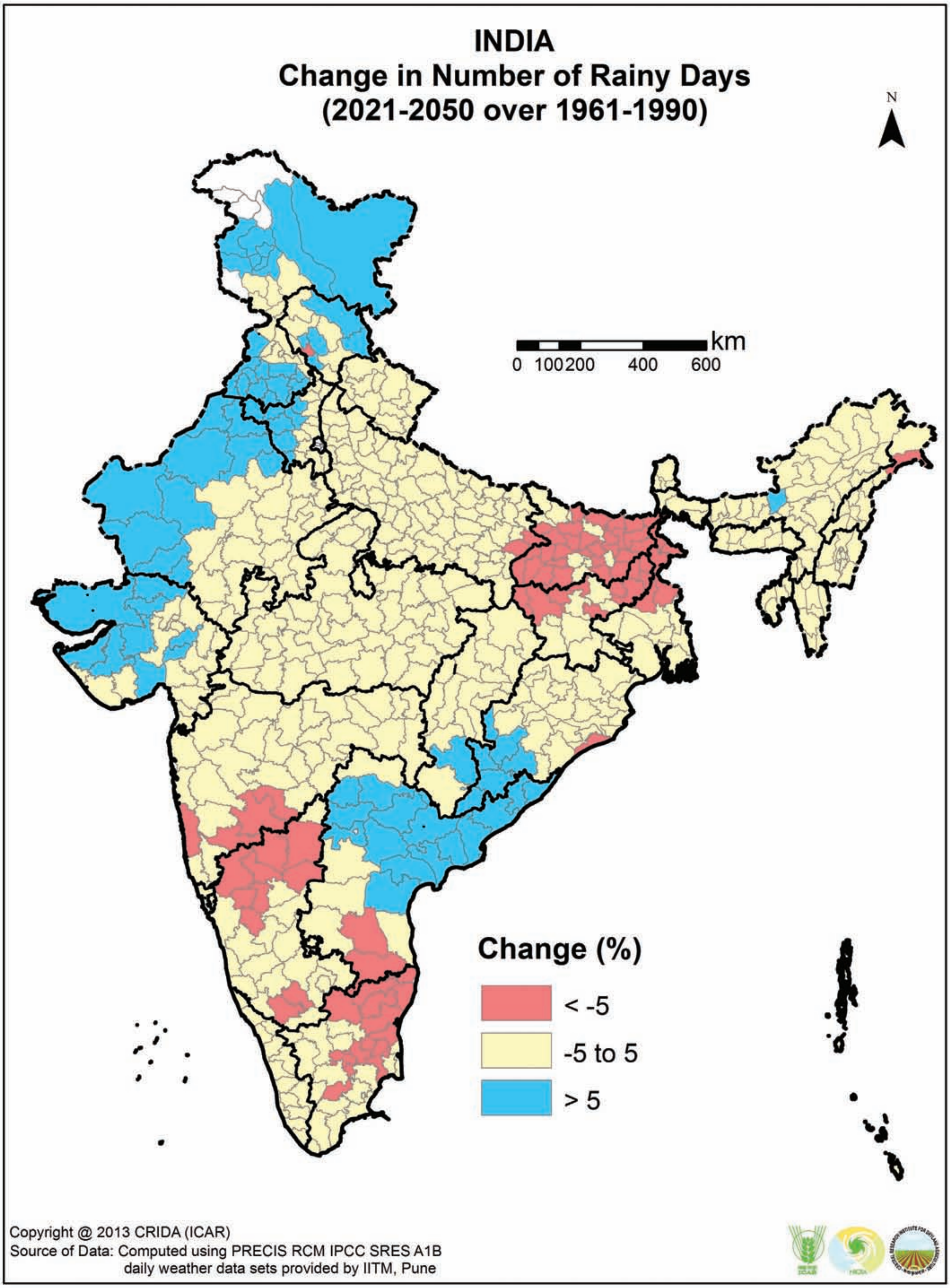
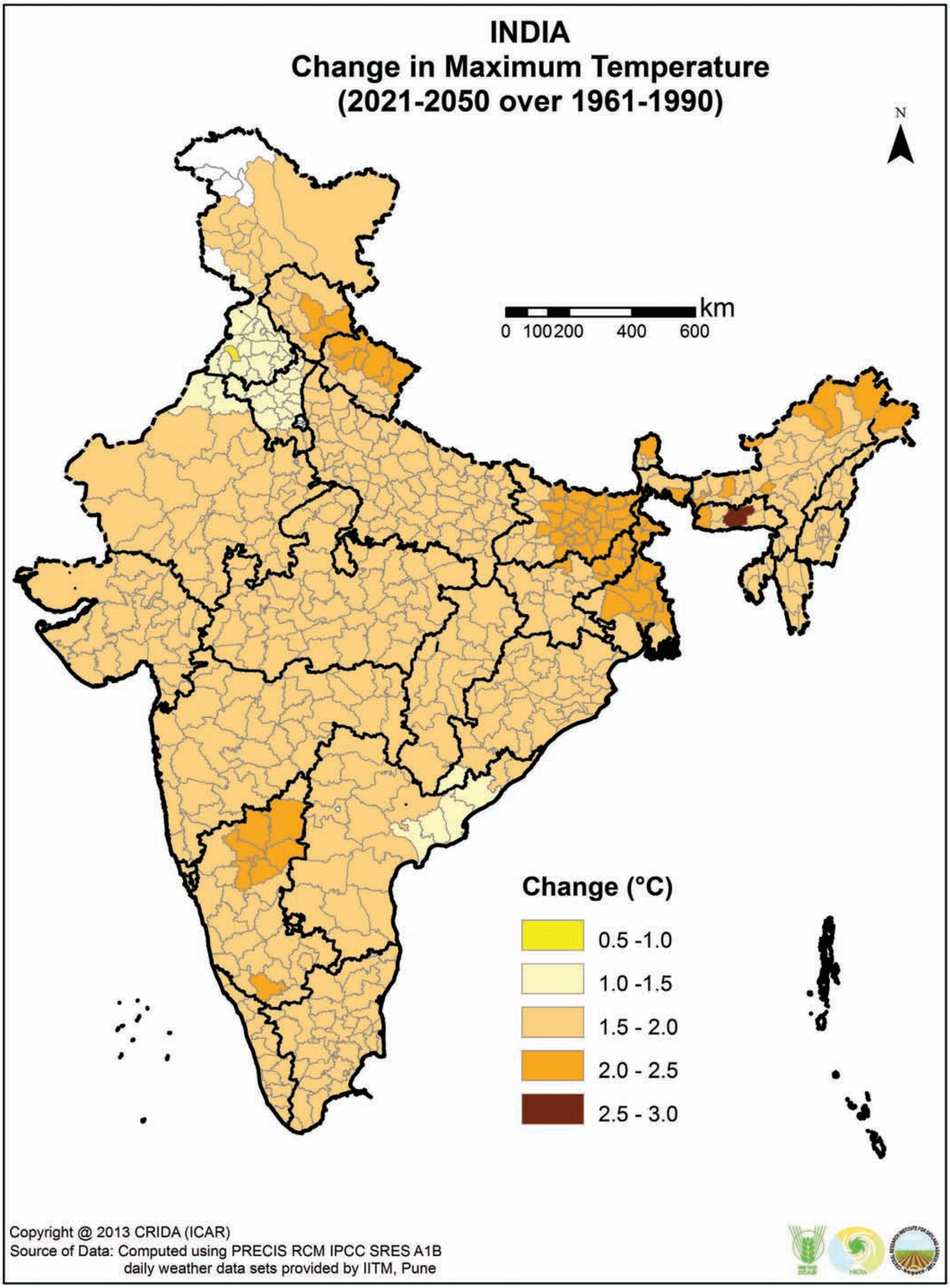

INDIA
Change in Number of Rainy Days
(2021-2050 over 1961-1990)
N
km
0 100 200 400 600
Change (%)
< -5
-5 to 5
> 5
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EM4


INDIA
Change in Maximum Temperature
(2021-2050 over 1961-1990)
N
km
0 100 200 400 600
Change (°C)
0.5 -1.0
1.0 -1.5
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
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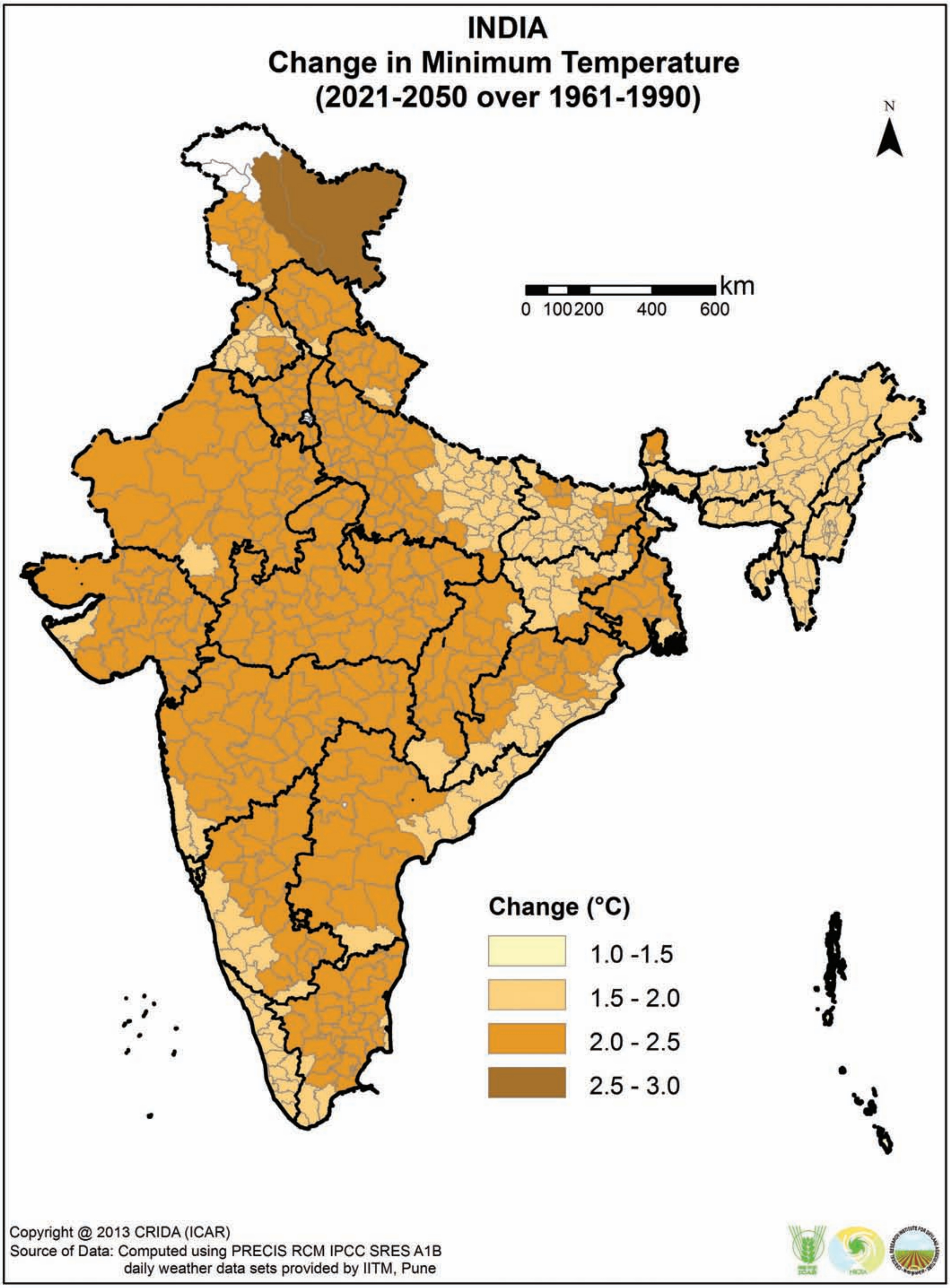
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EM5


INDIA
Change in Minimum Temperature
(2021-2050 over 1961-1990)
N
km
0 100 200 400 600
Change (°C)
1.0 -1.5
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
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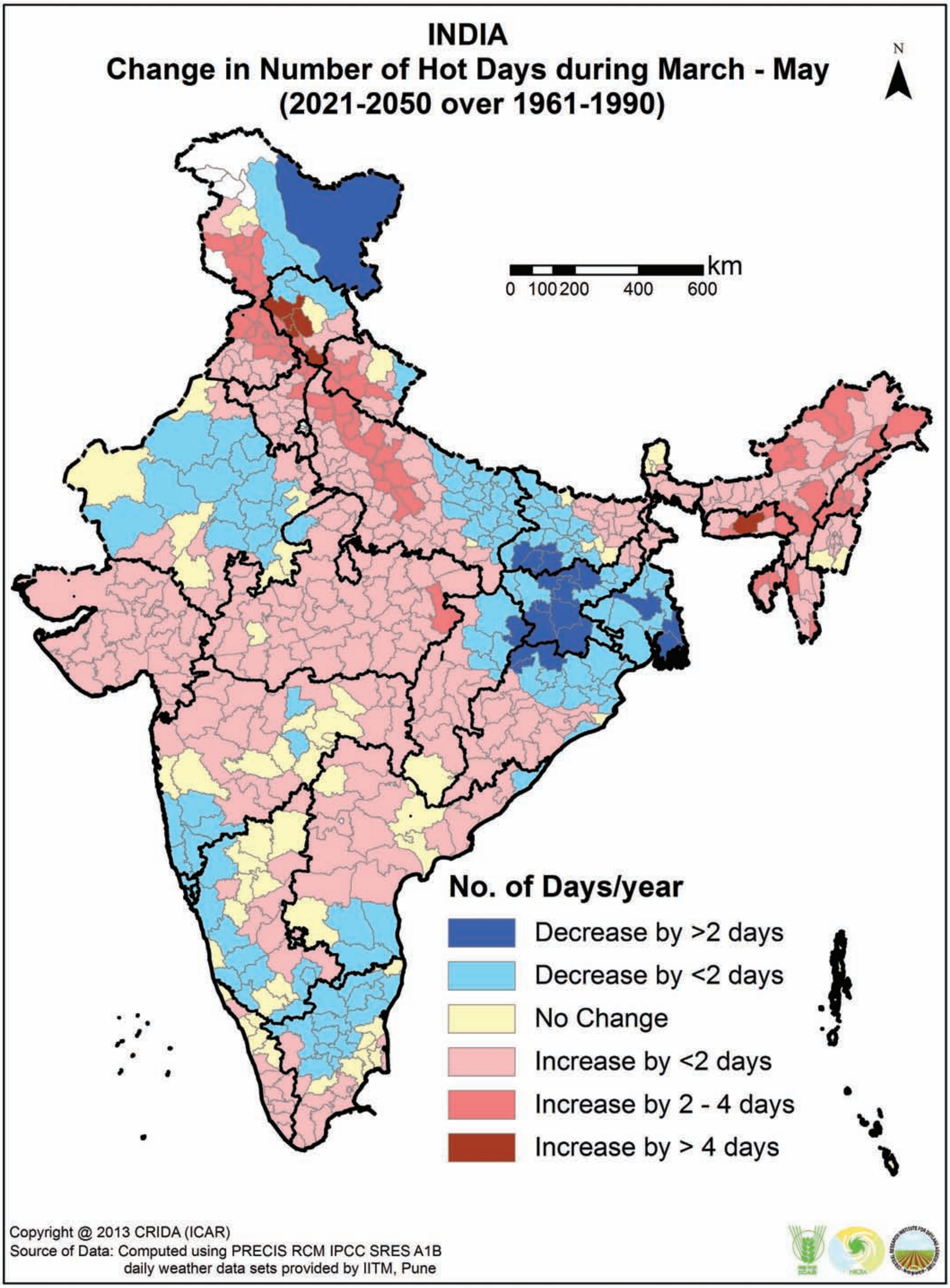
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EM6


INDIA
Change in Number of Hot Days during March - May
(2021-2050 over 1961-1990)
N
km
0 100 200 400 600
No. of Days/year
Decrease by >2 days
Decrease by <2 days
No Change
Increase by <2 days
Increase by 2 - 4 days
Increase by > 4 days
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Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EM7

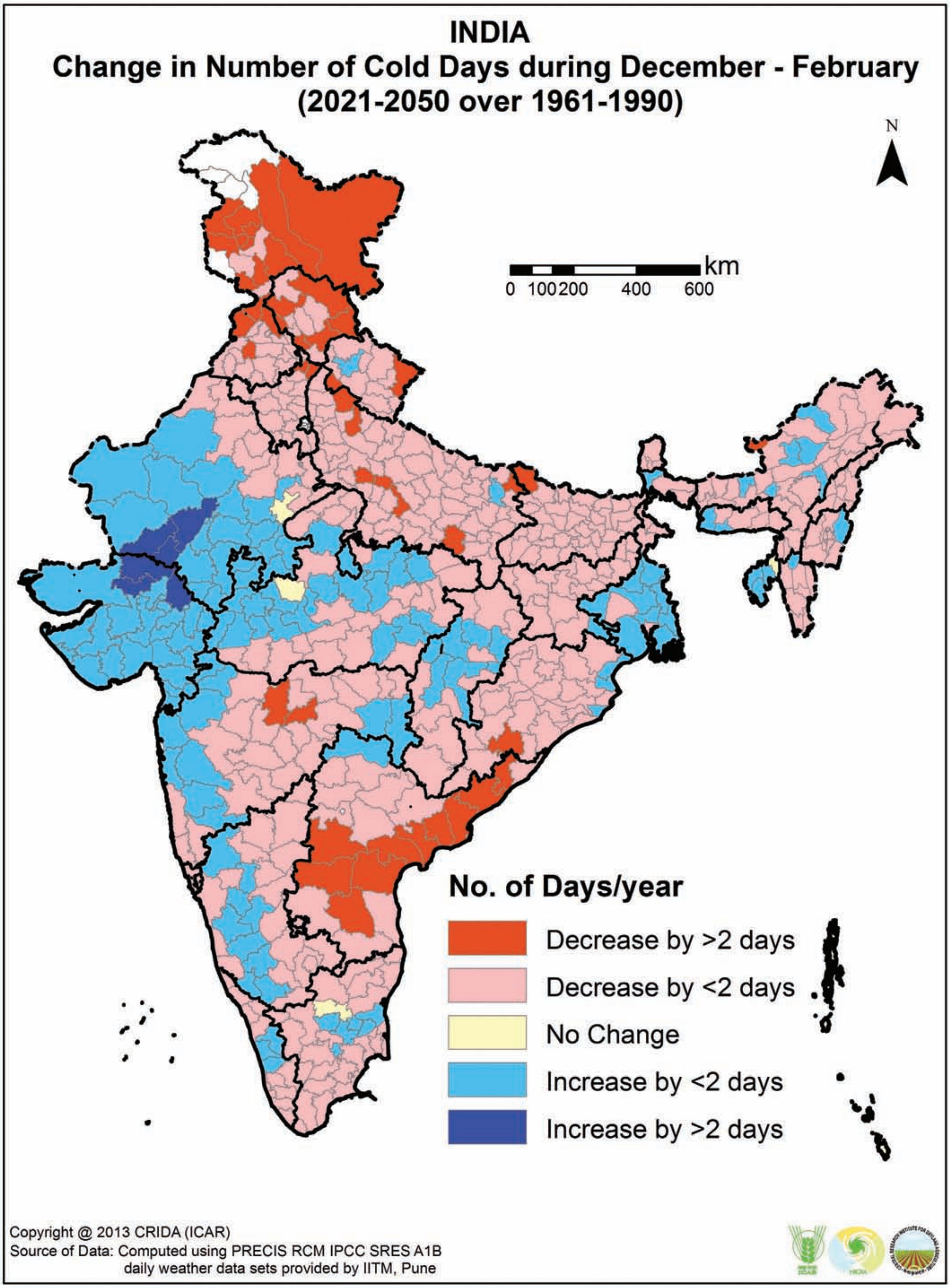
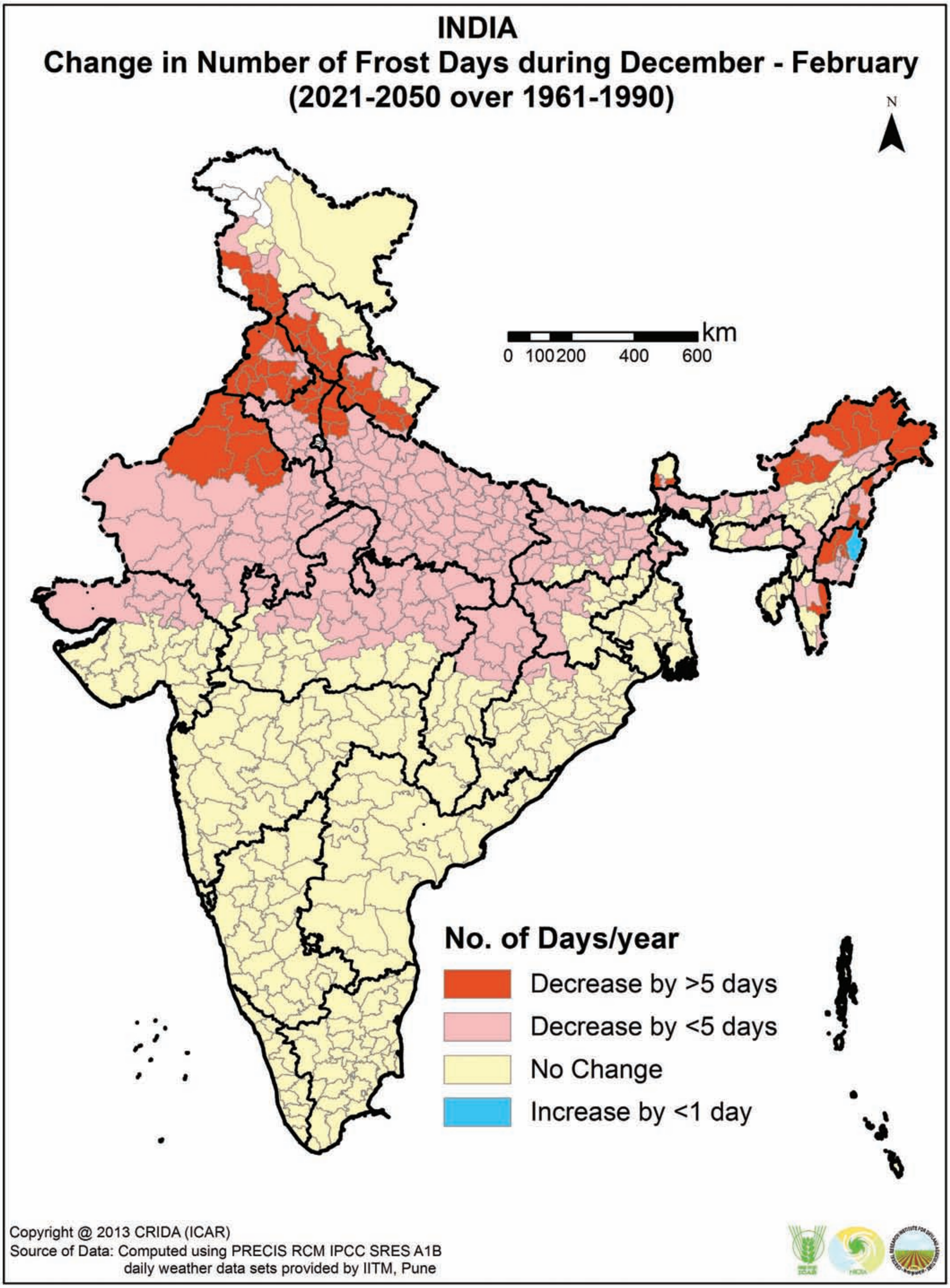

INDIA
Change in Number of Cold Days during December - February
(2021-2050 over 1961-1990)
N
km
0 100200 400 600
No. of Days/year
Decrease by >2 days
Decrease by <2 days
No Change
Increase by <2 days
Increase by >2 days
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EM8


INDIA
Change in Number of Frost Days during December - February
(2021-2050 over 1961-1990)
N
km
0 100 200 400 600
No. of Days/year
Decrease by >5 days
Decrease by <5 days
No Change
Increase by <1 day
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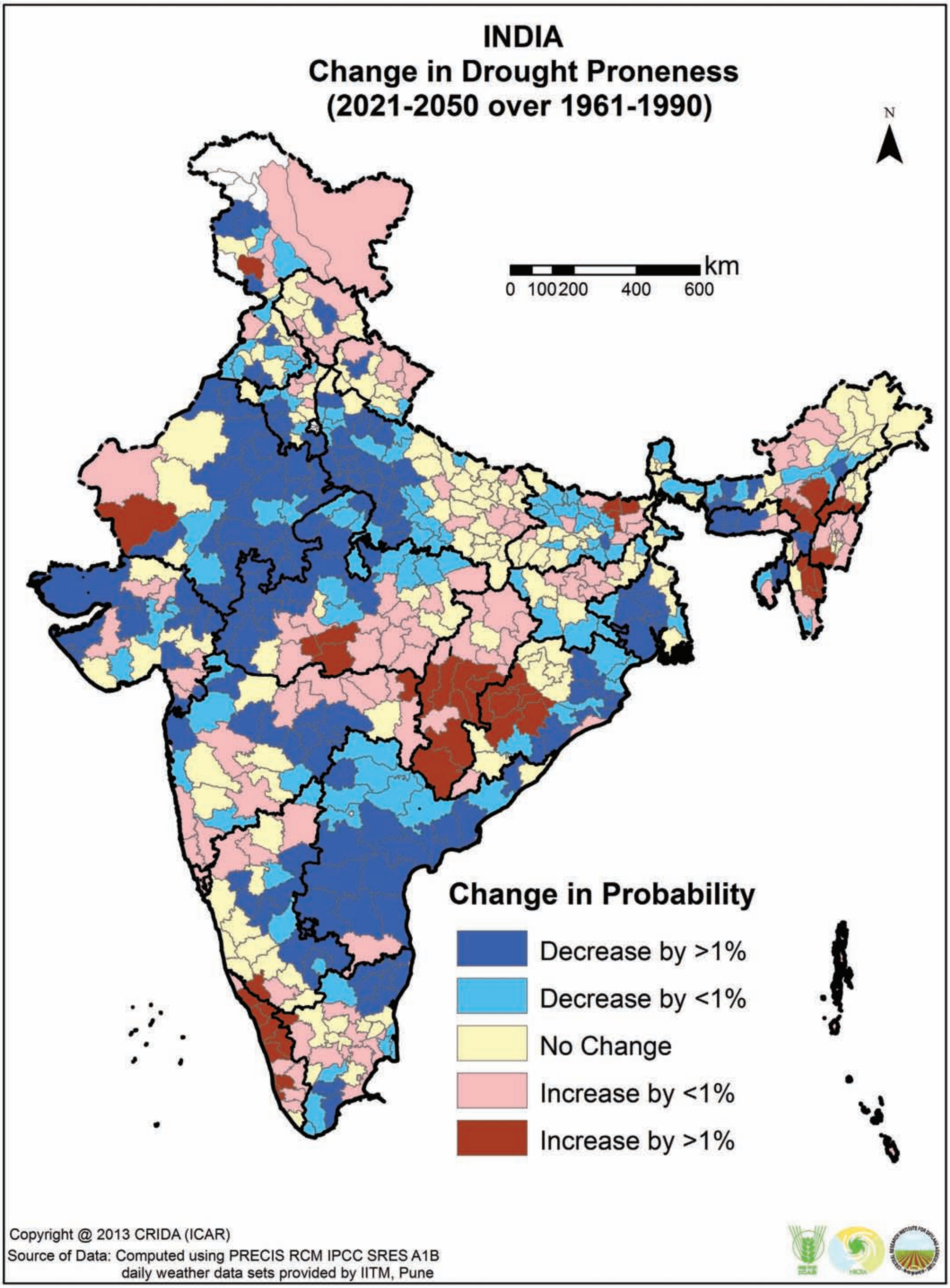
Source of Data: Computed using PRECIS RCM IPCC SRES A1B daily weather data sets provided by IITM, Pune

Fig. EM9



INDIA
Change in Drought Proneness
(2021-2050 over 1961-1990)
N
km
0 100 200 400 600
Change in Probability
Decrease by >1%
Decrease by <1%
No Change
Increase by <1%
Increase by >1%
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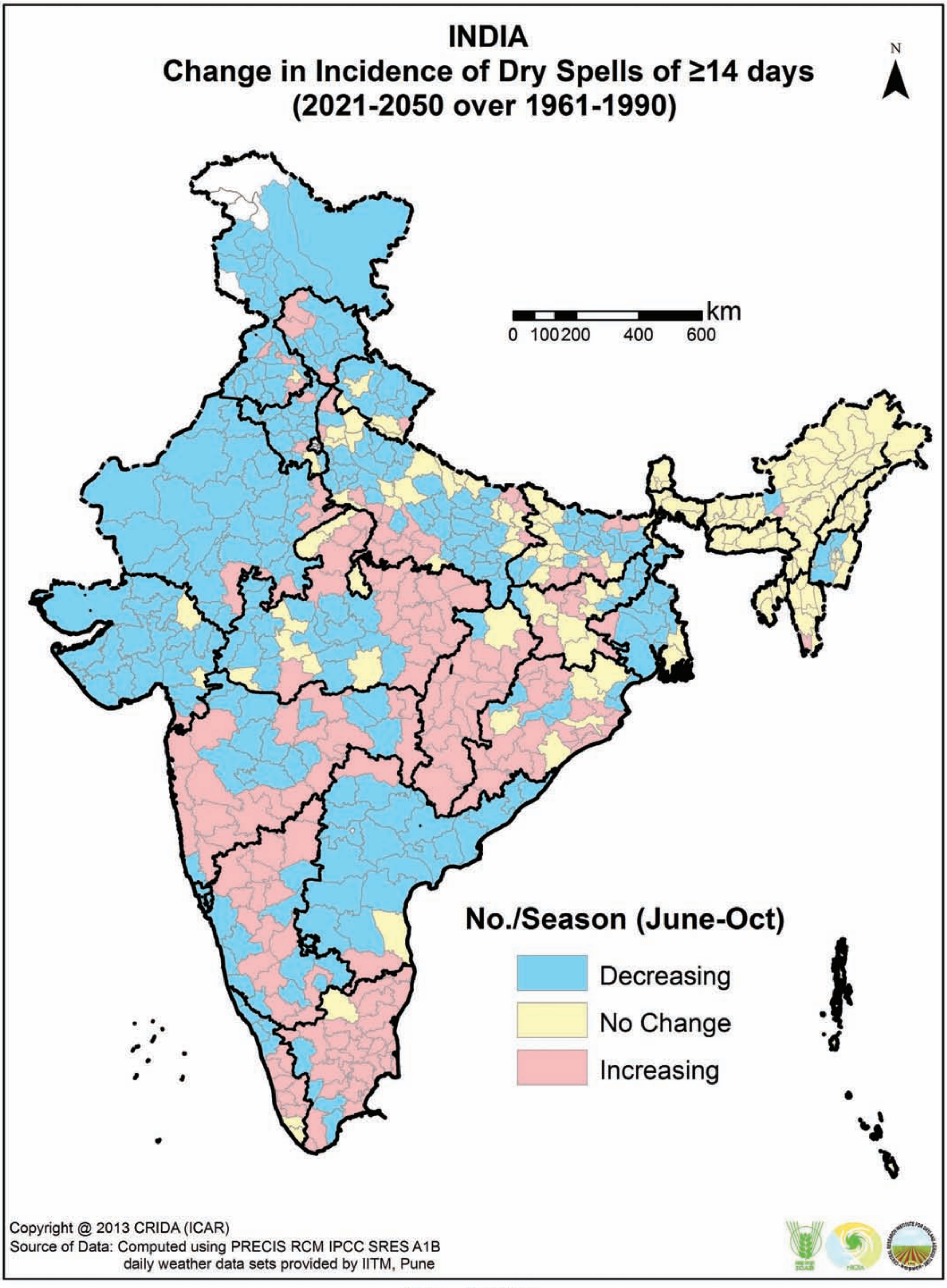
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EM10


INDIA
Change in Incidence of Dry Spells of ≥14 days
(2021-2050 over 1961-1990)
N
km
0 100 200 400 600
No./Season (June-Oct)
Decreasing
No Change
Increasing
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Source of Data: Computed using PRECIS RCM IPCC SRES A1B
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Fig. EM11

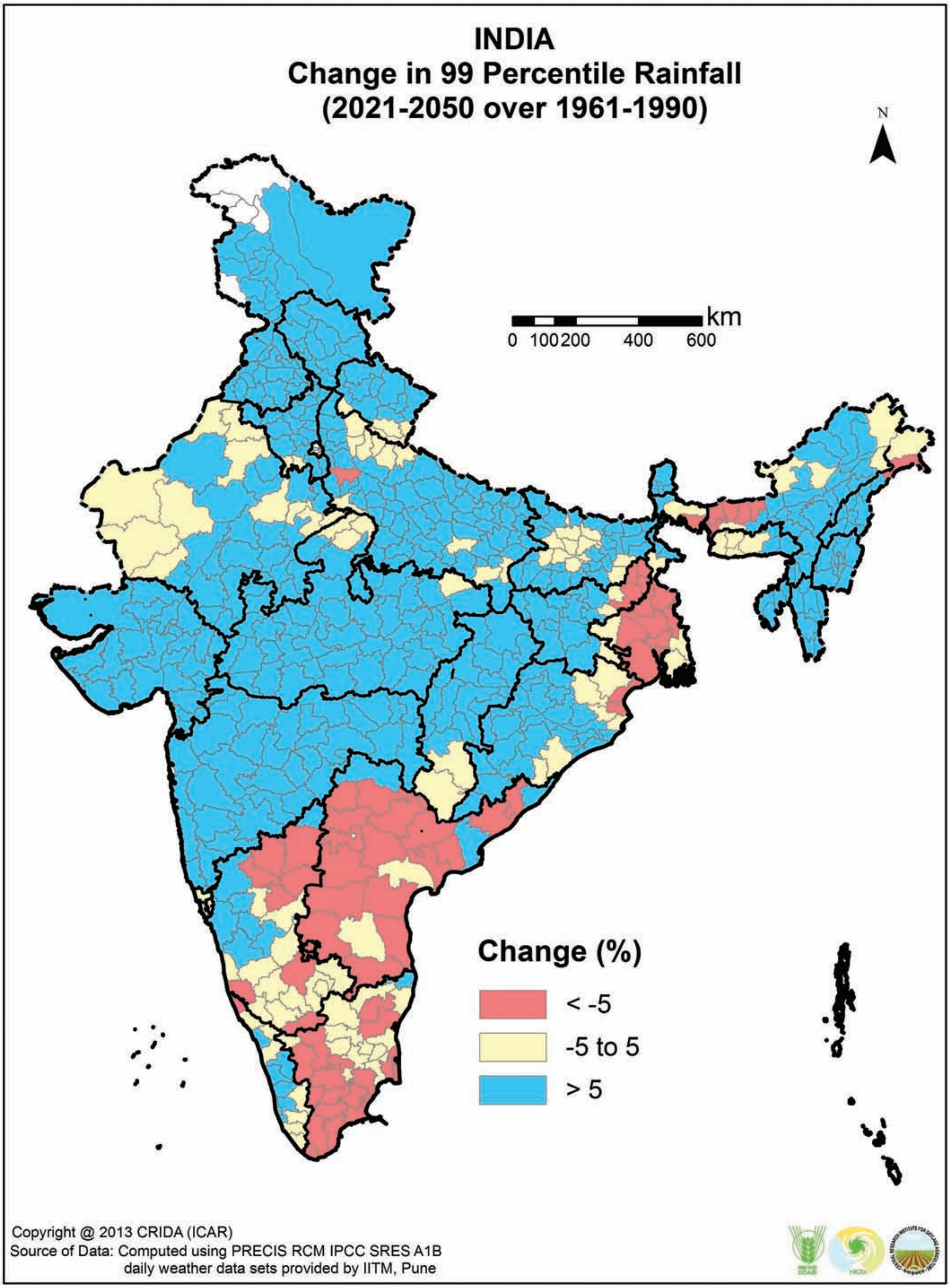

INDIA
Change in 99 Percentile Rainfall
(2021-2050 over 1961-1990)
N
km
0 100 200 400 600
Change (%)
< -5
-5 to 5
> 5
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EM12

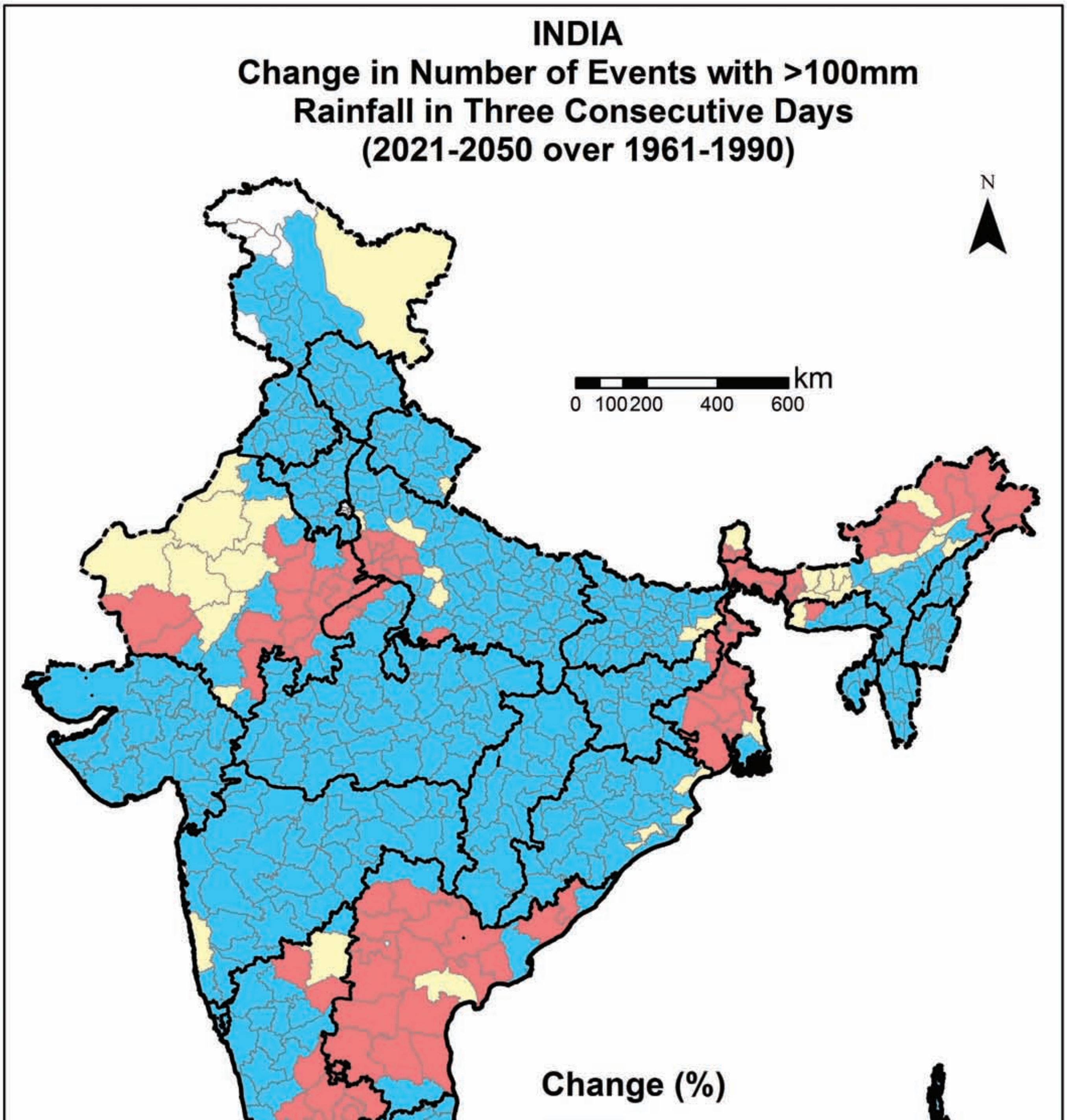
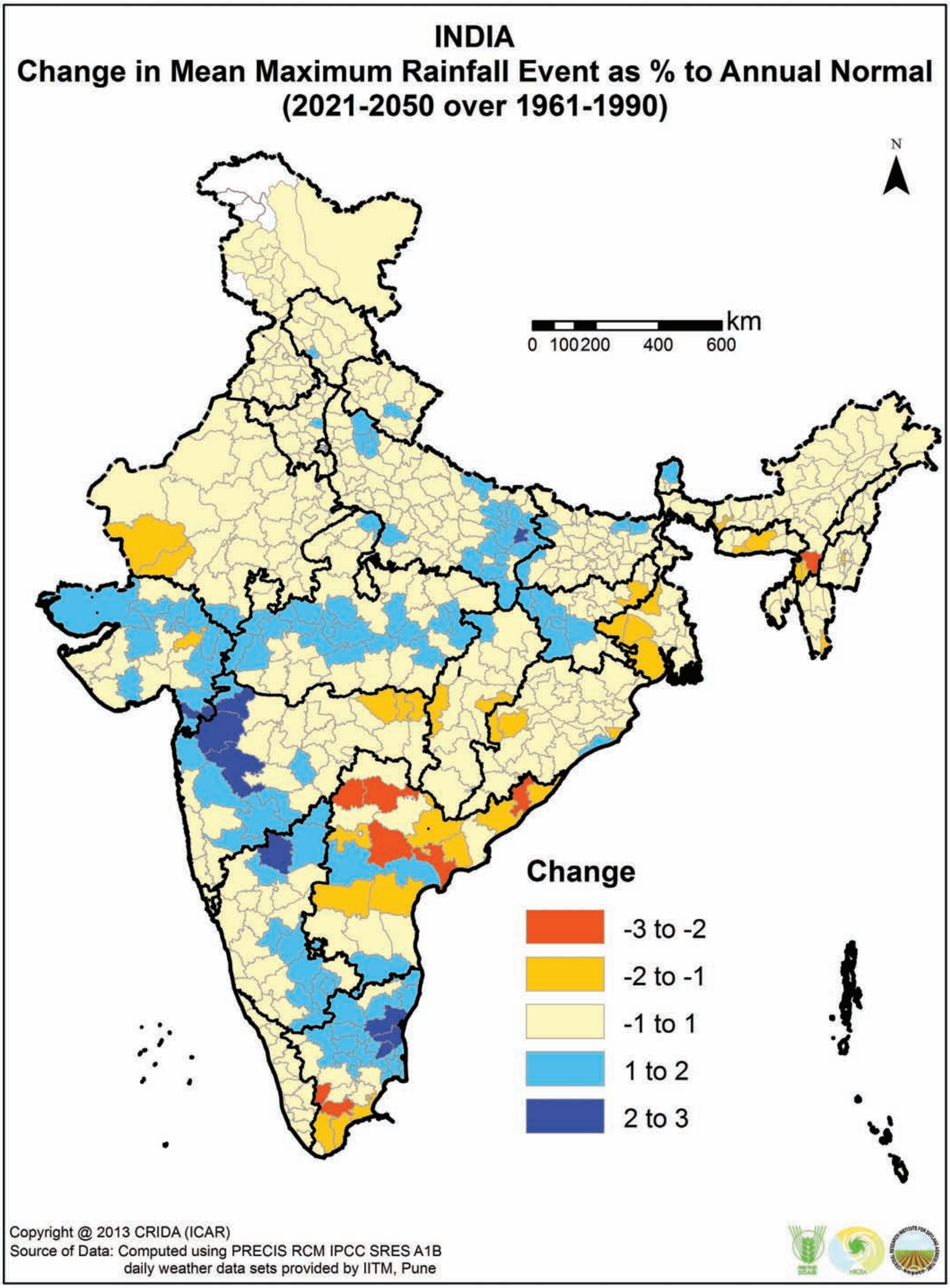

INDIA
Change in Number of Events with >100mm
Rainfall in Three Consecutive Days
(2021-2050 over 1961-1990)
N
km
0 100 200 400 600
Change (%)
< -5
-5 to 5
> 5
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EM13


INDIA
Change in Mean Maximum Rainfall Event as % to Annual Normal
(2021-2050 over 1961-1990)
N
km
0 100 200 400 600
Change
-3 to -2
-2 to -1
-1 to 1
1 to 2
2 to 3
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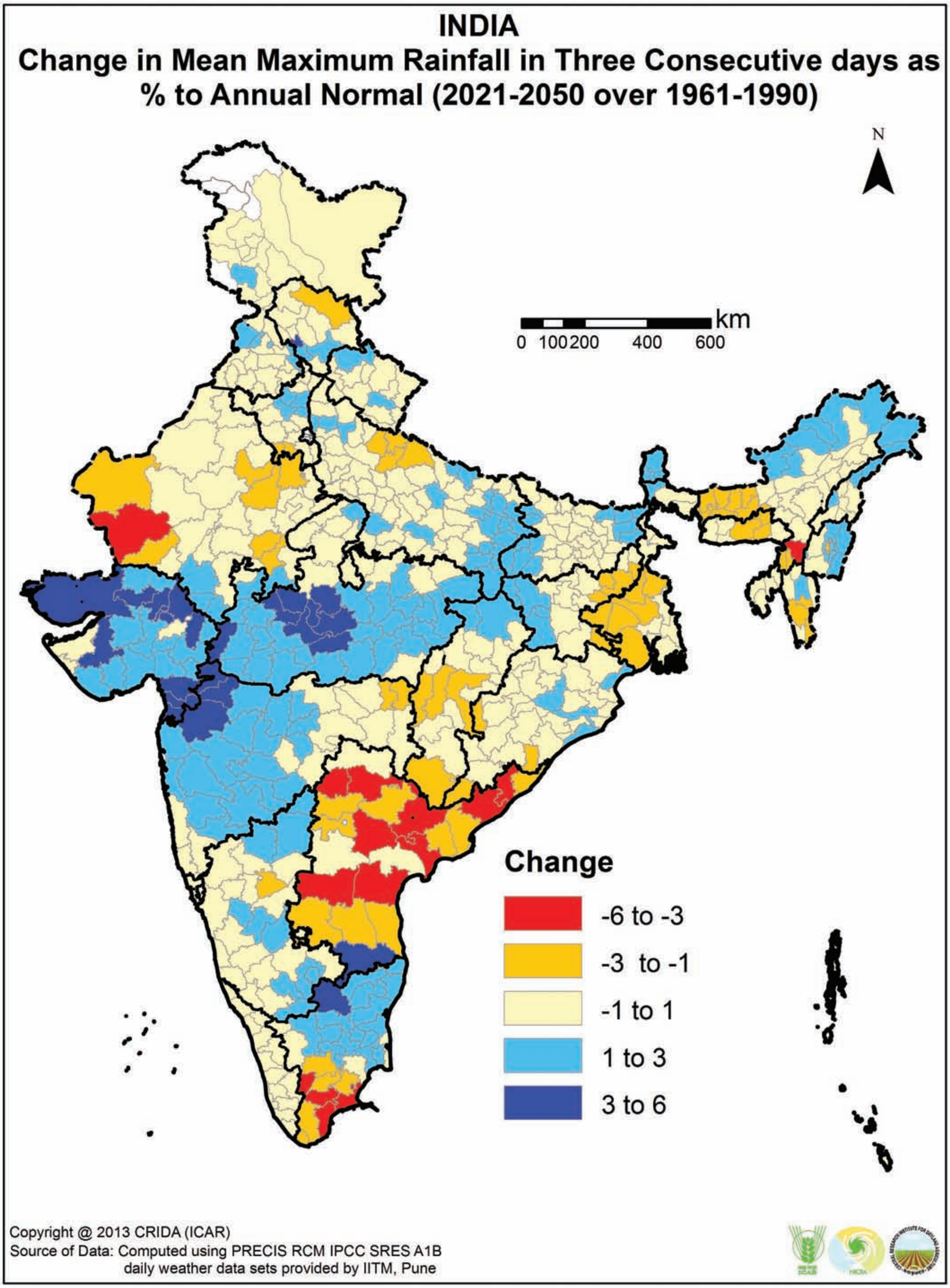
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EM14


INDIA
Change in Mean Maximum Rainfall in Three Consecutive days as % to Annual Normal (2021-2050 over 1961-1990)
N
km
0 100 200 400 600
Change
-6 to -3
-3 to -1
-1 to 1
1 to 3
3 to 6
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Source of Data: Computed using PRECIS RCM IPCC SRES A1B daily weather data sets provided by IITM, Pune

Fig. EM15

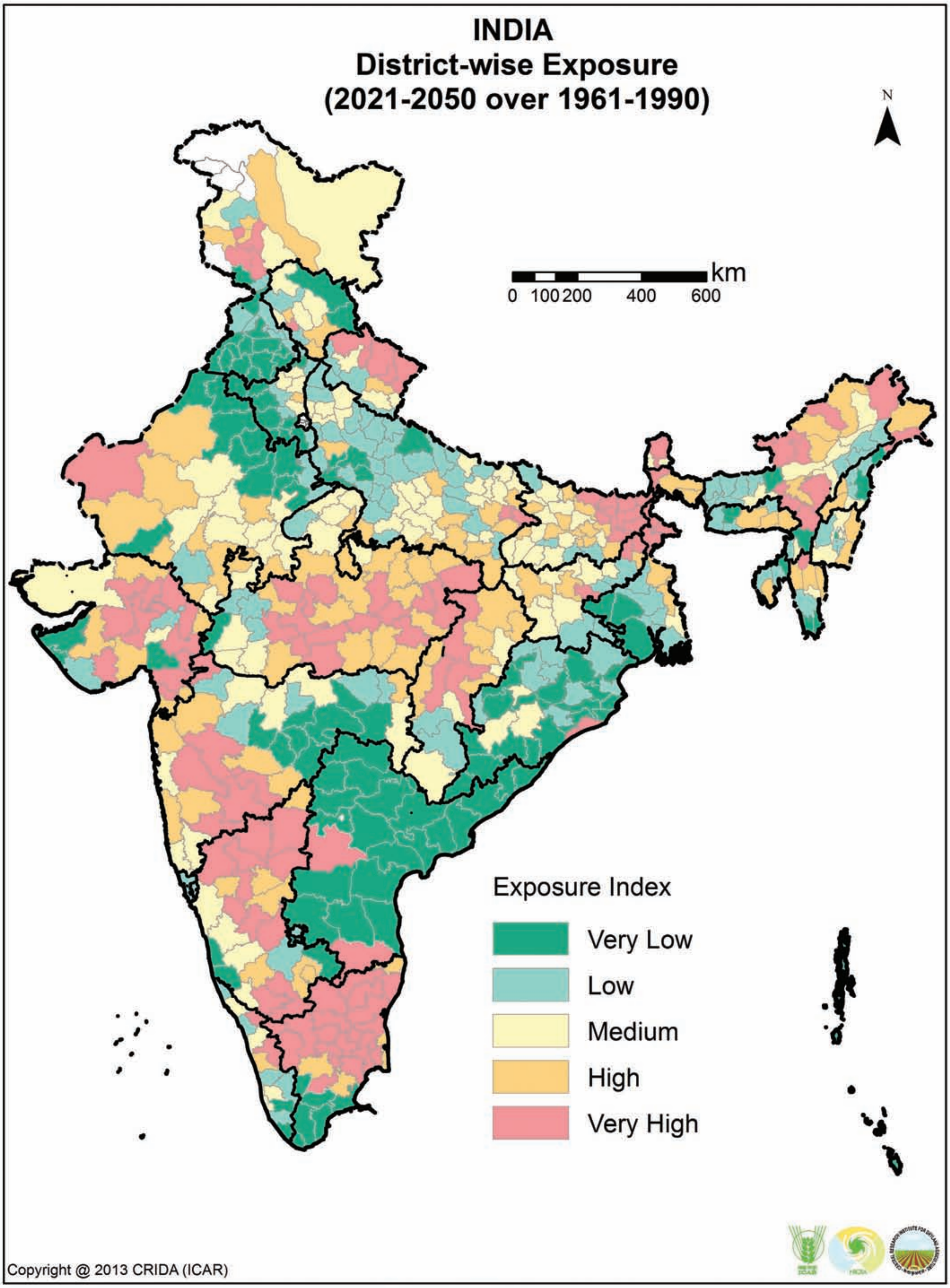
INDIA
District-wise Exposure
(2021-2050 over 1961-1990)
N
km
0 100 200 400 600
Exposure Index
Very Low
Low
Medium
High
Very High
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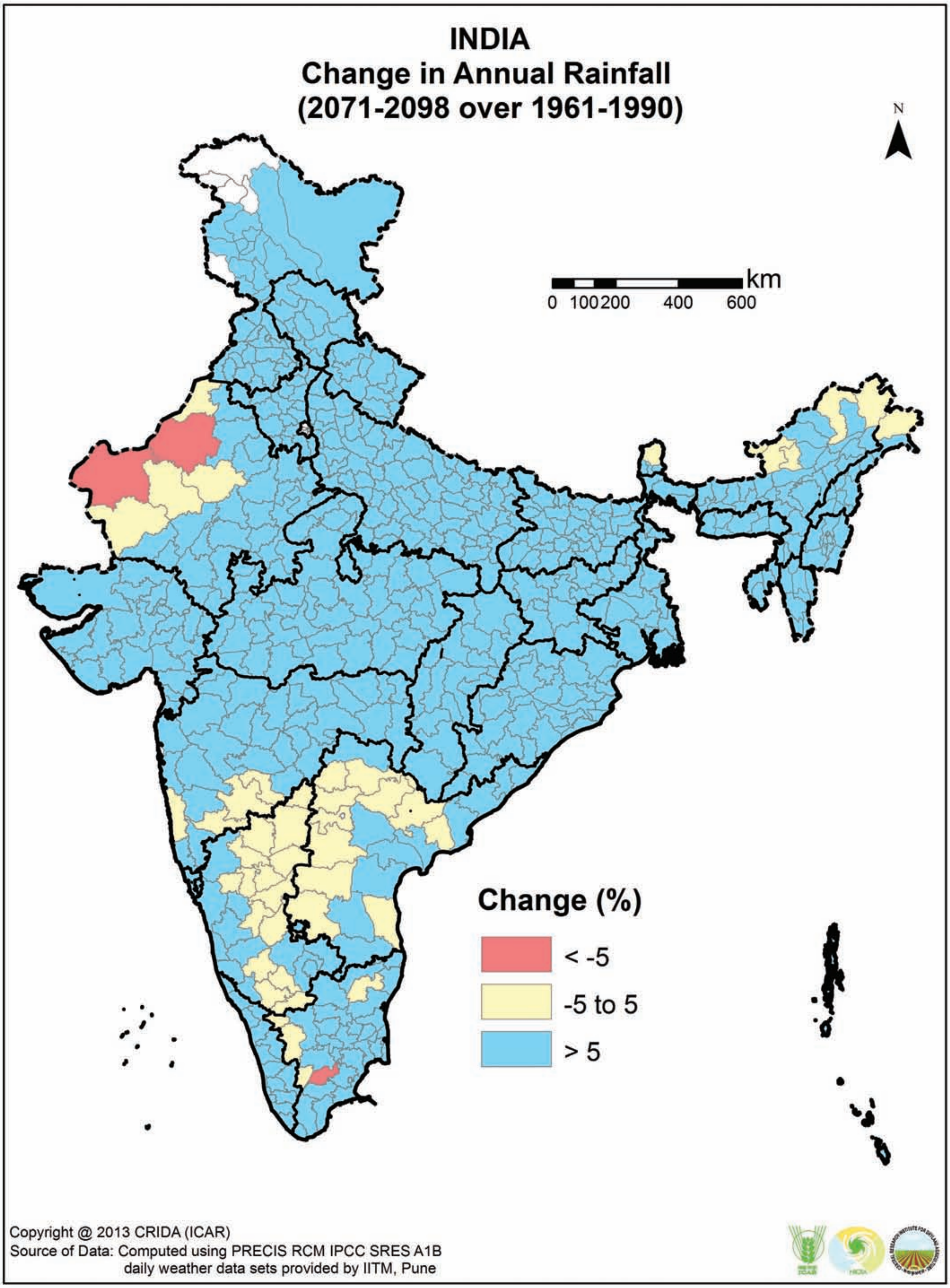
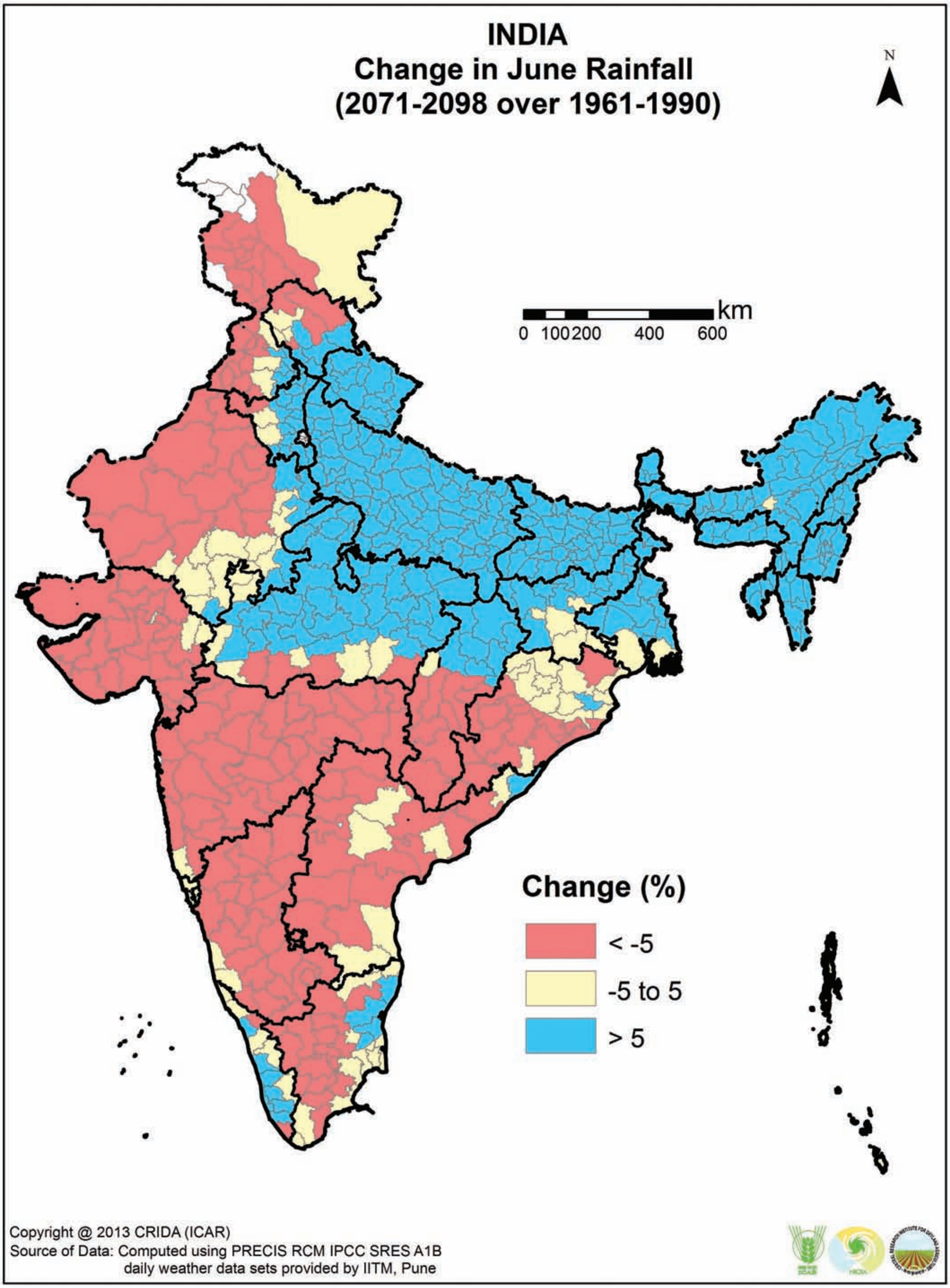
Fig. EM16



INDIA
Change in Annual Rainfall
(2071-2098 over 1961-1990)
N
km
0 100 200 400 600
Change (%)
< -5
-5 to 5
> 5
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EE1



INDIA
Change in June Rainfall
(2071-2098 over 1961-1990)
N
km
0 100 200 400 600
Change (%)
< -5
-5 to 5
> 5
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EE2

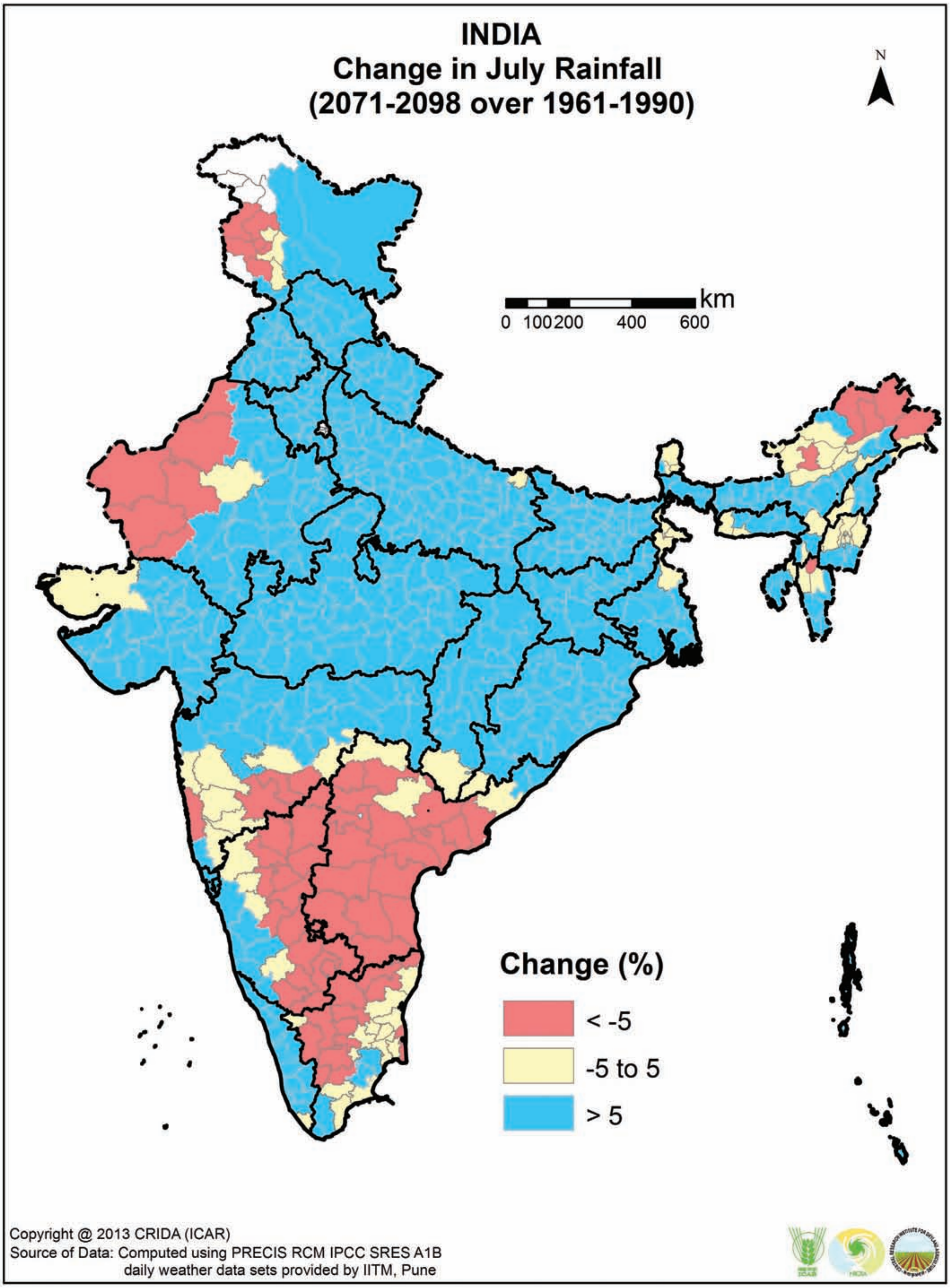
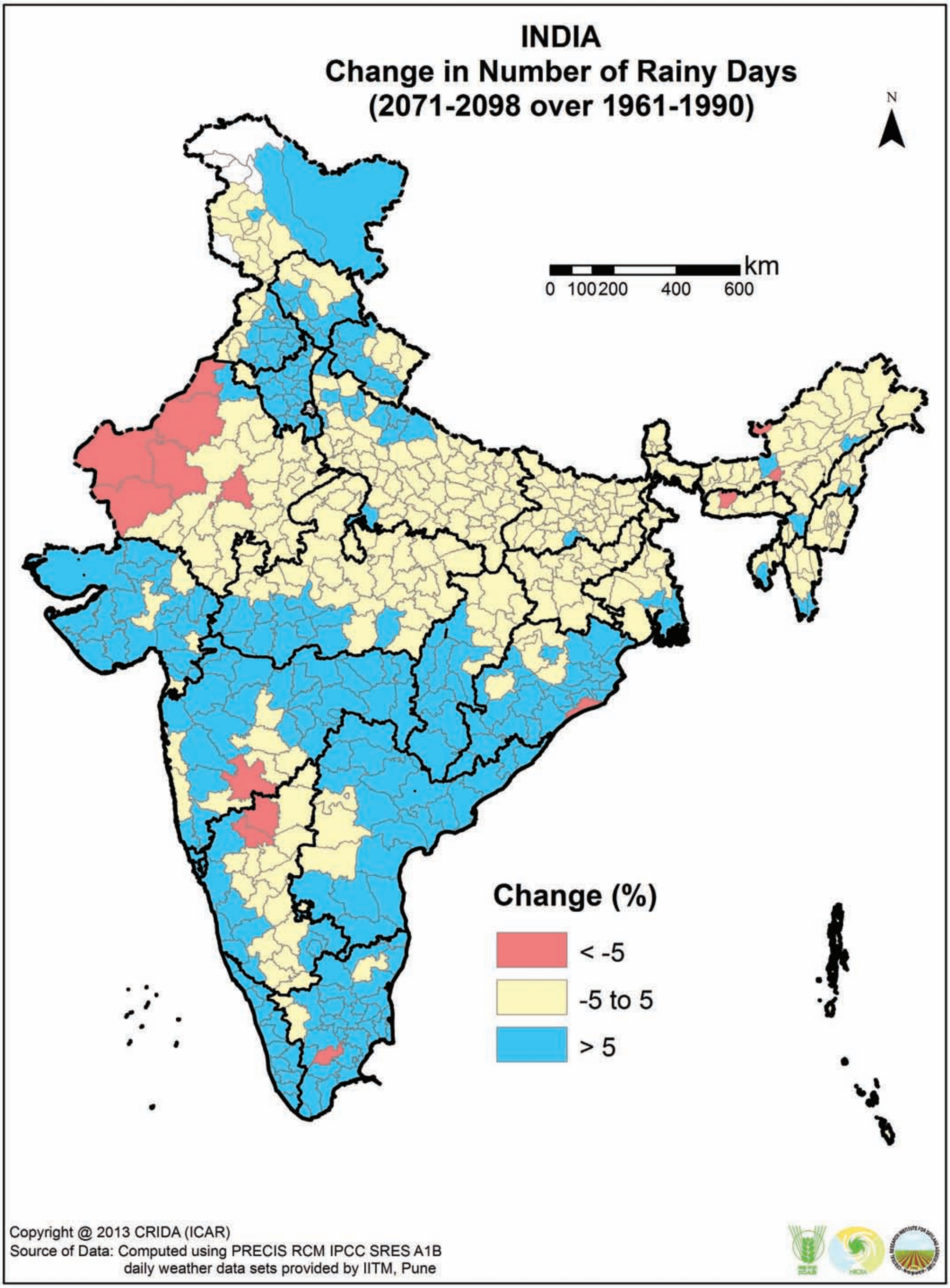

INDIA
Change in July Rainfall
(2071-2098 over 1961-1990)
N
km
0 100 200 400 600
Change (%)
< -5
-5 to 5
> 5
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EE3


INDIA
Change in Number of Rainy Days
(2071-2098 over 1961-1990)
N
km
0 100 200 400 600
Change (%)
< -5
-5 to 5
> 5
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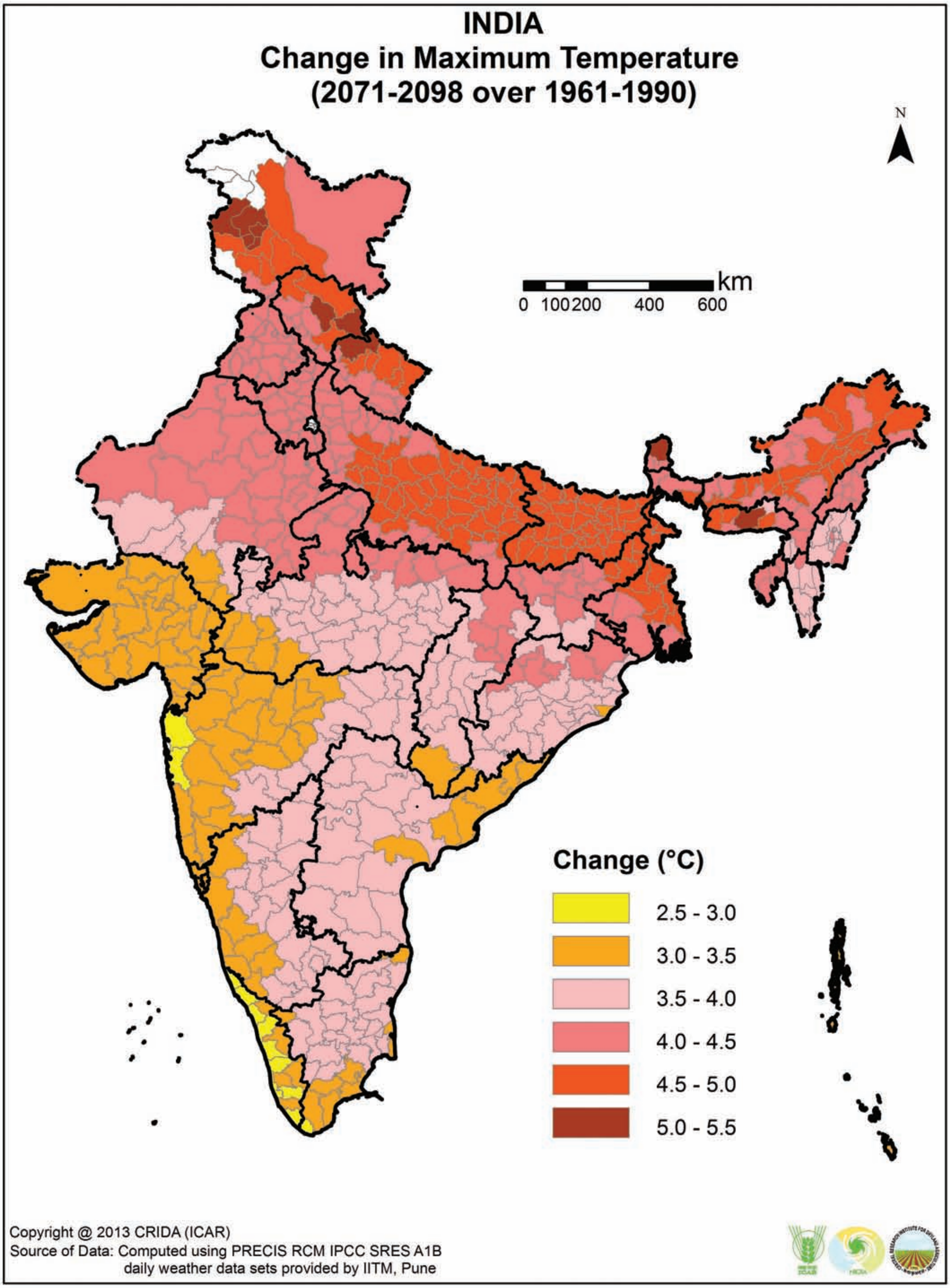
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EE4


INDIA
Change in Maximum Temperature
(2071-2098 over 1961-1990)
N
km
0 100 200 400 600
Change (°C)
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
5.0 - 5.5
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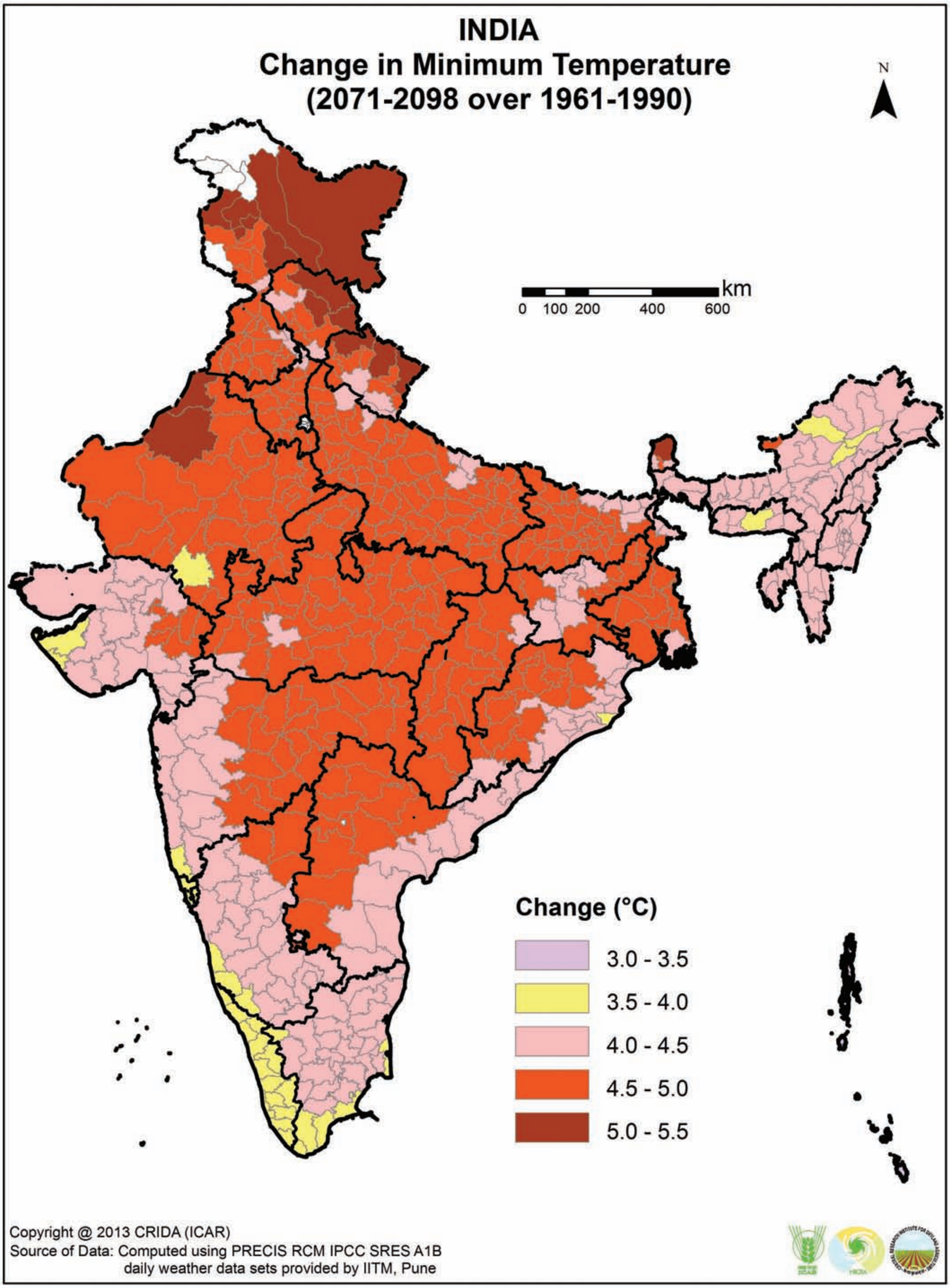
Source of Data: Computed using PRECIS RCM IPCC SRES A1B daily weather data sets provided by IITM, Pune

Fig. EE5


INDIA
Change in Minimum Temperature
(2071-2098 over 1961-1990)
N
km
0 100 200 400 600
Change (°C)
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
5.0 - 5.5
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Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EE6

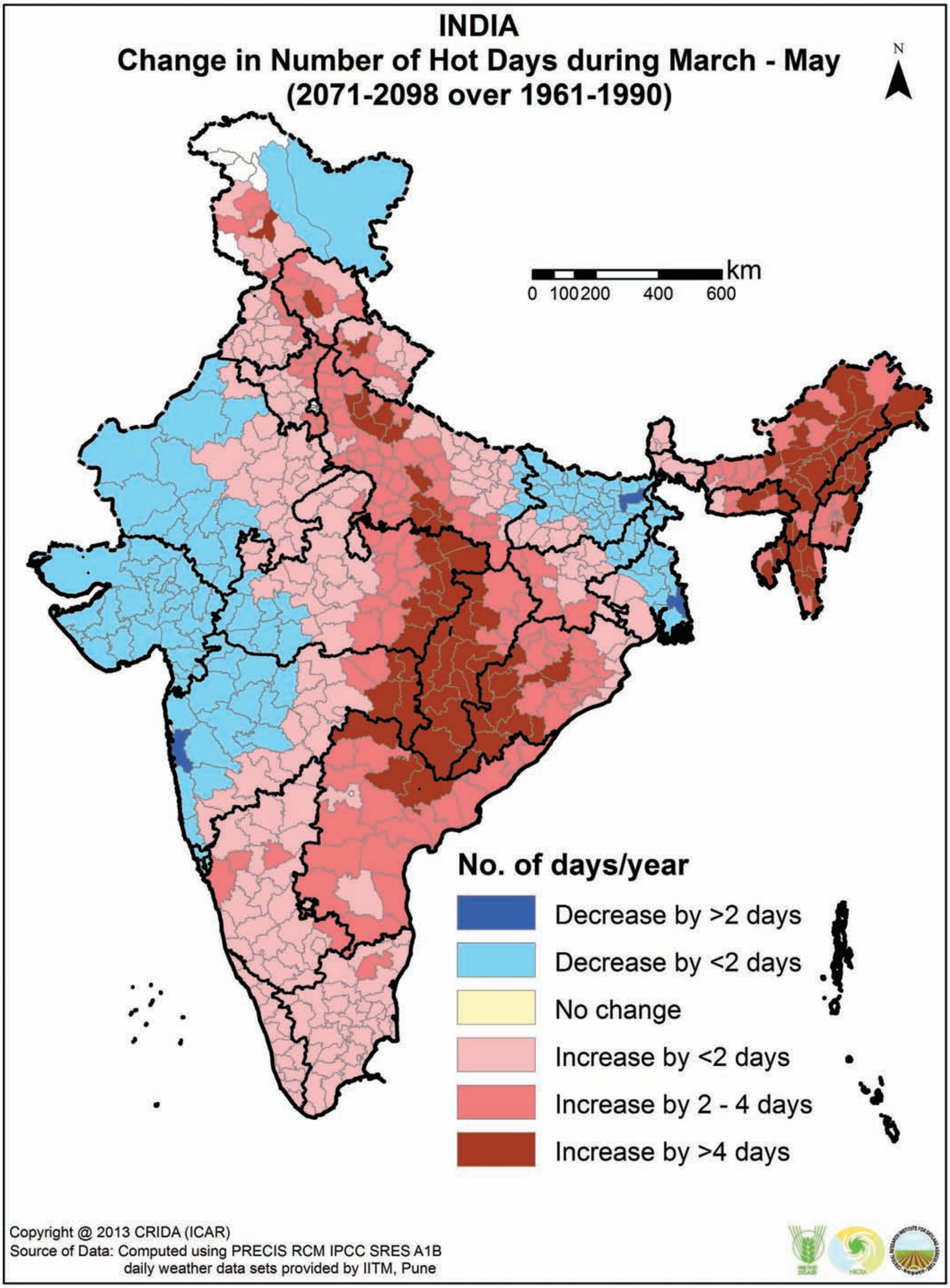

INDIA
Change in Number of Hot Days during March - May
(2071-2098 over 1961-1990)
N
km
0 100 200 400 600
No. of days/year
Decrease by >2 days
Decrease by <2 days
No change
Increase by <2 days
Increase by 2 - 4 days
Increase by >4 days
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EE7

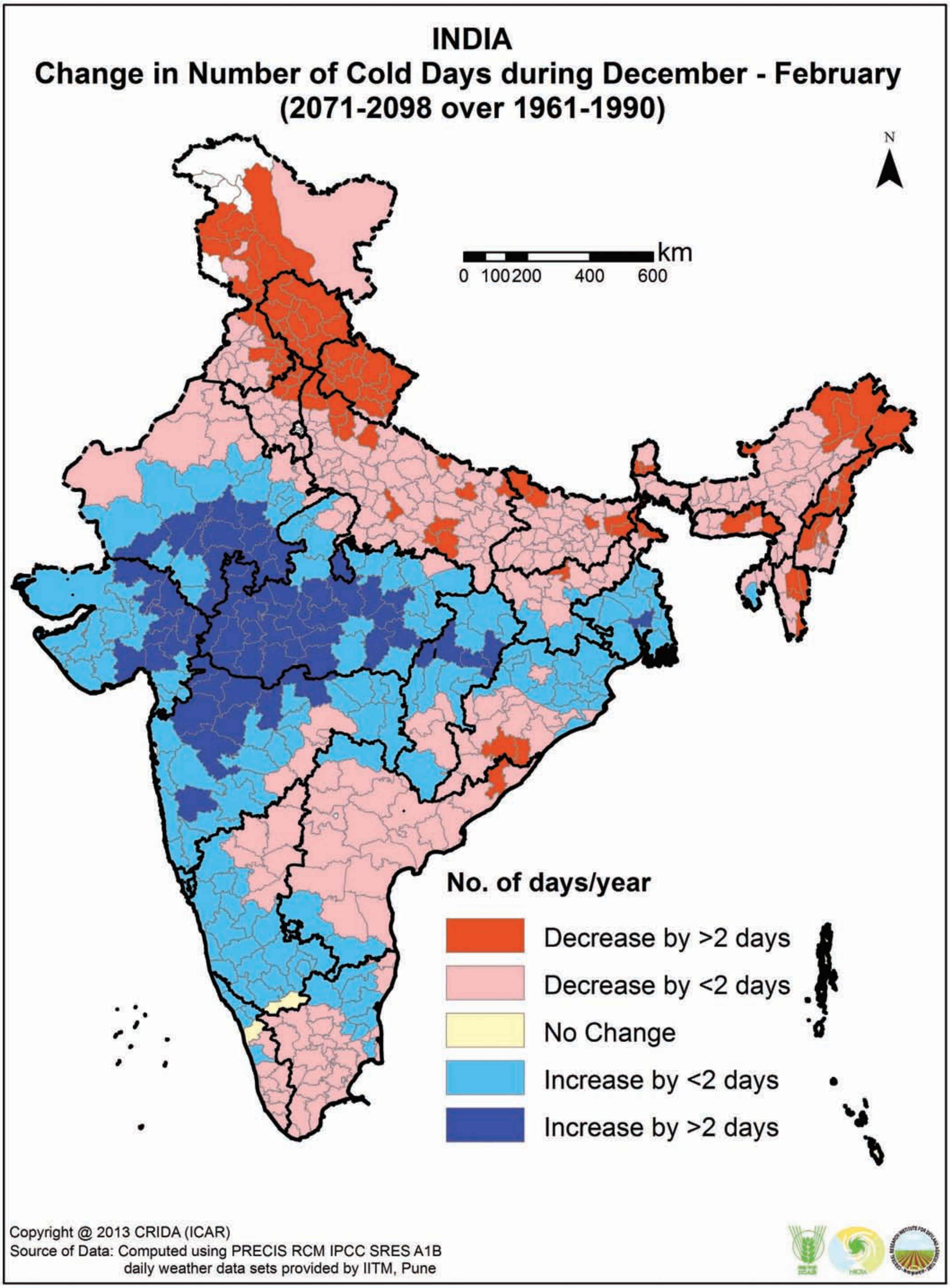
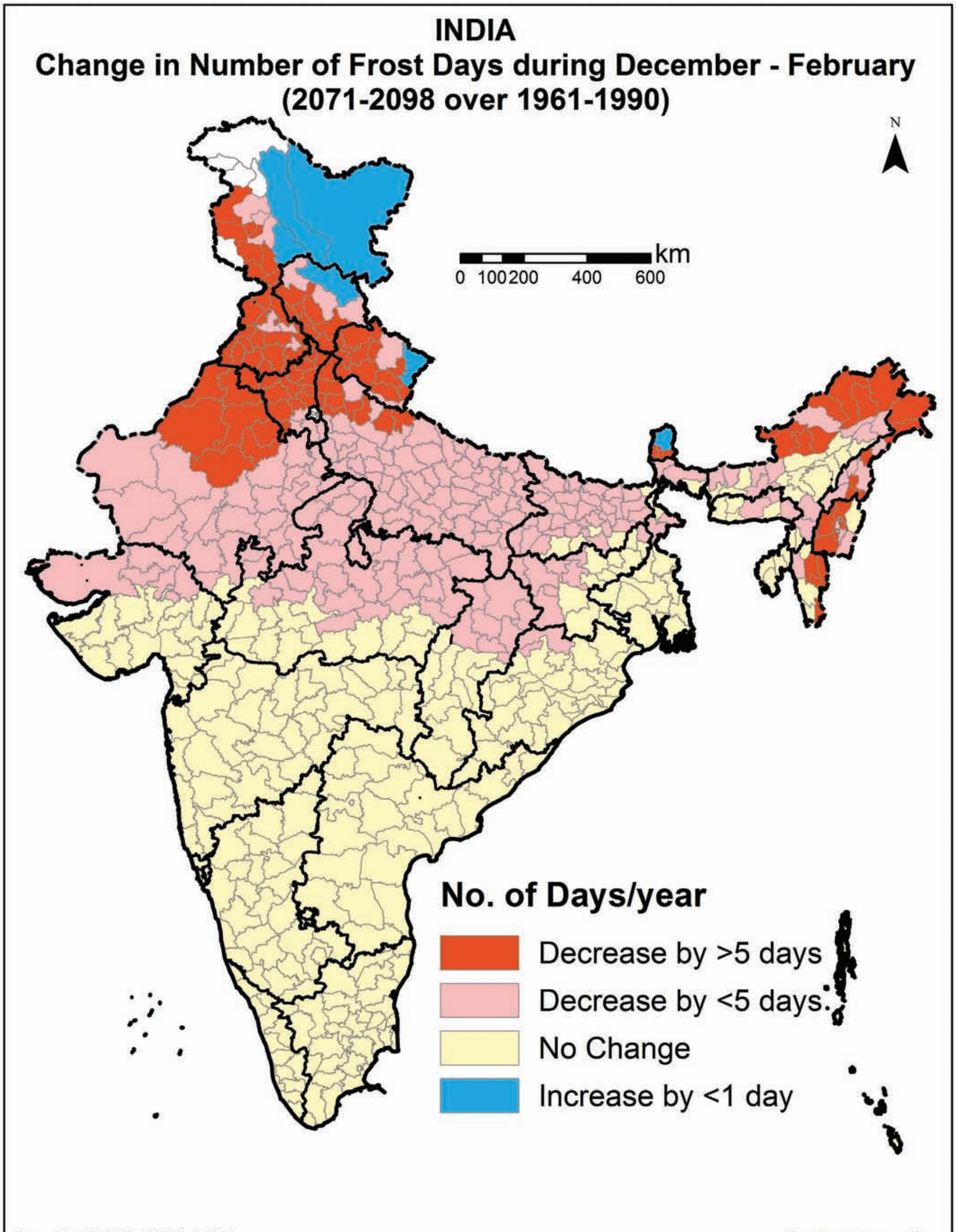

INDIA
Change in Number of Cold Days during December - February
(2071-2098 over 1961-1990)
N
km
0 100200 400 600
No. of days/year
Decrease by >2 days
Decrease by <2 days
No Change
Increase by <2 days
Increase by >2 days
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EE8



Source of Data: Computed using PRECIS RCM IPCC SRES A1B daily weather data sets provided by IITM, Pune

Fig. EE9

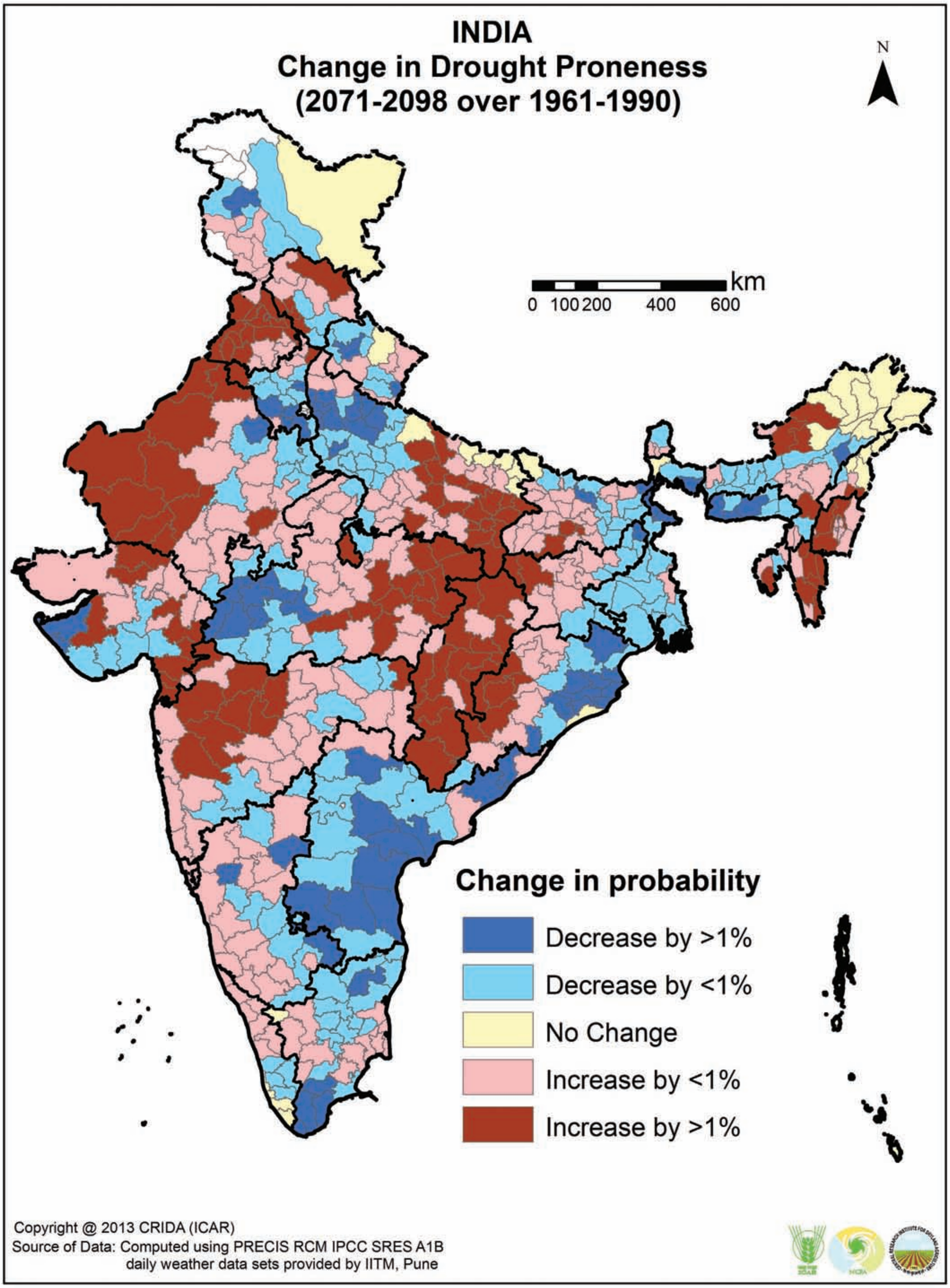

INDIA
Change in Drought Proneness
(2071-2098 over 1961-1990)
N
km
0 100 200 400 600
Change in probability
Decrease by >1%
Decrease by <1%
No Change
Increase by <1%
Increase by >1%
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EE10

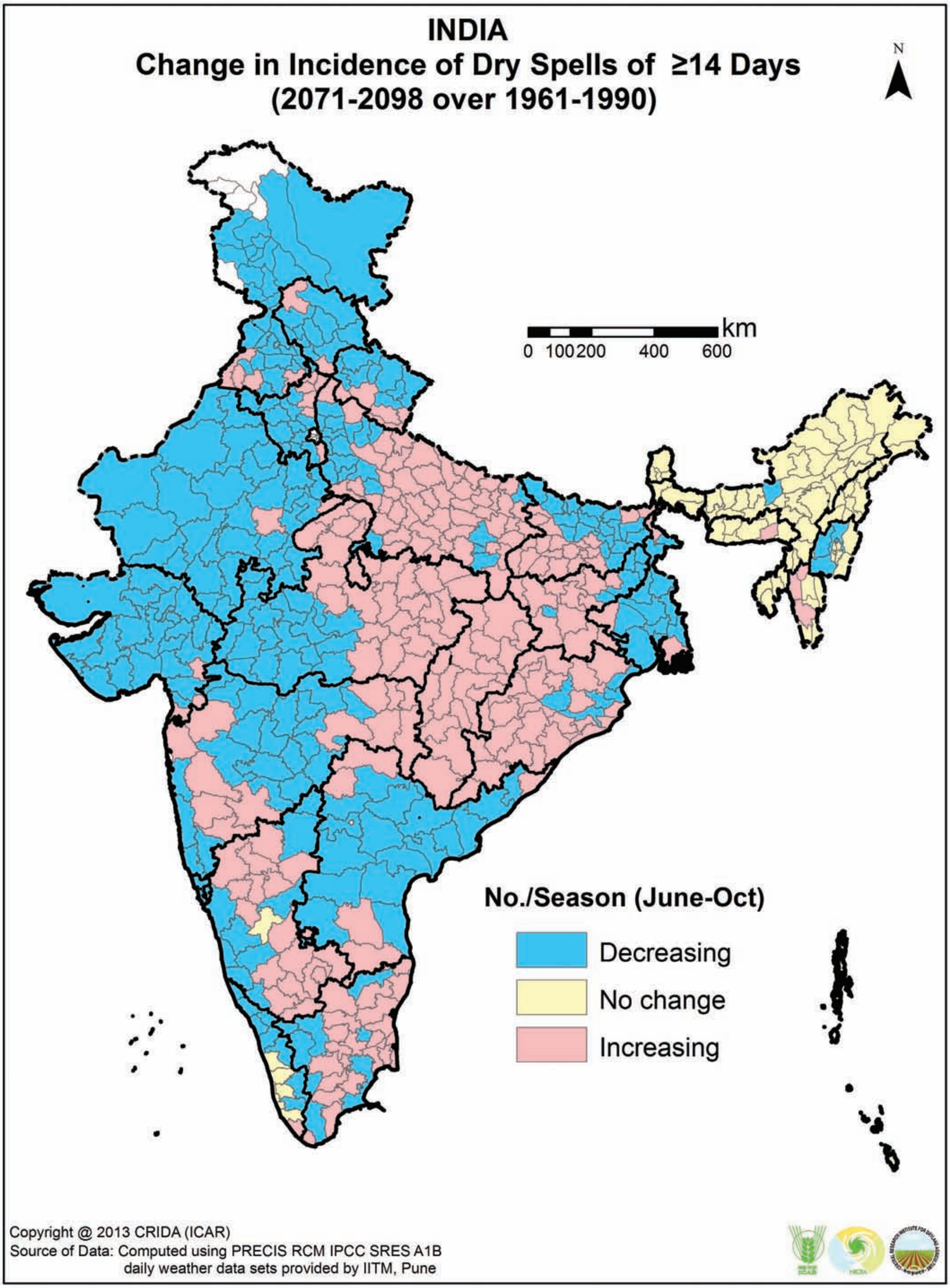

INDIA
Change in Incidence of Dry Spells of ≥14 Days
(2071-2098 over 1961-1990)
N
km
0 100 200 400 600
No./Season (June-Oct)
Decreasing
No change
Increasing
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EE11

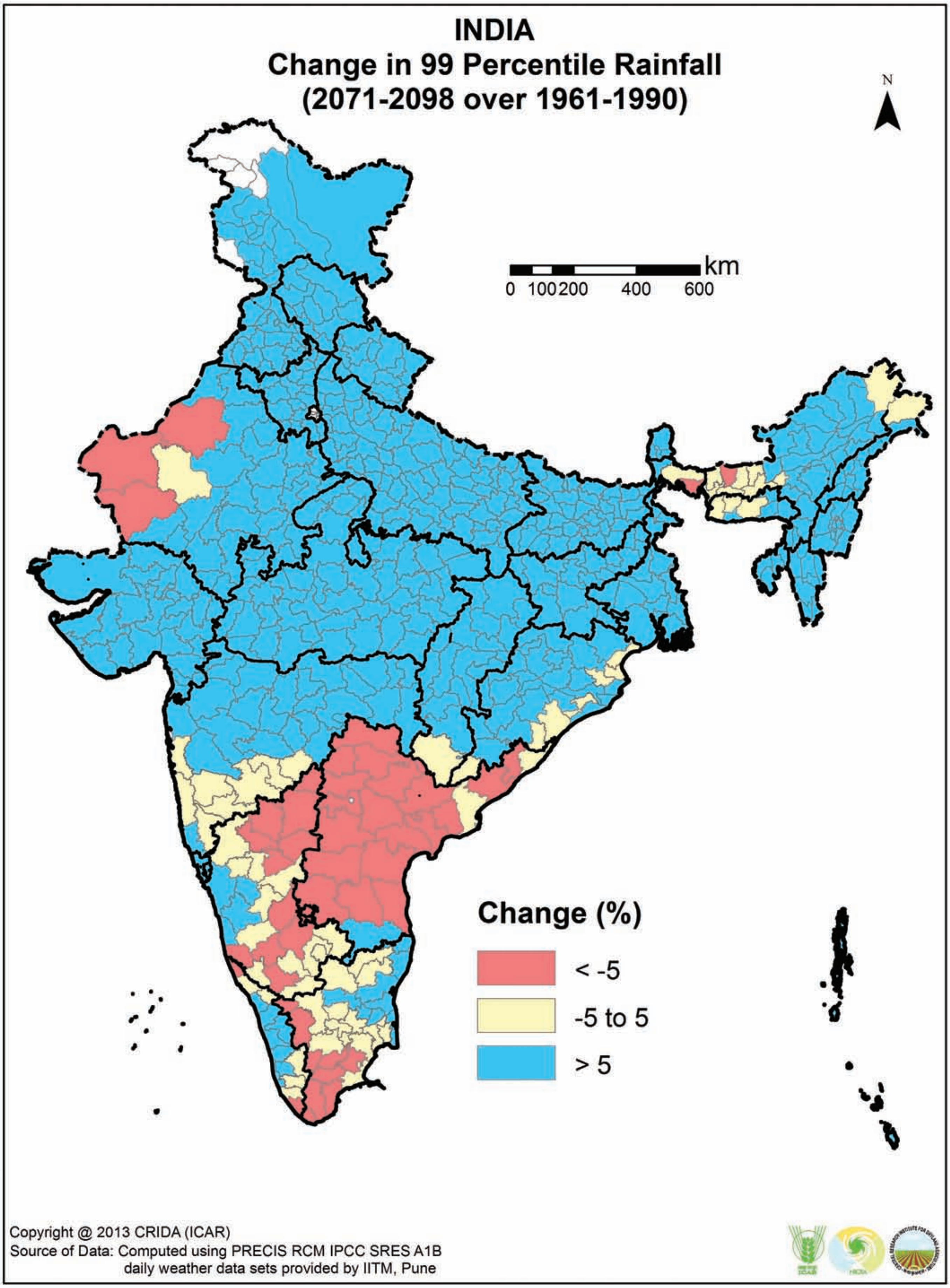

INDIA
Change in 99 Percentile Rainfall
(2071-2098 over 1961-1990)
N
km
0 100 200 400 600
Change (%)
< -5
-5 to 5
> 5
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EE12

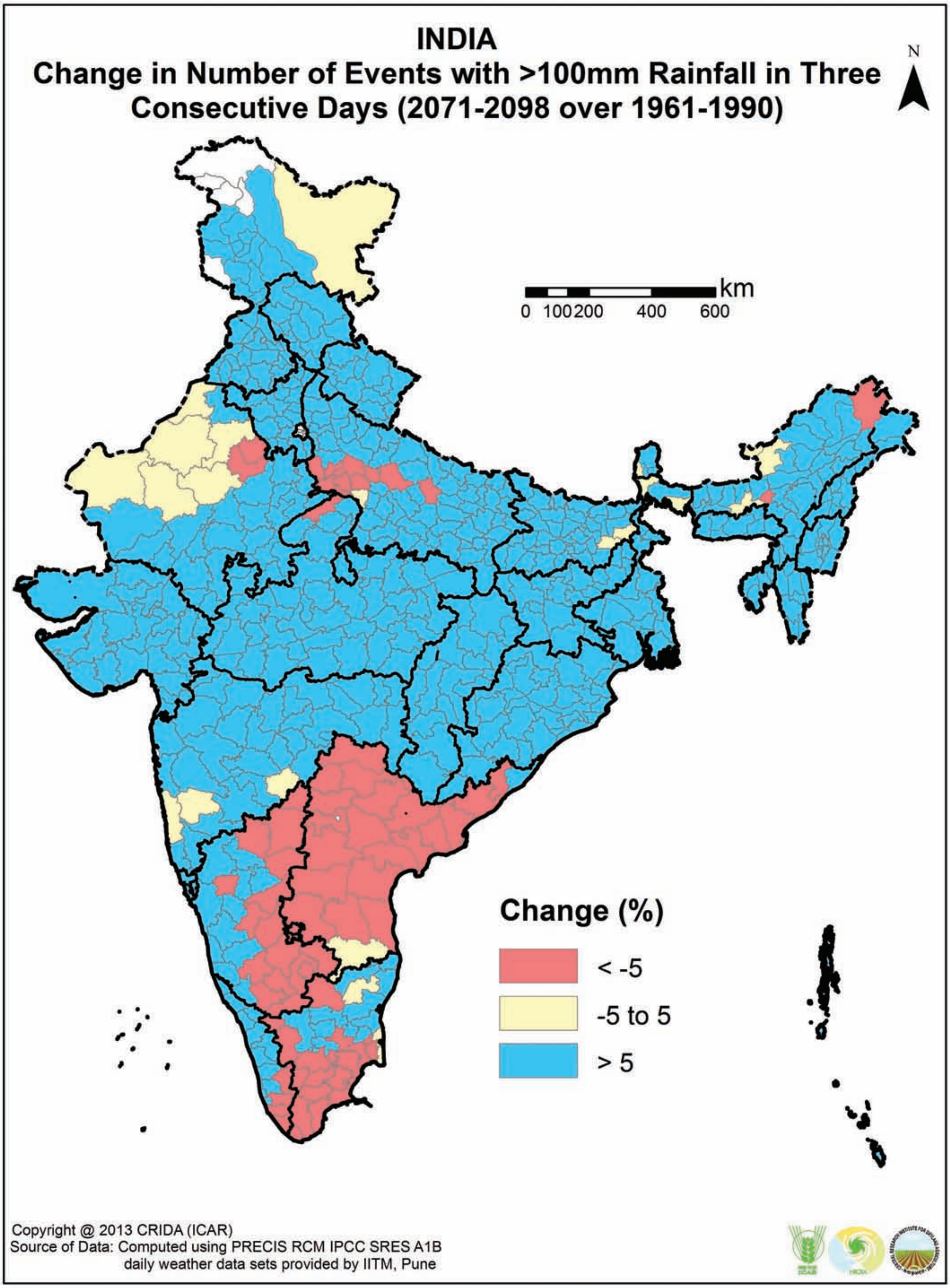

INDIA
Change in Number of Events with >100mm Rainfall in Three Consecutive Days (2071-2098 over 1961-1990)
N
km
0 100 200 400 600
Change (%)
< -5
-5 to 5
> 5
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B daily weather data sets provided by IITM, Pune

Fig. EE13

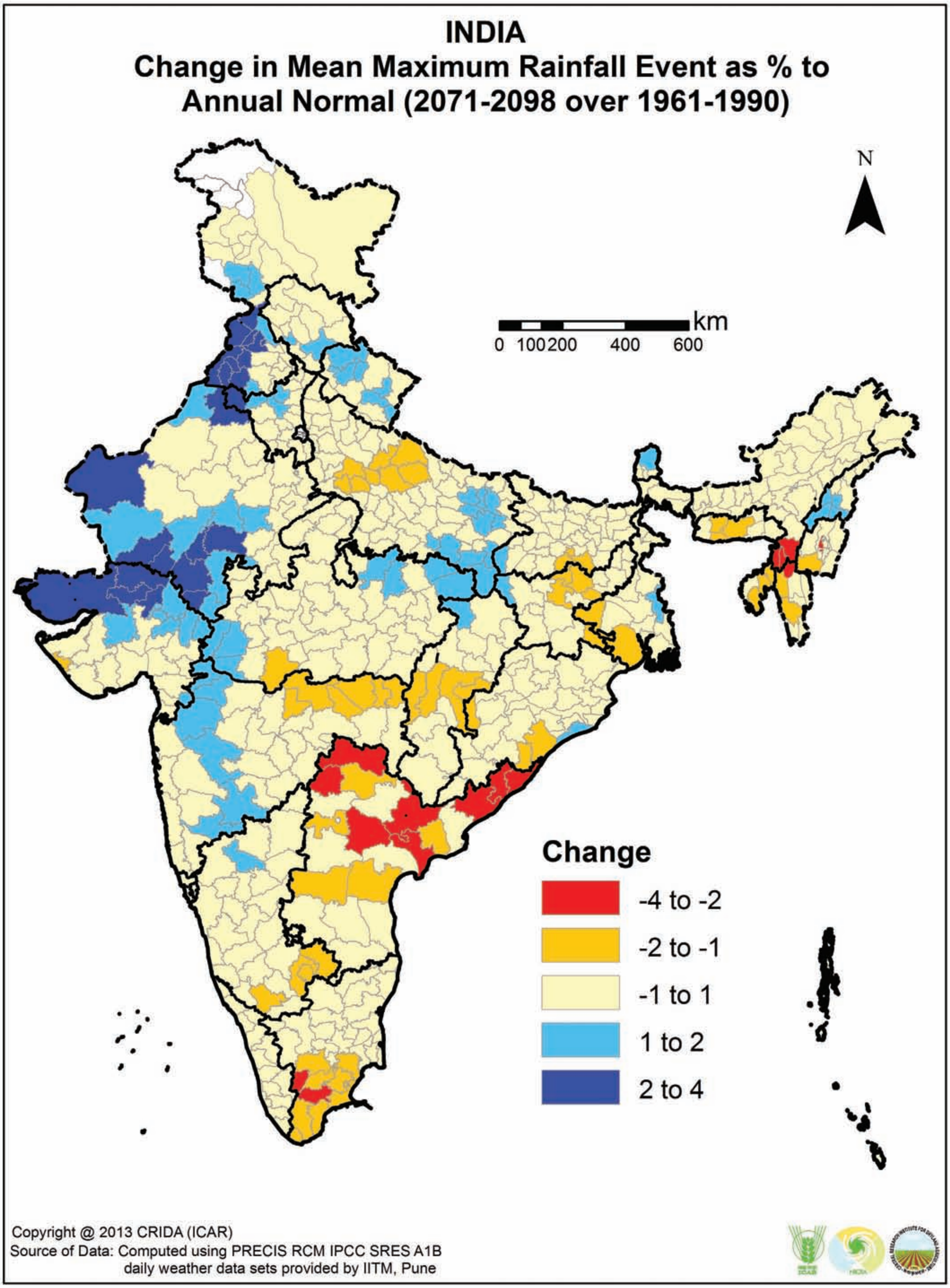

INDIA
Change in Mean Maximum Rainfall Event as % to Annual Normal (2071-2098 over 1961-1990)
N
km
0 100 200 400 600
Change
-4 to -2
-2 to -1
-1 to 1
1 to 2
2 to 4
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EE14

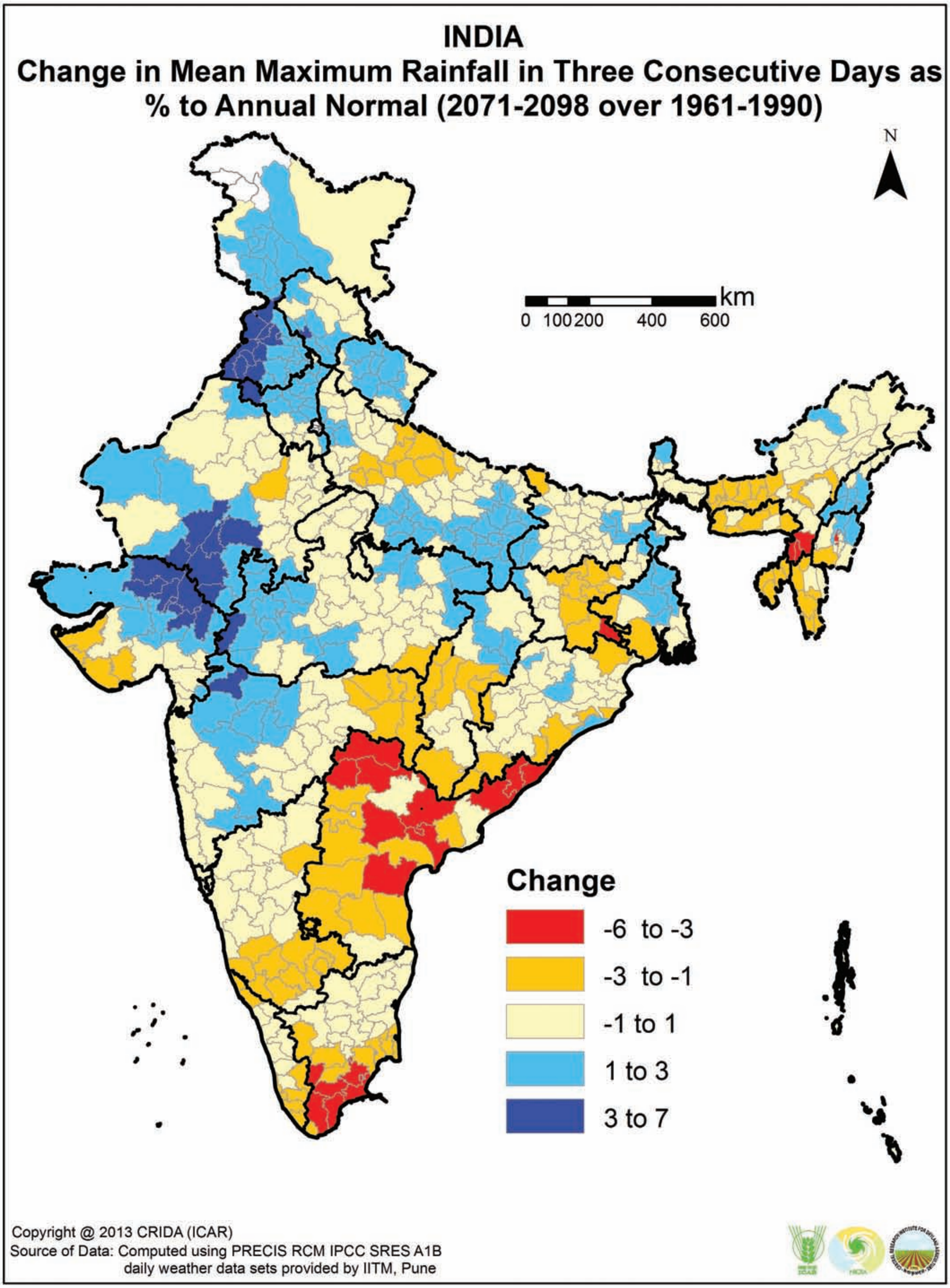

INDIA
Change in Mean Maximum Rainfall in Three Consecutive Days as % to Annual Normal (2071-2098 over 1961-1990)
N
km
0 100 200 400 600
Change
-6 to -3
-3 to -1
-1 to 1
1 to 3
3 to 7
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. EE15

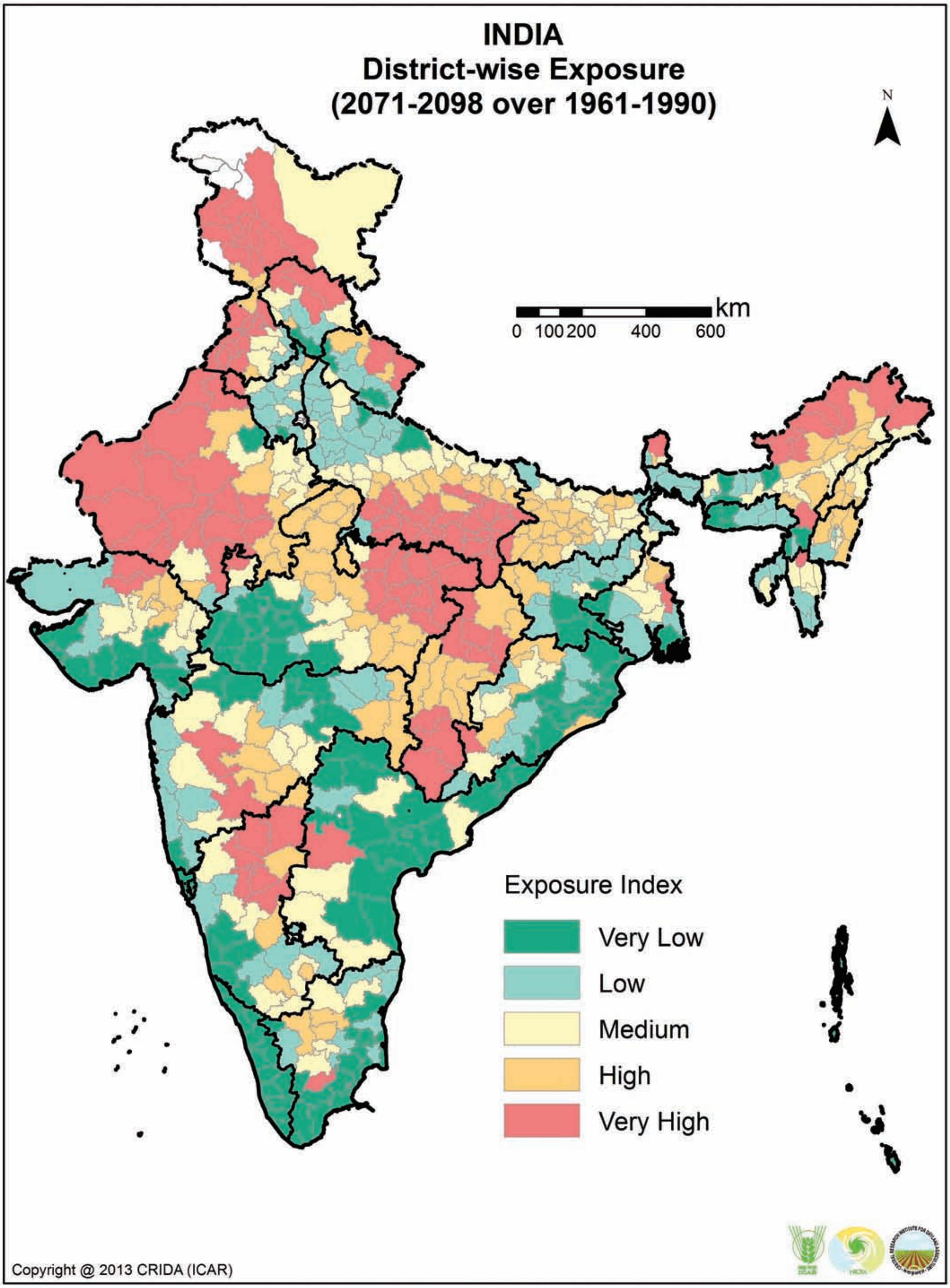

INDIA
District-wise Exposure
(2071-2098 over 1961-1990)
N
km
0 100 200 400 600
Exposure Index
Very Low
Low
Medium
High
Very High
Copyright @ 2013 CRIDA (ICAR)

Fig. EE16

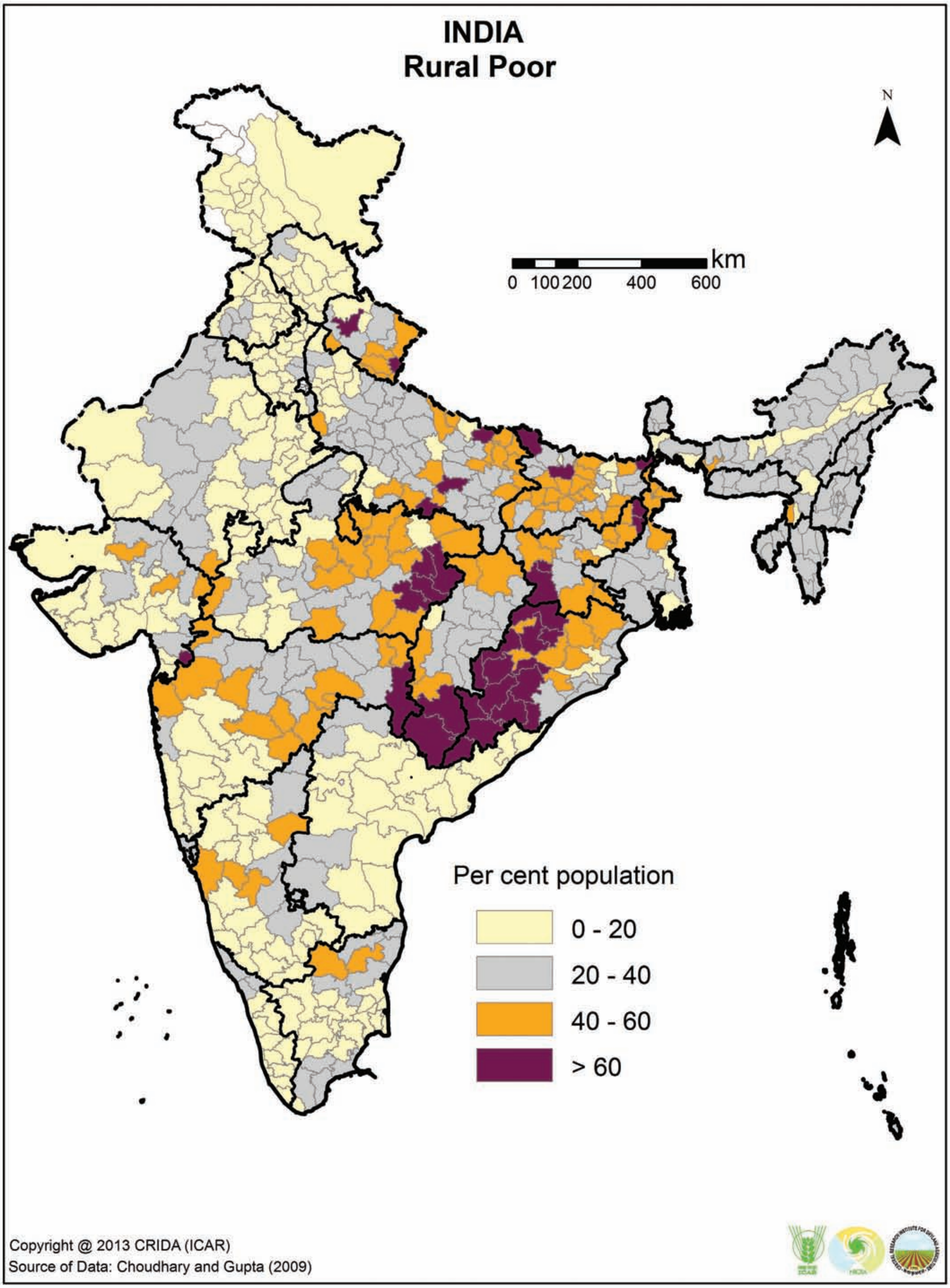

INDIA
Rural Poor
N
km
0 100 200 400 600
Per cent population
0 - 20
20 - 40
40 - 60
> 60
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Choudhary and Gupta (2009)

Fig. A1

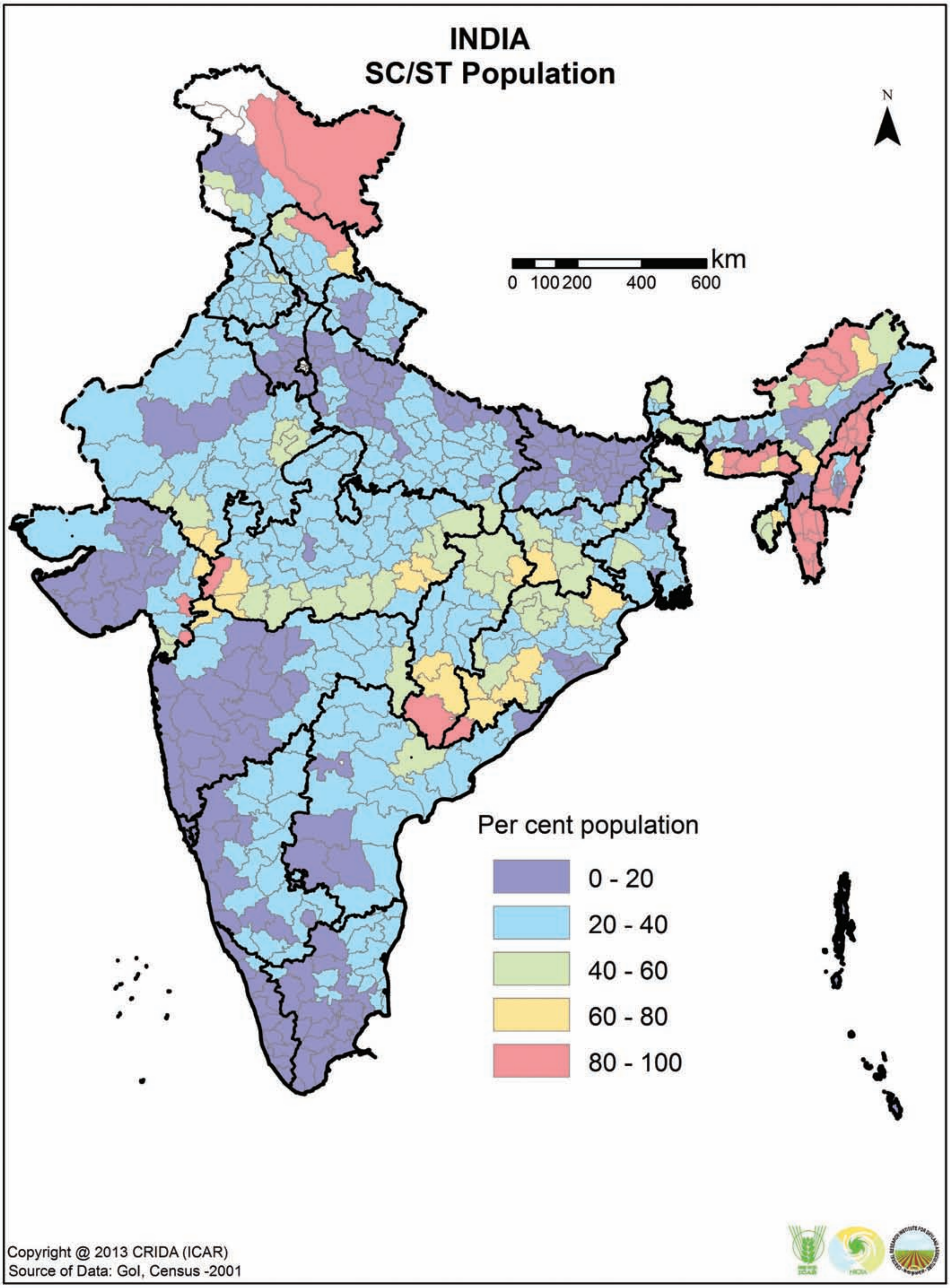

INDIA
SC/ST Population
N
0 100 200 400 600 km
Per cent population
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Copyright @ 2013 CRIDA (ICAR)
Source of Data: GoI, Census -2001

Fig. A2

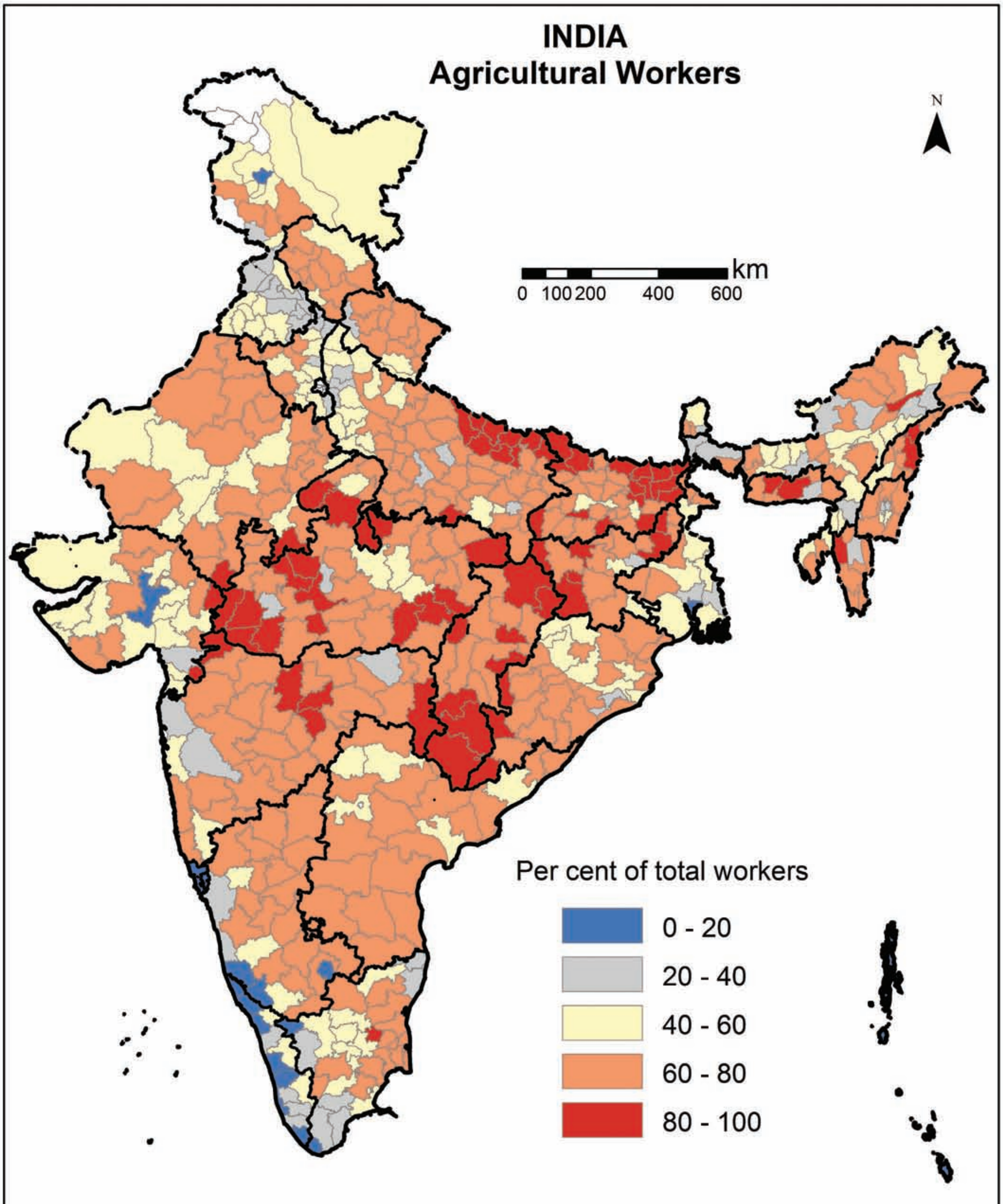

INDIA
Agricultural Workers
N
km
0 100 200 400 600
Per cent of total workers
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Copyright @ 2013 CRIDA (ICAR)
Source of Data:GoI, Census-2001

Fig. A3

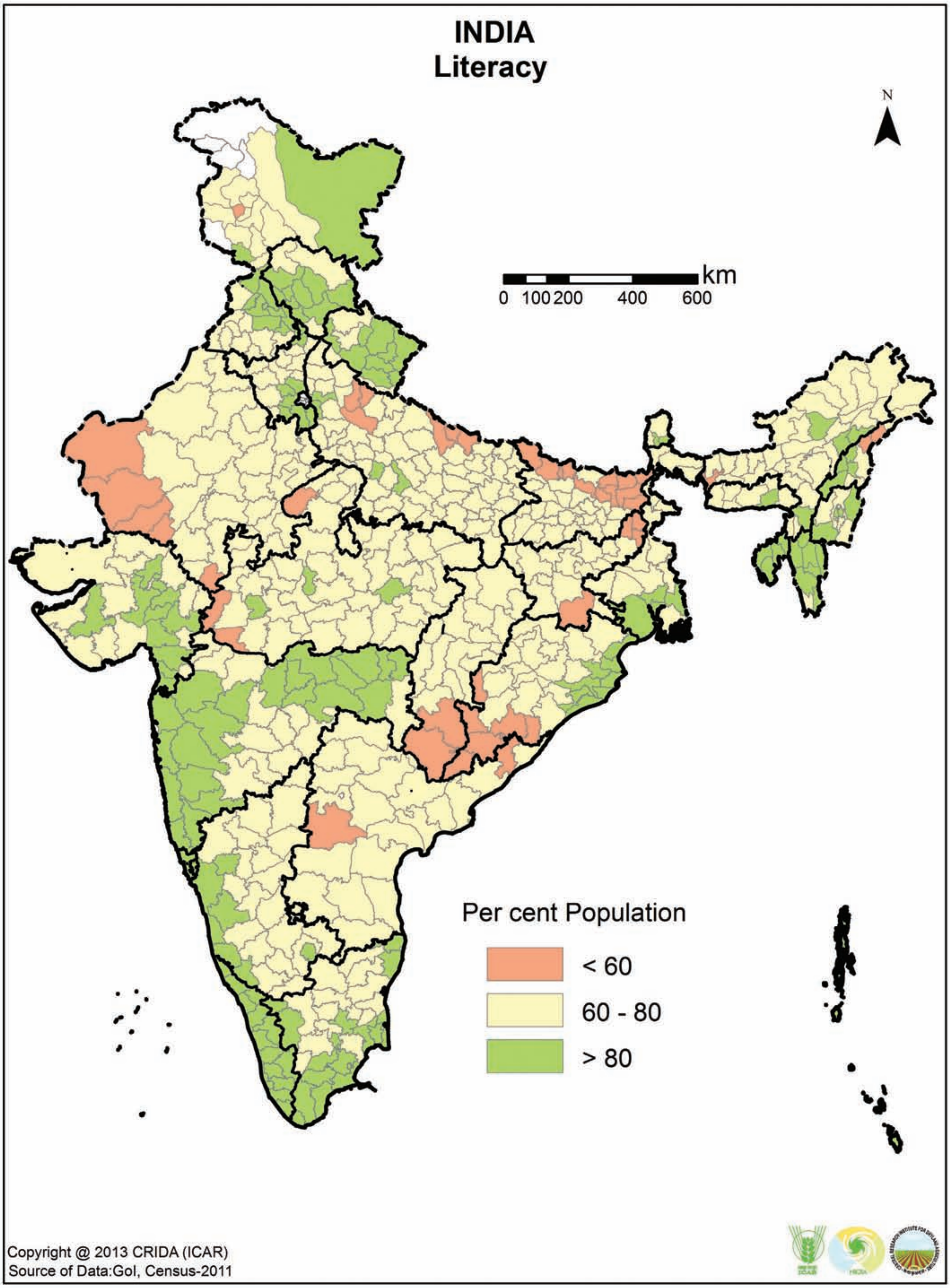

INDIA
Literacy
N
km
0 100 200 400 600
Per cent Population
< 60
60 - 80
> 80
Copyright @ 2013 CRIDA (ICAR)
Source of Data:GoI, Census-2011

Fig. A4

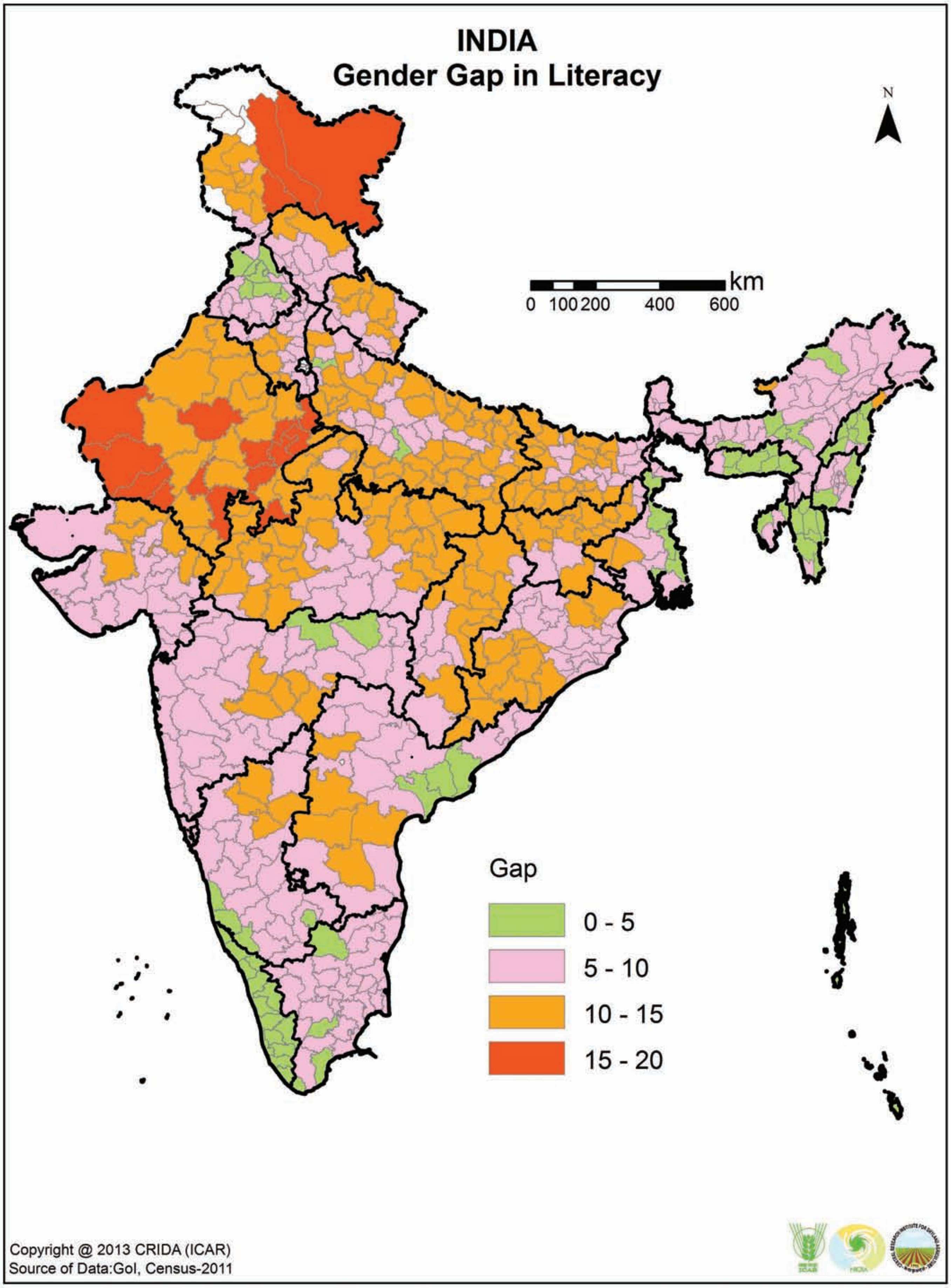

INDIA
Gender Gap in Literacy
N
km
0 100 200 400 600
Gap
0 - 5
5 - 10
10 - 15
15 - 20
Copyright @ 2013 CRIDA (ICAR)
Source of Data:GoI, Census-2011

Fig. A5

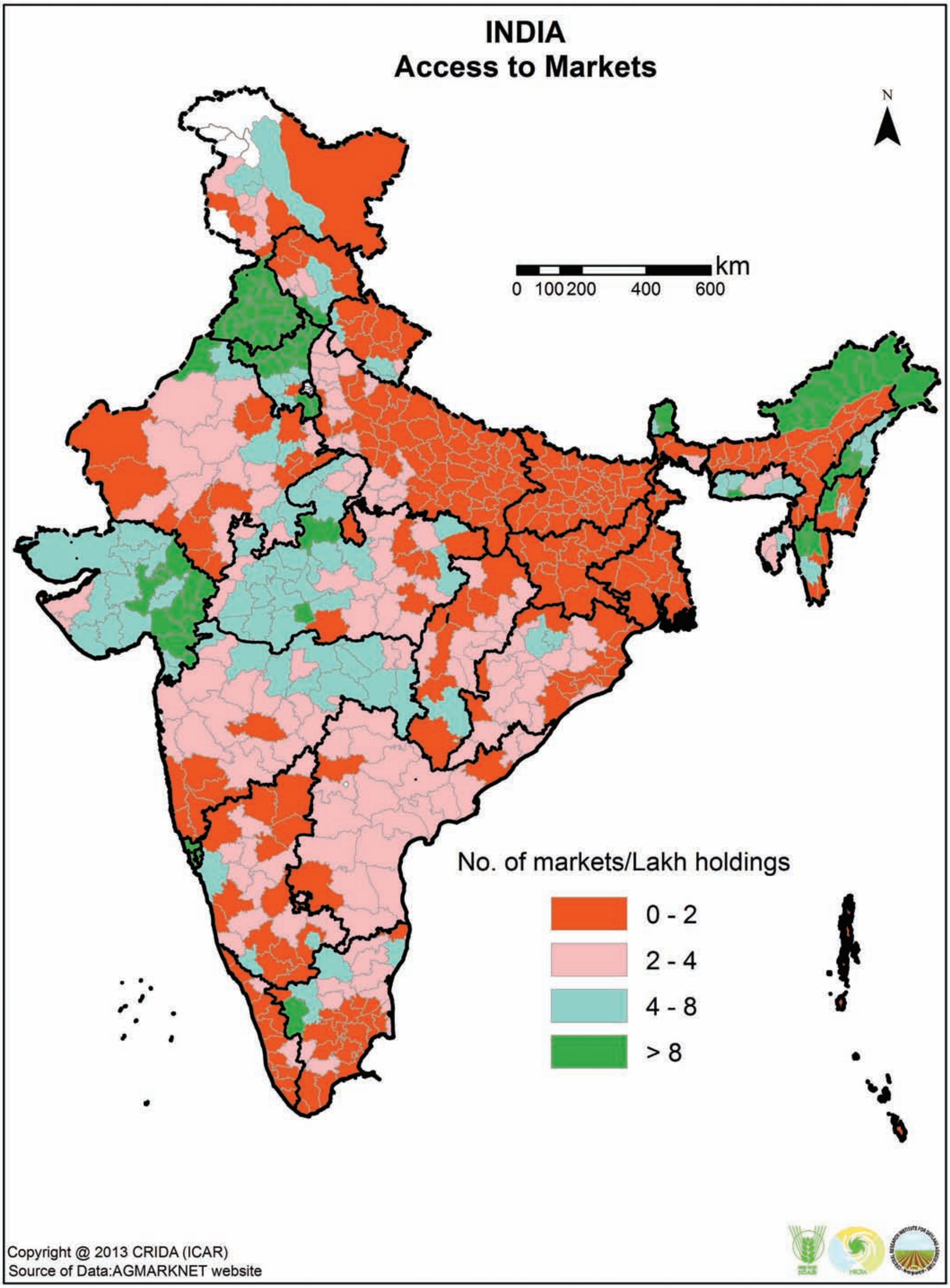

INDIA
Access to Markets
N
km
0 100 200 400 600
No. of markets/Lakh holdings
0 - 2
2 - 4
4 - 8
> 8
Copyright @ 2013 CRIDA (ICAR)
Source of Data:AGMARKNET website

Fig. A6

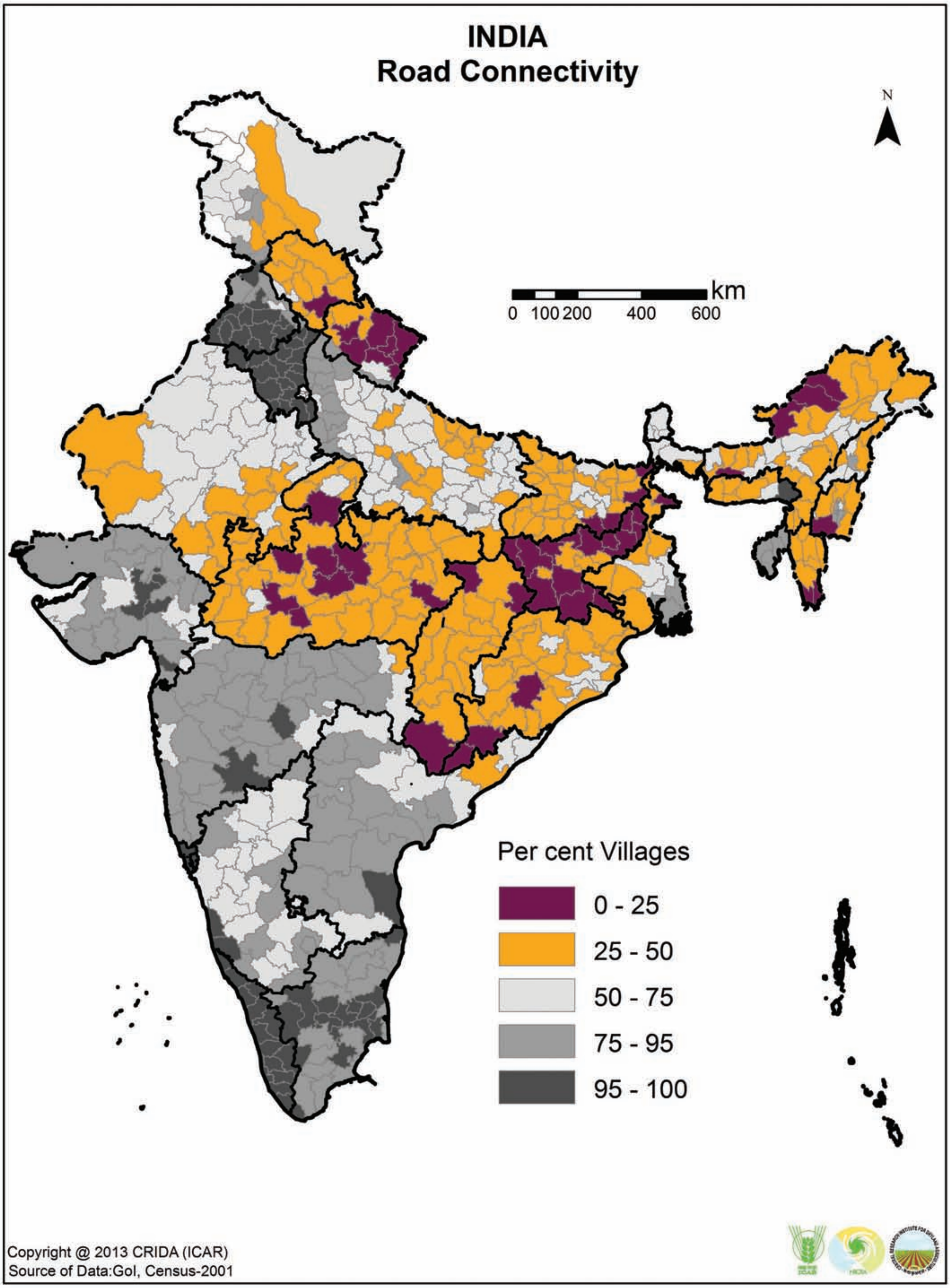

INDIA
Road Connectivity
N
km
0 100 200 400 600
Per cent Villages
0 - 25
25 - 50
50 - 75
75 - 95
95 - 100
Copyright @ 2013 CRIDA (ICAR)
Source of Data:GoI, Census-2001

Fig. A7

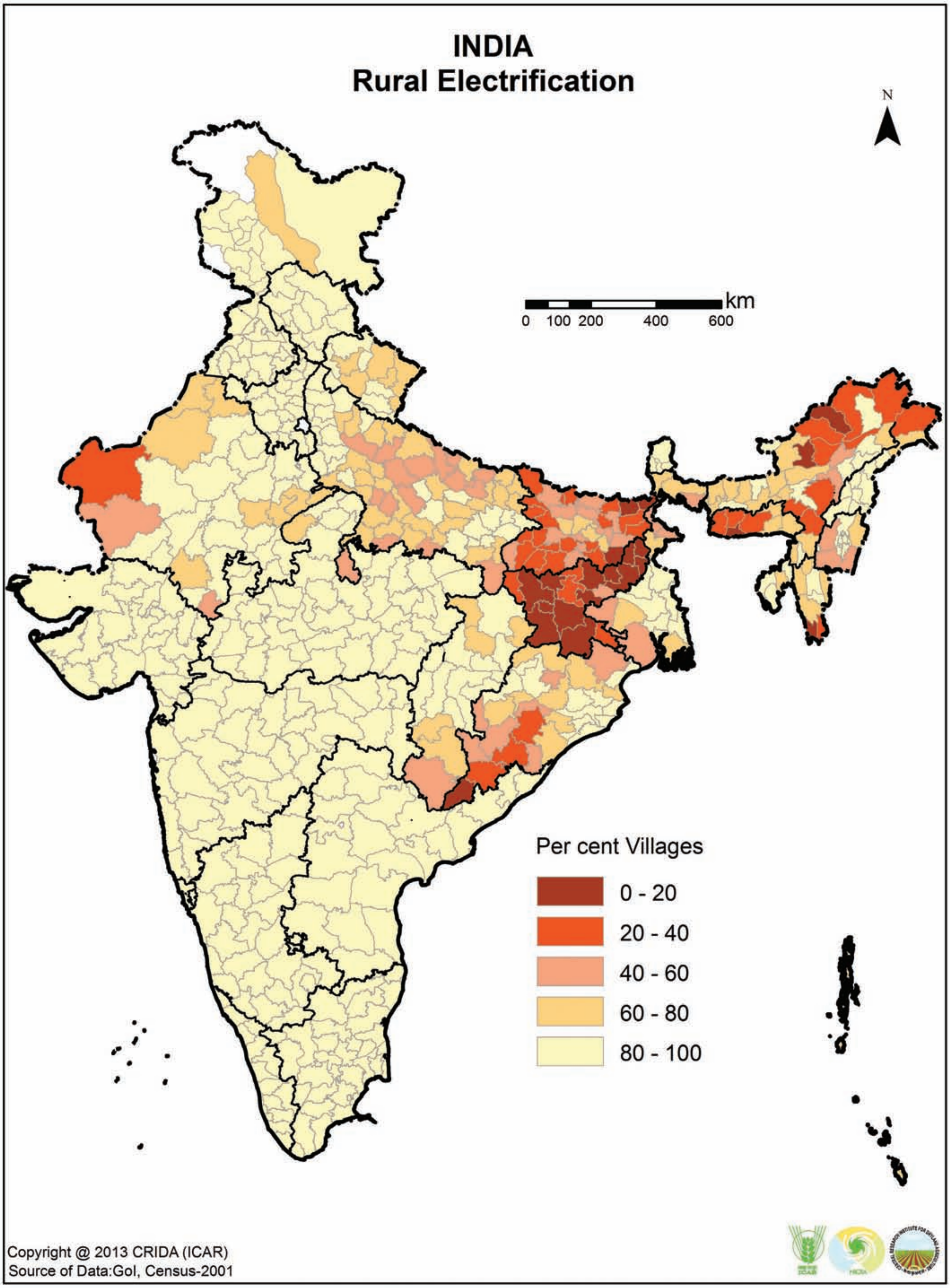

INDIA
Rural Electrification
N
km
0 100 200 400 600
Per cent Villages
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Copyright @ 2013 CRIDA (ICAR)
Source of Data:GoI, Census-2001

Fig. A8

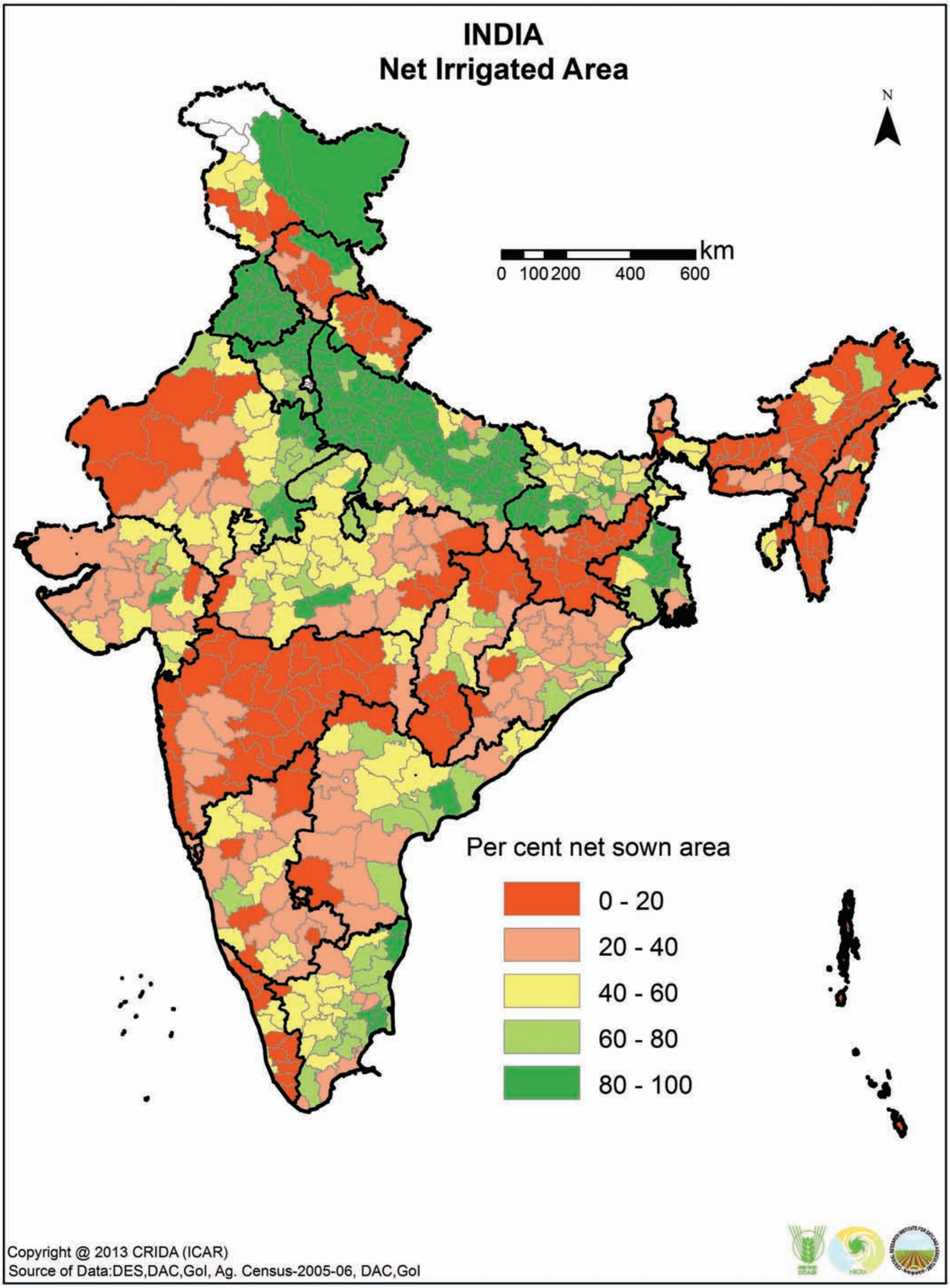

INDIA
Net Irrigated Area
N
km
0 100 200 400 600
Per cent net sown area
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Copyright @ 2013 CRIDA (ICAR)
Source of Data:DES,DAC,GoI, Ag. Census-2005-06, DAC,GoI

Fig. A9

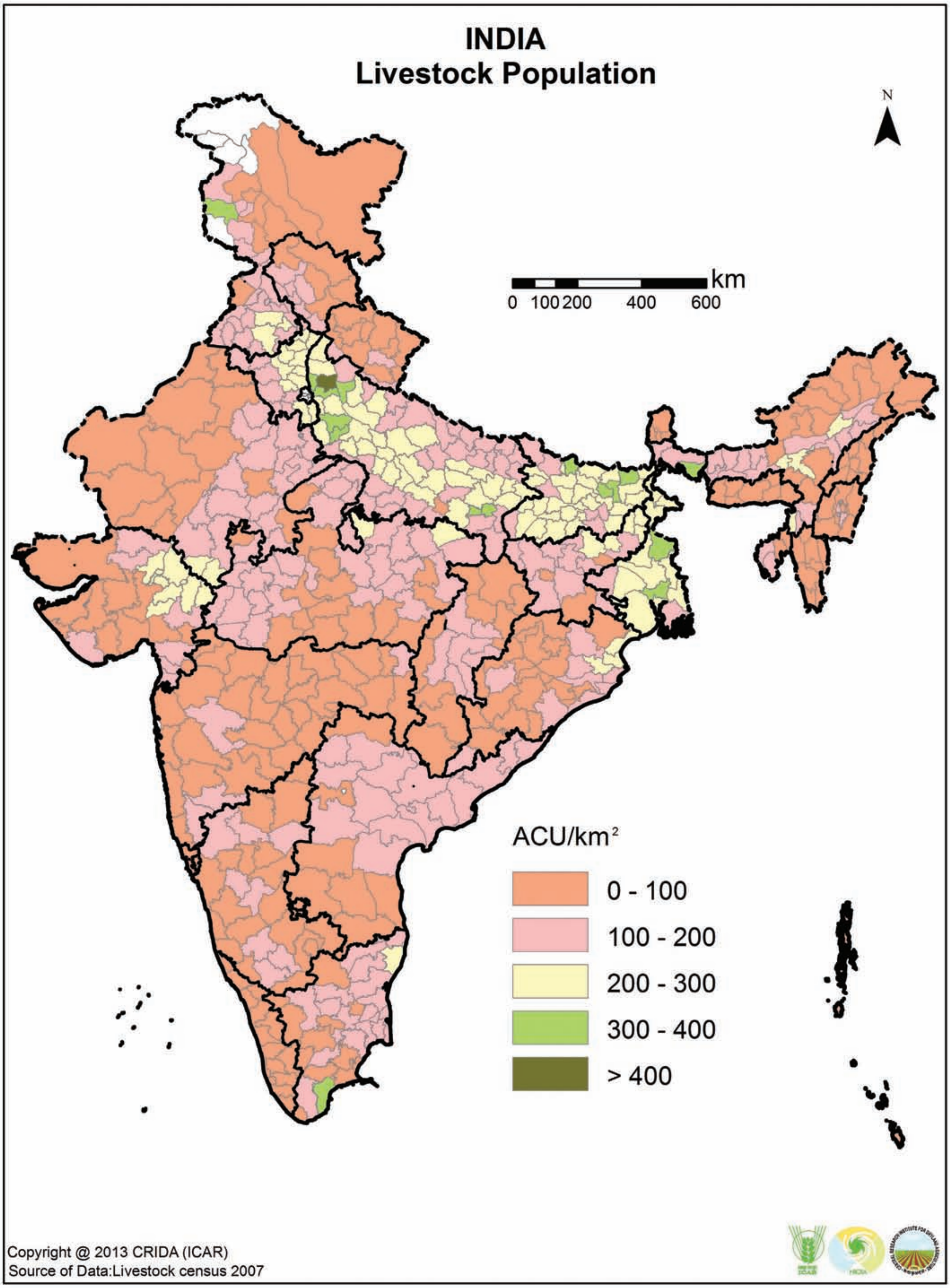

INDIA
Livestock Population
N
km
0 100 200 400 600
ACU/km²
0 - 100
100 - 200
200 - 300
300 - 400
> 400
Copyright @ 2013 CRIDA (ICAR)
Source of Data:Livestock census 2007

Fig. A10

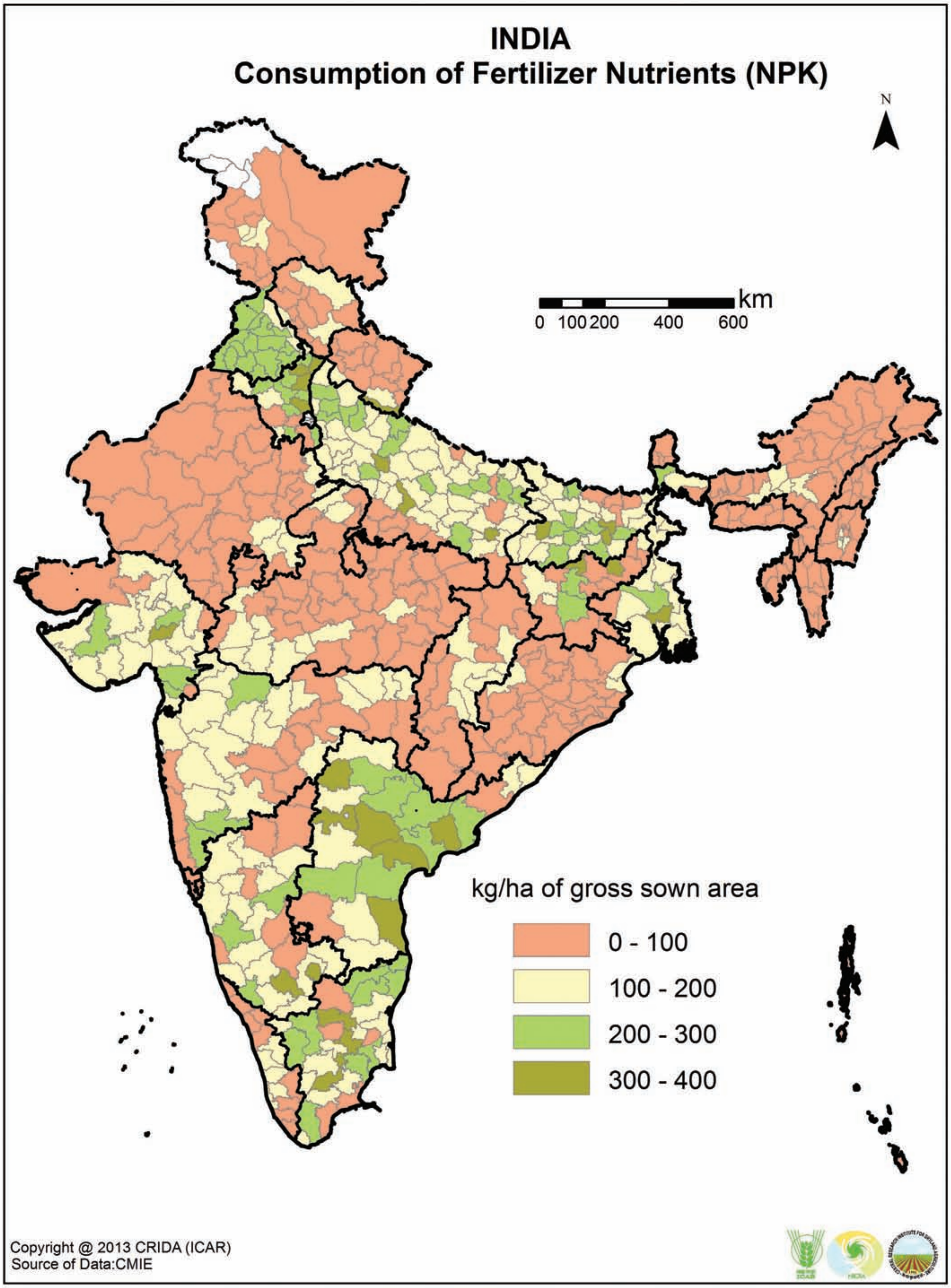
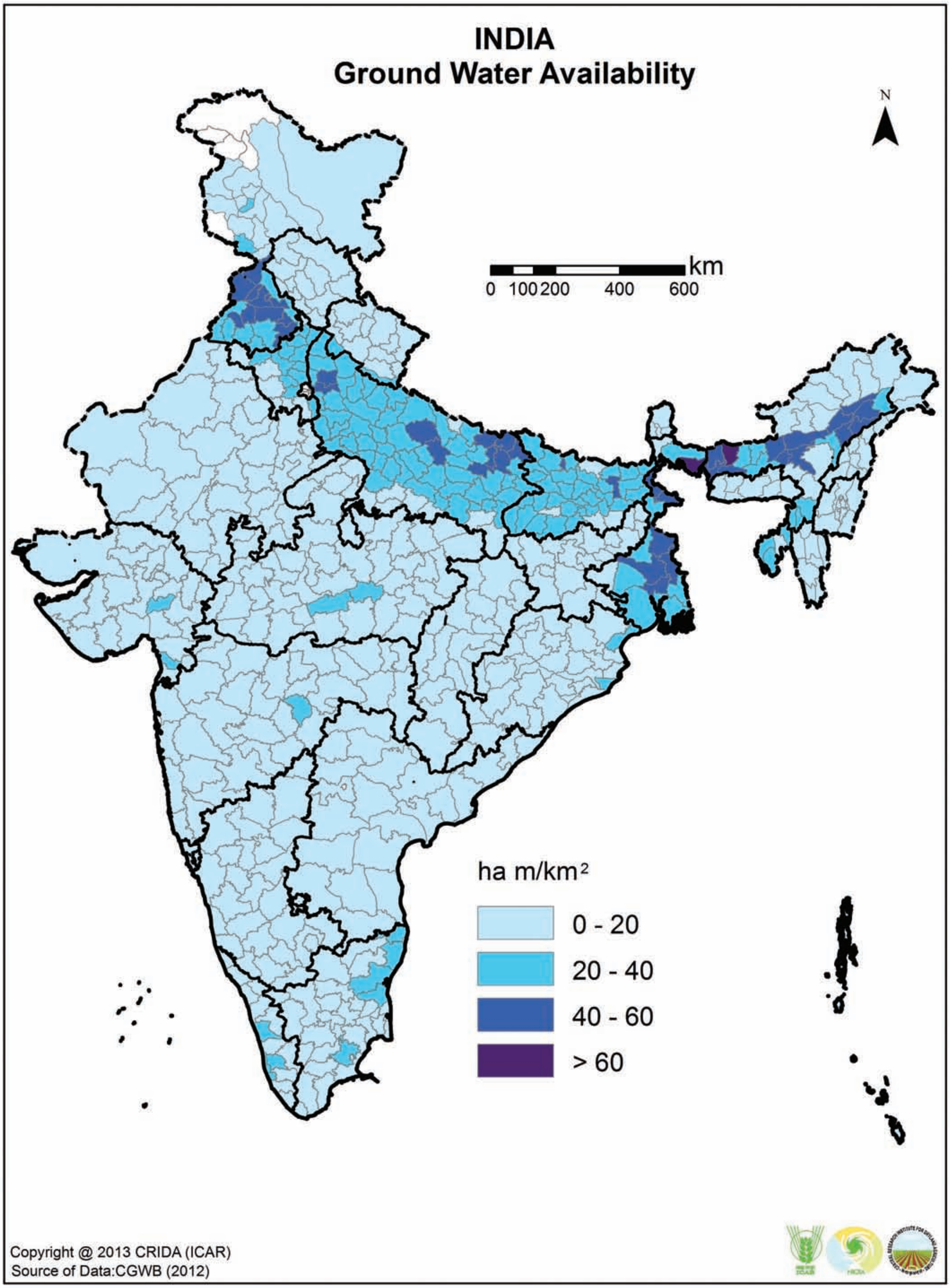

INDIA
Consumption of Fertilizer Nutrients (NPK)
N
km
0 100 200 400 600
kg/ha of gross sown area
0 - 100
100 - 200
200 - 300
300 - 400
Copyright @ 2013 CRIDA (ICAR)
Source of Data:CMIE

Fig. A11



INDIA
Ground Water Availability
N
km
0 100 200 400 600
ha m/km2
0 - 20
20 - 40
40 - 60
> 60
Copyright @ 2013 CRIDA (ICAR)
Source of Data:CGWB (2012)

Fig. A12

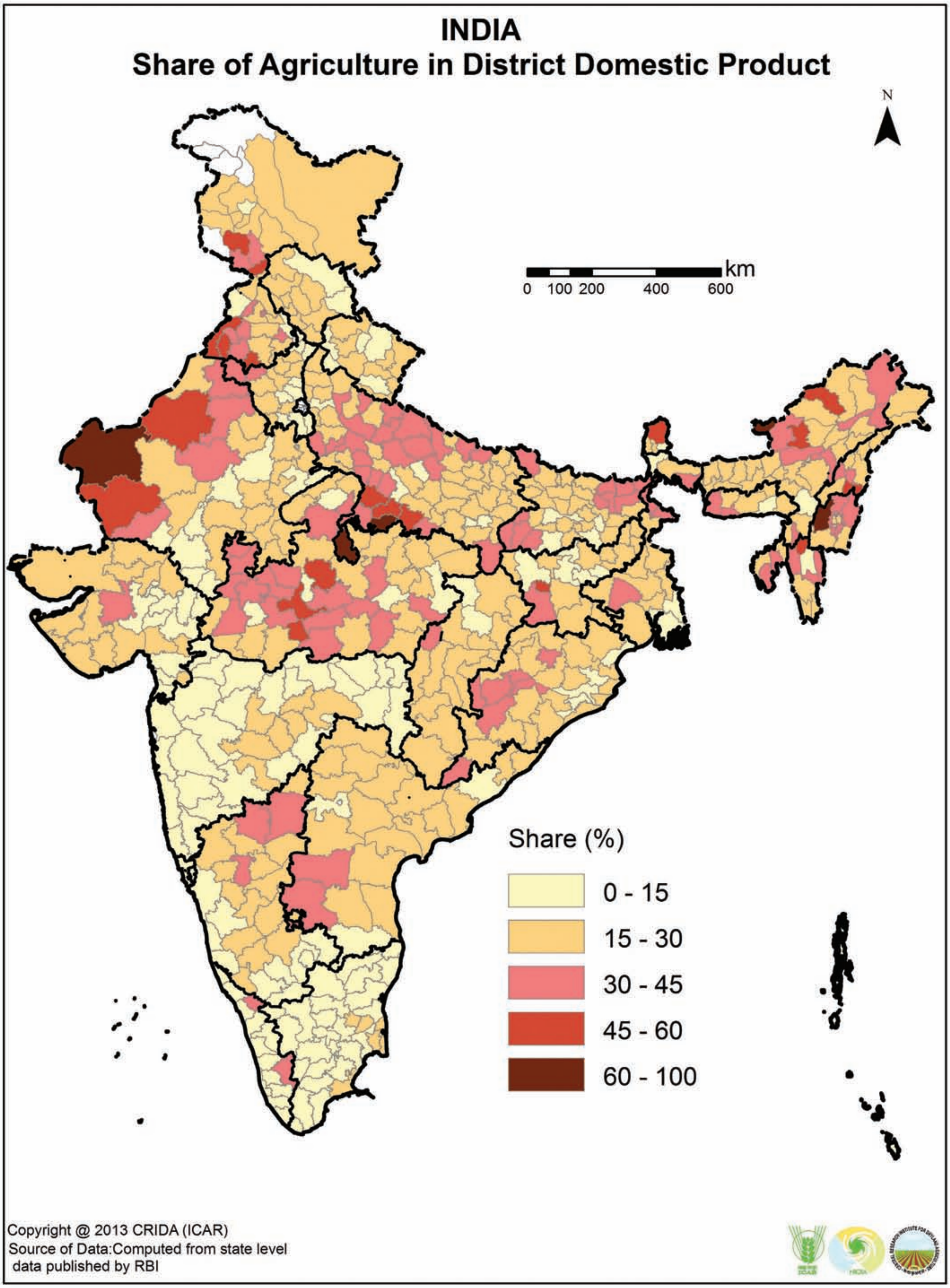

INDIA
Share of Agriculture in District Domestic Product
N
km
0 100 200 400 600
Share (%)
0 - 15
15 - 30
30 - 45
45 - 60
60 - 100
Copyright @ 2013 CRIDA (ICAR)
Source of Data:Computed from state level
data published by RBI

Fig. A13

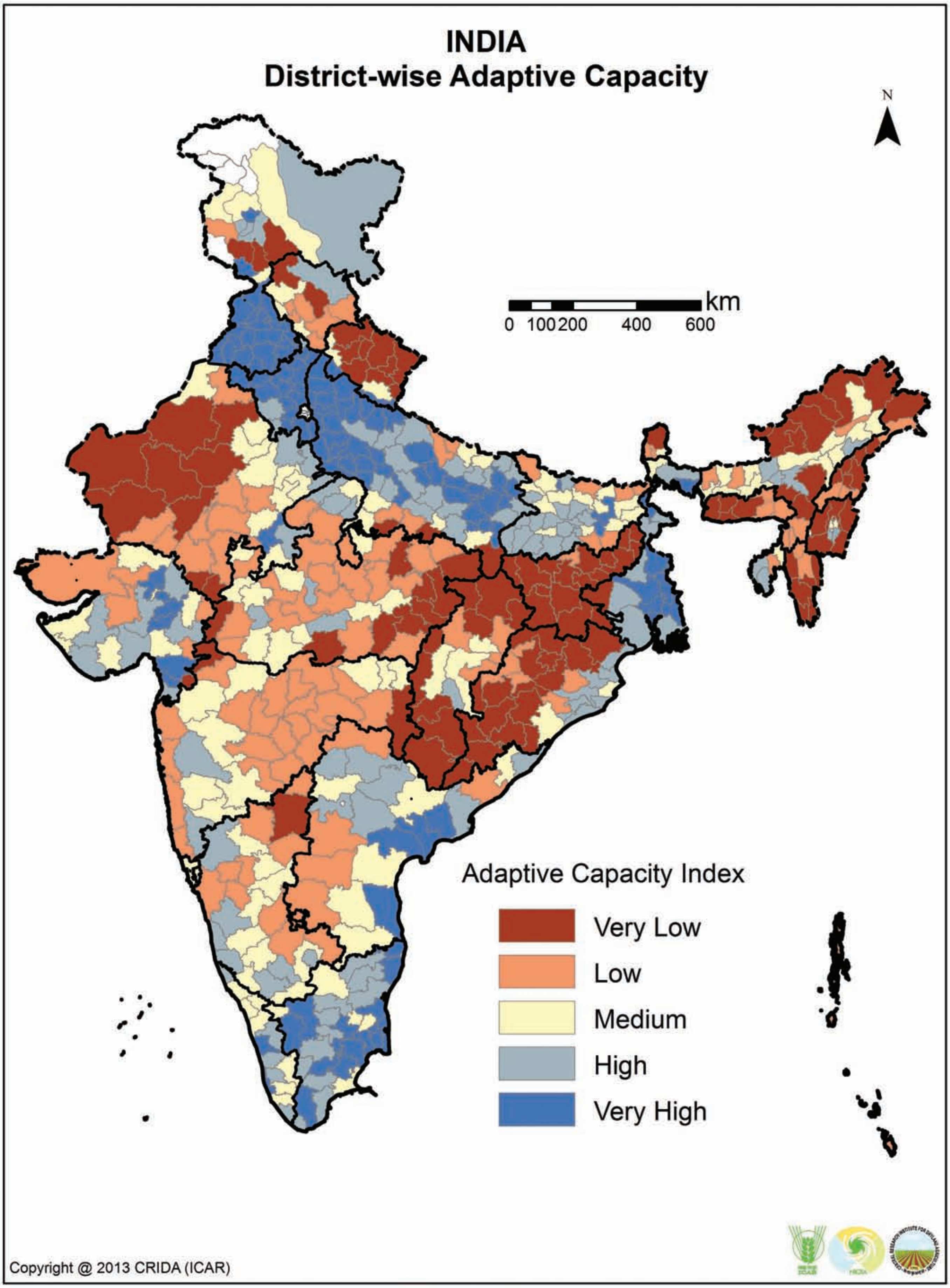

INDIA
District-wise Adaptive Capacity
N
km
0 100 200 400 600
Adaptive Capacity Index
Very Low
Low
Medium
High
Very High
Copyright @ 2013 CRIDA (ICAR)

Fig. A14

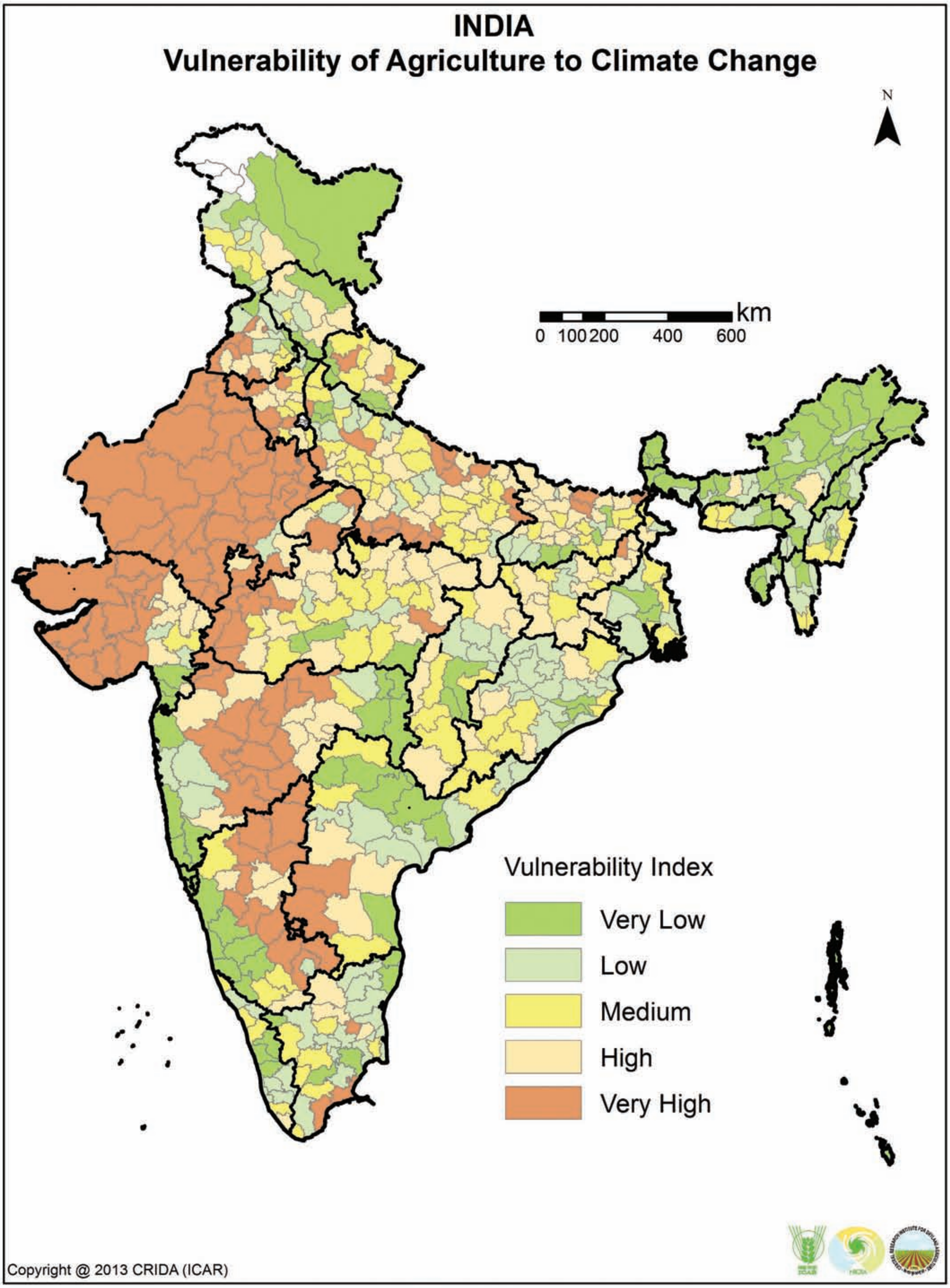

INDIA
Vulnerability of Agriculture to Climate Change
N
km
0 100 200 400 600
Vulnerability Index
Very Low
Low
Medium
High
Very High
Copyright @ 2013 CRIDA (ICAR)

Fig. V1

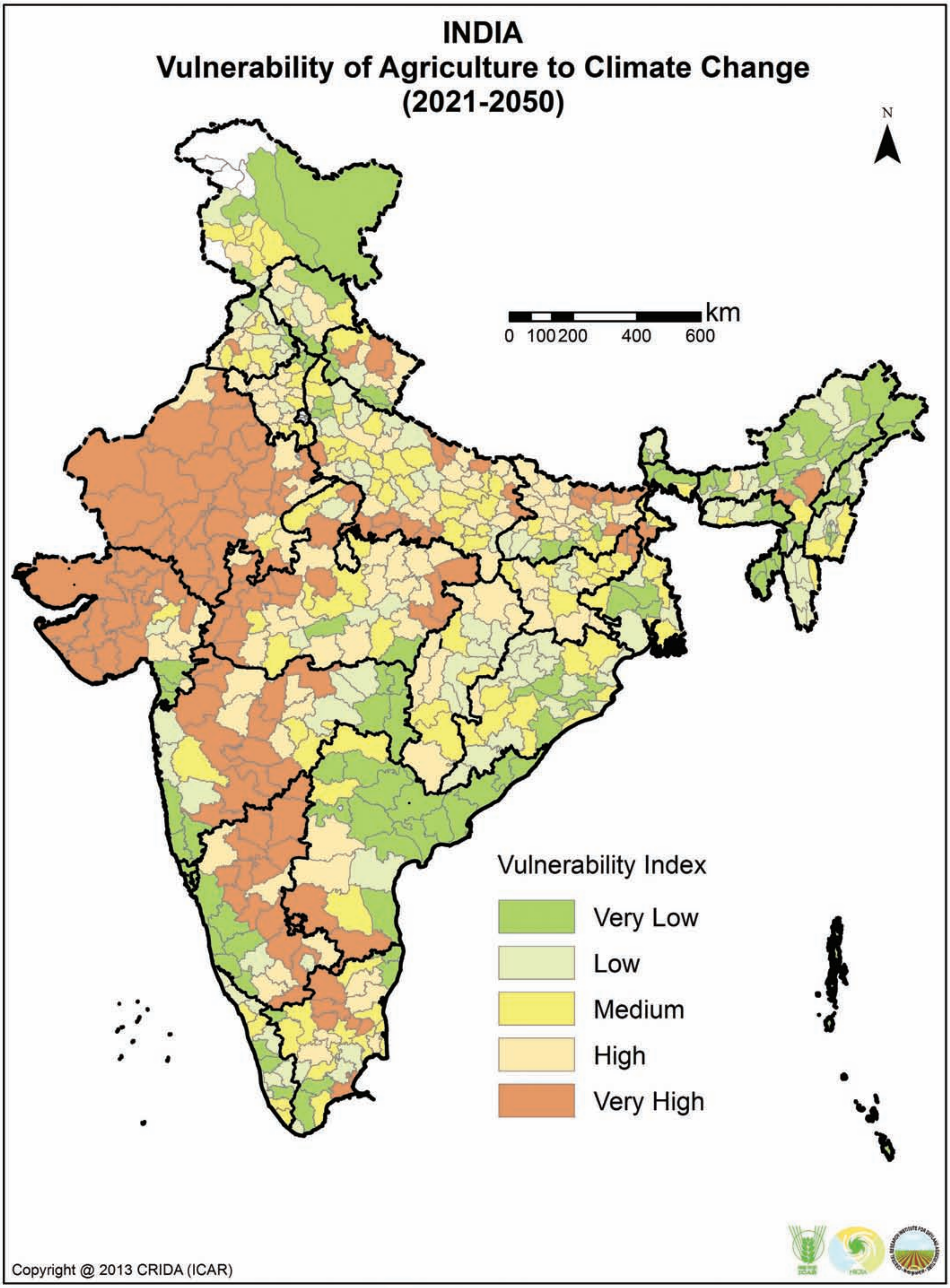

INDIA
Vulnerability of Agriculture to Climate Change
(2021-2050)
N
km
0 100 200 400 600
Vulnerability Index
Very Low
Low
Medium
High
Very High
Copyright @ 2013 CRIDA (ICAR)

Fig. V2

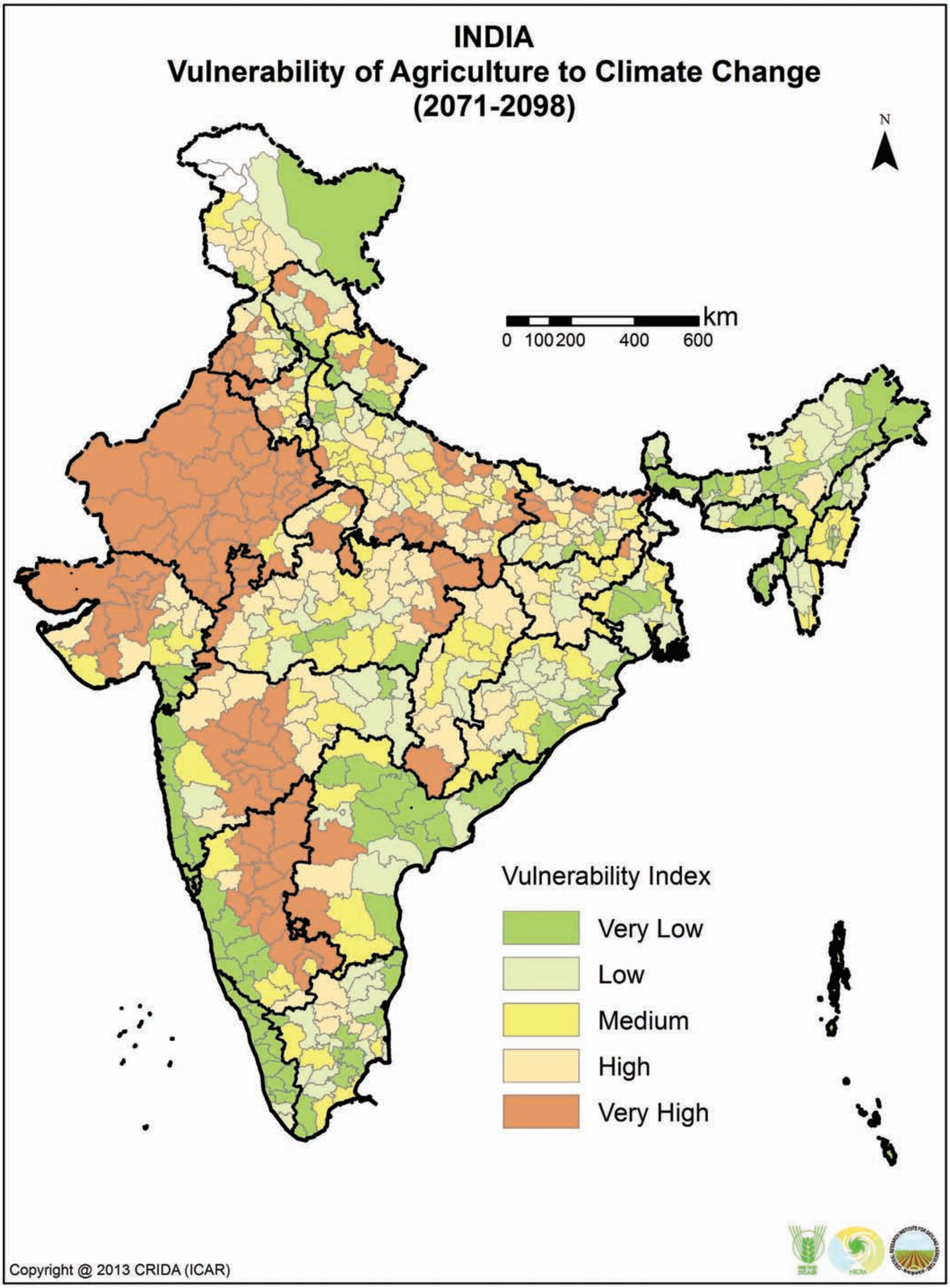

INDIA
Vulnerability of Agriculture to Climate Change
(2071-2098)
N
km
0 100 200 400 600
Vulnerability Index
Very Low
Low
Medium
High
Very High
Copyright @ 2013 CRIDA (ICAR)

Fig. V3

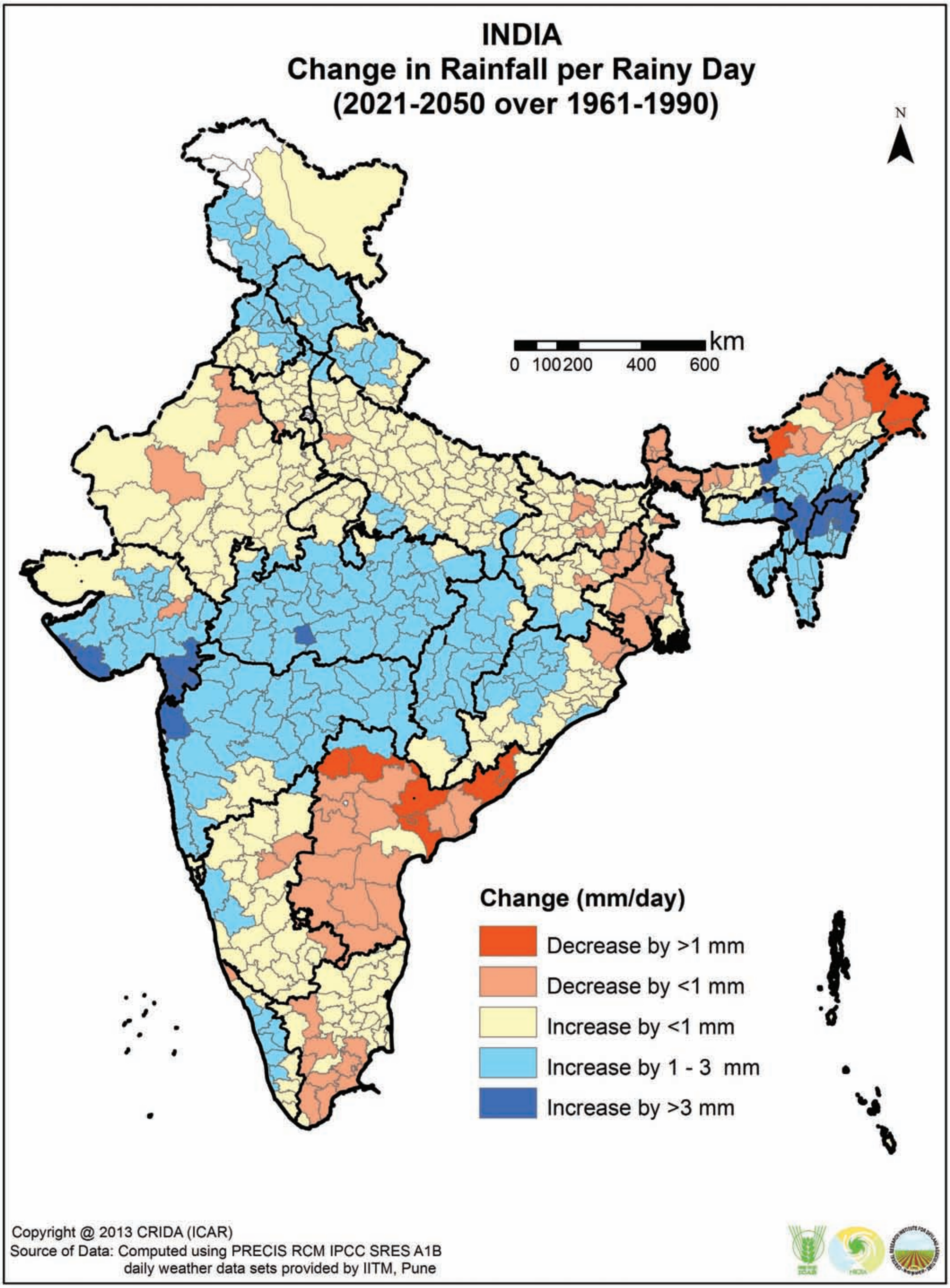

INDIA
Change in Rainfall per Rainy Day
(2021-2050 over 1961-1990)
N
km
0 100 200 400 600
Change (mm/day)
Decrease by >1 mm
Decrease by <1 mm
Increase by <1 mm
Increase by 1 - 3 mm
Increase by >3 mm
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B daily weather data sets provided by IITM, Pune

Fig. O1

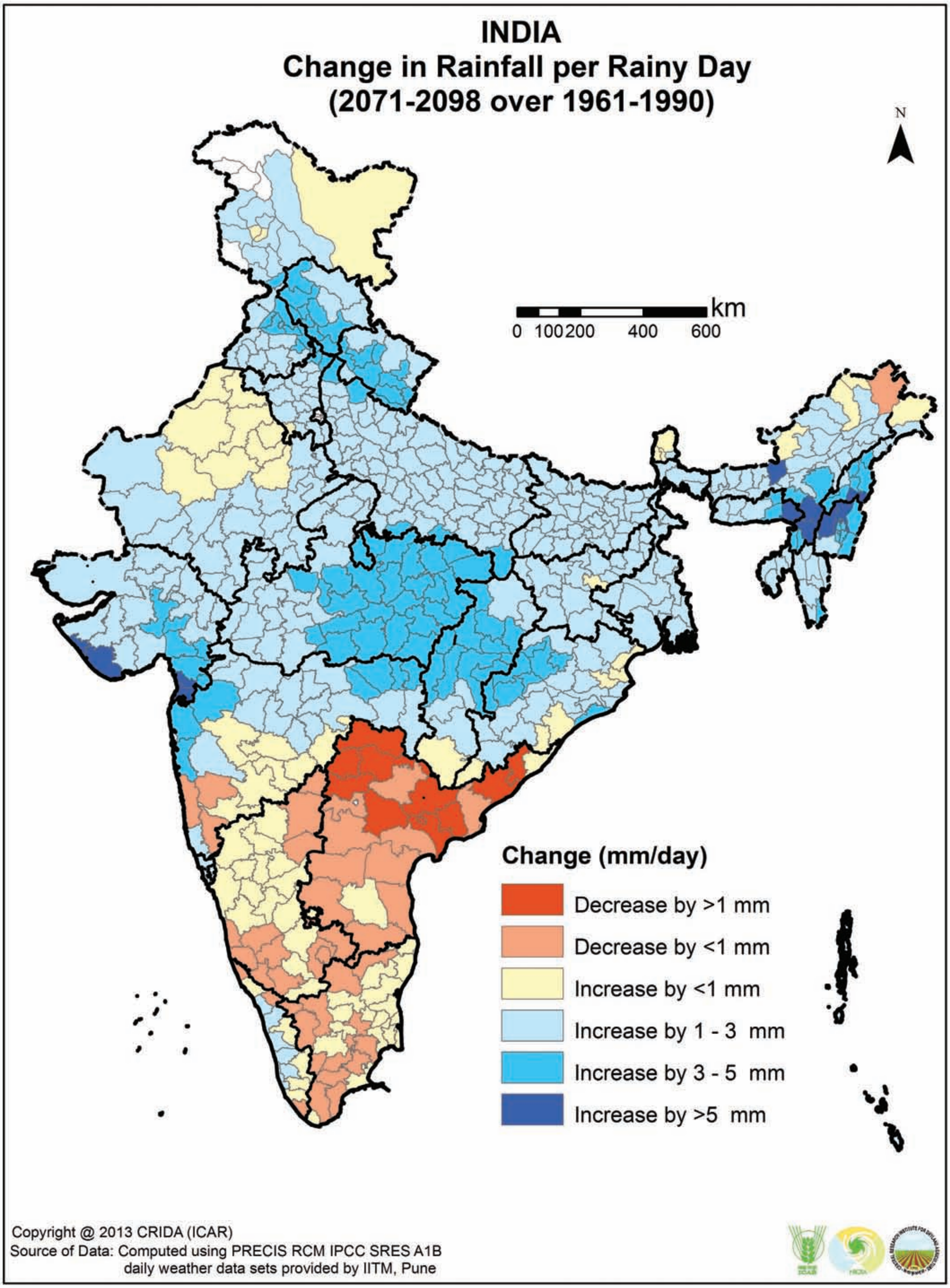

INDIA
Change in Rainfall per Rainy Day
(2071-2098 over 1961-1990)
N
km
0 100 200 400 600
Change (mm/day)
Decrease by >1 mm
Decrease by <1 mm
Increase by <1 mm
Increase by 1 - 3 mm
Increase by 3 - 5 mm
Increase by >5 mm
Copyright @ 2013 CRIDA (ICAR)
Source of Data: Computed using PRECIS RCM IPCC SRES A1B
daily weather data sets provided by IITM, Pune

Fig. O2

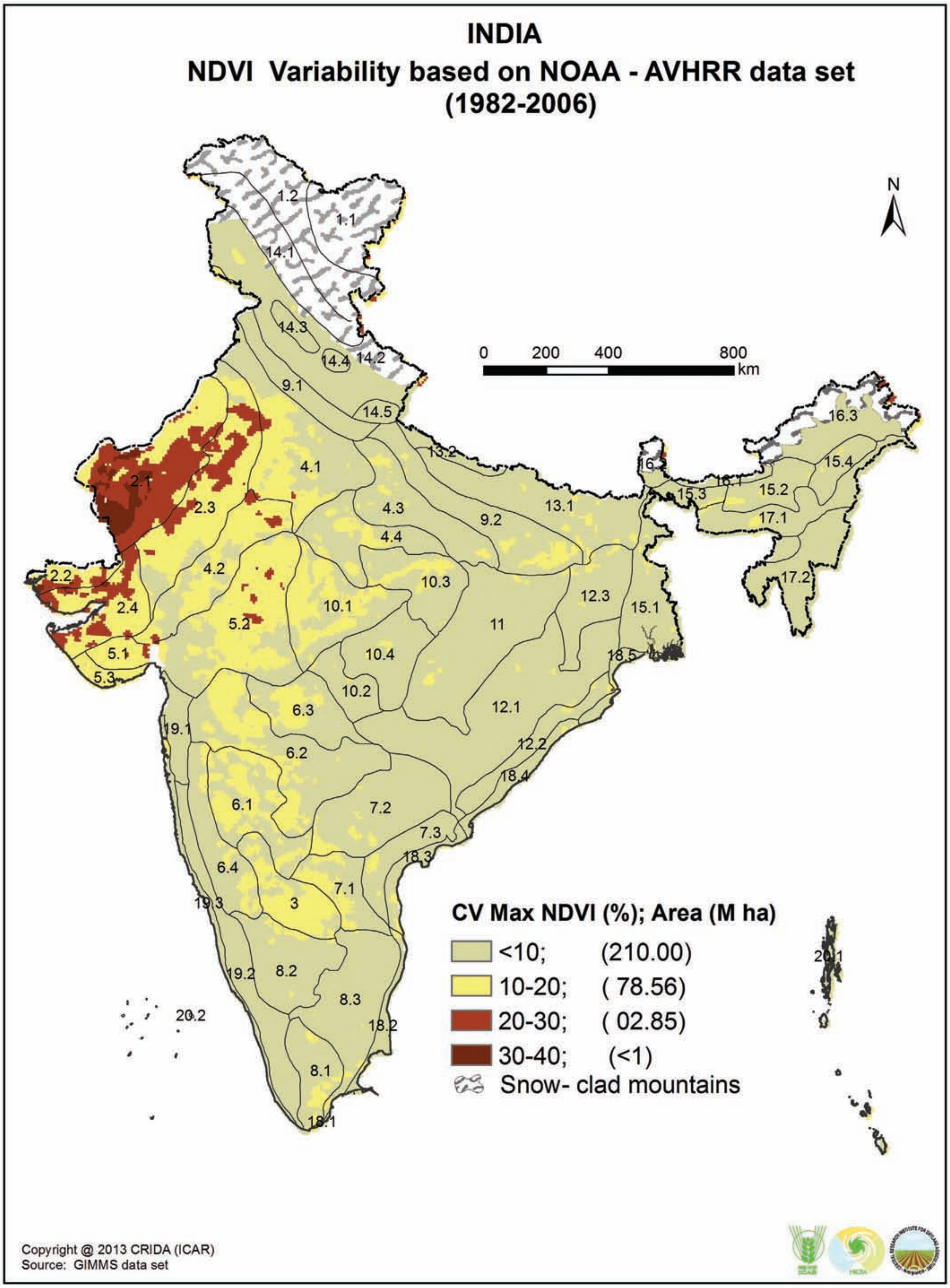

INDIA
NDVI Variability based on NOAA - AVHRR data set
(1982-2006)
N
0 200 400 800
km
1.2
1.1
14.1
14.3
14.4
14.2
9.1
14.5
13.2
4.1
2.1
2.3
4.3
9.2
13.1
4.4
2.2
4.2
10.3
12.3
15.1
2.4
5.2
10.1
11
5.1
10.4
18.5
5.3
10.2
6.3
12.1
19.1
6.2
12.2
18.4
6.1
7.2
7.3
18.3
6.4
7.1
19.3
3
19.2
8.2
8.3
20.2
18.2
8.1
18.1
16.3
15.4
16.2
15.3
16.1
15.2
17.1
17.2
20.1
CV Max NDVI (%); Area (M ha)
<10; (210.00)
10-20; (78.56)
20-30; (02.85)
30-40; (<1)
Snow- clad mountains
Copyright @ 2013 CRIDA (ICAR)
Source: GIMMS data set

Fig.O3

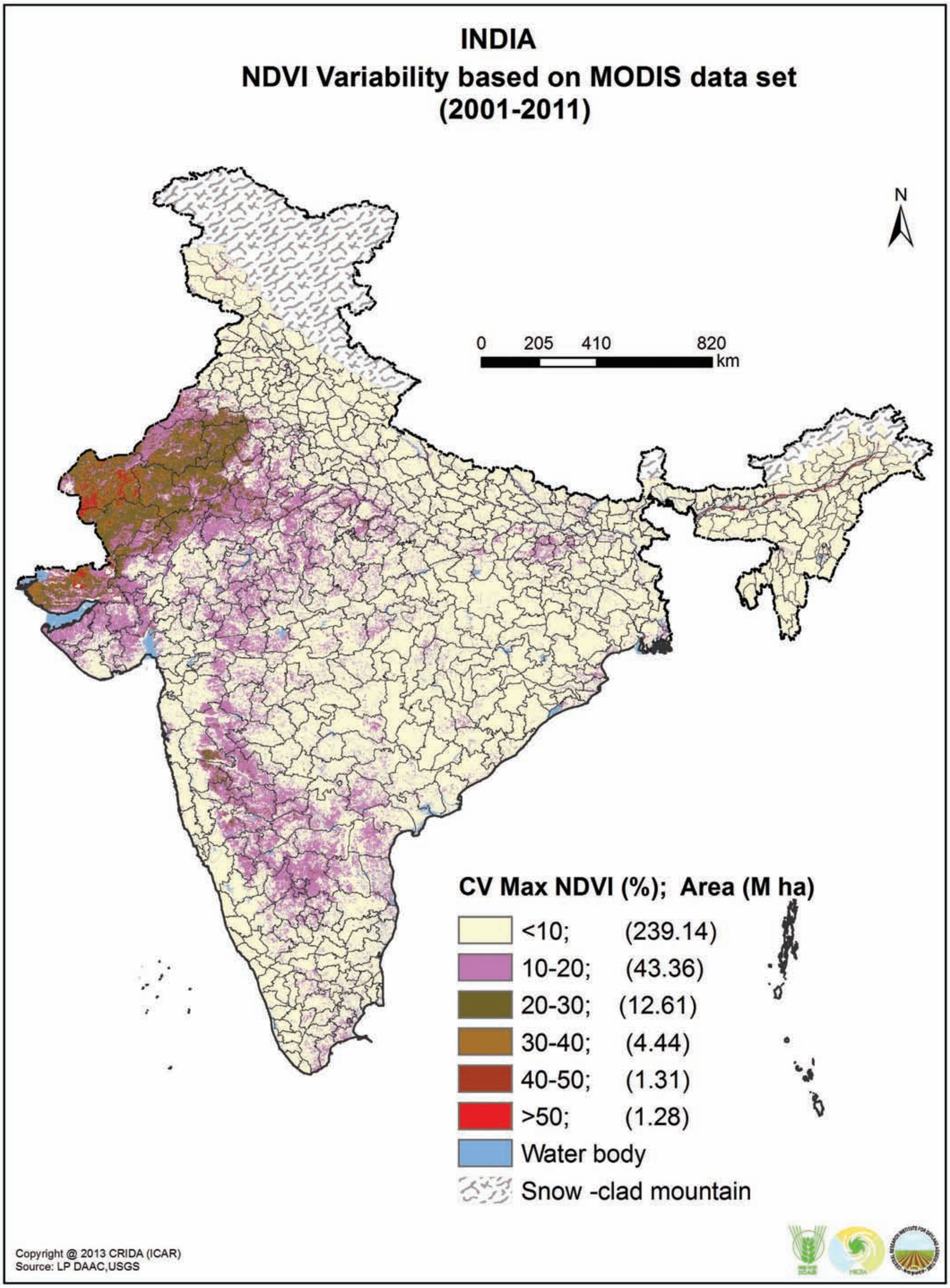

INDIA
NDVI Variability based on MODIS data set
(2001-2011)
N
0 205 410 820
km
CV Max NDVI (%); Area (M ha)
<10; (239.14)
10-20; (43.36)
20-30; (12.61)
30-40; (4.44)
40-50; (1.31)
>50; (1.28)
Water body
Snow -clad mountain
Copyright @ 2013 CRIDA (ICAR)
Source: LP DAAC,USGS

Fig.O4

6 Targeting Investments and Sources of Vulnerability

Table 6 gives the distribution of districts with varying degree of vulnerability. It can be seen that most of the districts with very high and high vulnerability are in the states of Rajasthan, Gujarat, Uttar Pradesh, Madhya Pradesh, Karnataka and Maharashtra. Similarly, of the 115 districts that are highly vulnerable to climate change and variability, 18 are in Uttar Pradesh, 16 in Madhya Pradesh, 15 in Bihar, 9 in Haryana, 7 in Chhattisgarh and 6 each in Jharkhand, Gujarat and Rajasthan. Investments that enhance adaptive capacity and resilience may be targeted in these districts.

Table 7 lists the most important three factors that are responsible for vulnerability in case of more vulnerable districts, those with 'very high' and 'high' vulnerability. These three factors are identified by selecting one variable that is contributing most to the vulnerability from each of the three components. Thus, in case of variables that determine exposure of the district to climate change and variability, increase in the drought incidence, increase in minimum temperature, decrease in rainfall during June and July emerged as important factors suggesting the possible technological and other interventions needed. For example, changes in rainfall pattern are better tackled by a combination of measures such as altering the sowing dates, altering the crop duration to maturity and by enabling supplemental irrigation wherever possible. In districts where likely increase in the incidence of extreme rainfall events is an important source of vulnerability, interventions that protect the human and physical resources, a more coordinated settlement planning are needed. This increased frequency may also be, wherever possible, seen as an opportunity to harvest and store water for later use. Low rainfall, high drought incidence, low available water holding capacity of soils, high flood proneness, larger area under agriculture are the most important sensitivity-related factors contributing to vulnerability suggesting that the current approaches and interventions related to rain water harvesting, watershed development, breeding for drought tolerant crop varieties should continue to receive priority. The information provided is also helpful in prioritizing the investments. For example in case of drought management, it may be useful to invest more in watershed development in the districts where drought incidence is currently high and is also projected to increase in future. The agencies concerned with watershed development like DoLR, NABARD, NRAA, State Level Nodal Agencies (SLNA) may find this information quite useful for taking up watershed projects. Similarly, investments and interventions may be planned in the districts with a larger area prone to incidence of floods and where extreme rainfall events are likely to increase. The possible interventions include modernizing drainage systems, strengthening embankments and promote submergence tolerant crop varieties. A combination of measures such as advancing sowing dates, breeding of varieties with shorter duration, diversification of cropping pattern may be needed where the temperatures are projected to increase with possible adverse effects on crop yields.

In some districts, a very high proportion of land is under crop production pointing to the pressure on land. With very little scope for expansion of cultivation, changing climate and its manifestations can hit livelihoods harder by causing production and productivity losses. In these cases, there is a need to explore the possibility of enhancing non-farm employment opportunities. In case of adaptive capacity, lack of or inadequate irrigation facilities and low groundwater availability are important factors determining vulnerability. The importance of irrigation in agricultural development can hardly be over emphasized.

What is more important is that making irrigation sustainable and more equitable. The changing rainfall pattern, spatial and temporal, is to be appropriately and adequately factored in planning for expansion of irrigation facilities. It is also needed to give more emphasis on supplemental and critical irrigation using rain water harvesting. The planning for irrigation should also consider developing appropriate crop plans/ cropping pattern that optimize returns to farmers as well as maximize returns to water use. The connotation of water use efficiency is to be taken in its broader meaning. Strengthening adaptive capacity is also helpful for farmers in dealing with other development problems as well. In any case, consideration of information related to all the indicators used in the construction of vulnerability index will be helpful in identifying interventions that are more specific to the district. It may be added that considering any intervention that is not relevant to and useful in dealing with the current problems of agriculture are less likely to be accepted by farming community, it is preferable to identify the interventions that help farmers deal with future climatic stress as well as with current climatic variability.

A look at different indicators related to climatic projections also showed some districts where the annual rainfall is likely to increase and the number of rainy days to increase which actually present some opportunities for harvesting more rain water which can be helpful in improving crop production and productivity. There is a need to redesign rain water harvesting structures and strategies to handle higher runoff in a shorter period so that surplus water is harvested while preventing soil loss too. There are also some districts where the incidence of drought is projected to decline. Plans and strategies are therefore to be put in place to optimize crop yields and incomes from such improved situation. Such opportunities can be gainfully harnessed which in fact will be a significant step towards making Indian agriculture more climate resilient and smart.

In summary, well thought-out strategic planning and coordinated implementation are needed to tackle impacts of changing climate on Indian agriculture. Such planning is to be backed by sound scientific understanding for targeting and prioritizing investments for technology development, infrastructure creation and capacity building.

Table 6 : Distribution of districts according to the degree of vulnerability (2021-50) in different states

S No	State	Vulnerability					Total
		Very High	High	Medium	Low	Very low	
1	A & N Islands	0	0	0	0	1	1
2	Andhra Pradesh	2	2	3	1	14	22
3	Arunachal Pradesh	0	0	0	5	9	14
4	Assam	1	1	1	7	13	23
5	Bihar	6	15	7	6	3	37
6	Chhattisgarh	0	7	4	5	0	16
7	Dadra & Nagar Haveli	0	0	0	0	1	1
8	Daman & Diu	1	0	0	0	0	1
9	Goa	0	0	0	0	1	1
10	Gujarat	14	6	1	1	3	25
11	Haryana	0	9	6	2	2	19
12	Himachal Pradesh	0	4	2	3	3	12
13	Jammu & Kashmir	0	1	6	3	4	14
14	Jharkhand	3	6	7	2	0	18
15	Karnataka	14	5	0	2	6	27
16	Kerala	0	0	4	7	3	14
17	Madhya Pradesh	14	16	9	4	2	45
18	Maharashtra	12	5	3	6	7	33
19	Manipur	0	0	3	3	3	9
20	Meghalaya	0	0	1	3	3	7
21	Mizoram	0	0	1	7	0	8
22	Nagaland	0	0	0	3	5	8
23	Orissa	0	1	9	14	6	30
24	Pondicherry	0	0	0	0	1	1
25	Punjab	1	4	4	6	2	17
26	Rajasthan	25	6	1	0	0	32
27	Sikkim	0	0	0	2	2	4
28	Tamilnadu	6	5	9	4	5	29
29	Tripura	0	0	0	0	4	4
30	Uttar Pradesh	12	18	24	14	2	70
31	Uttrakhand	3	4	1	1	4	13
32	West Bengal	1	0	8	3	5	17
	India	115	115	114	114	114	572

Table 7 : Most important factors contributing to vulnerability

State	District	Vulnera-bility	Exposure Factor	Sensitivity Factor	Adaptive Capacity factor
Andhra Pradesh	Chittoor	Very High	Projected decrease in July rainfall	Low Rainfall	Low groundwater availability
Andhra Pradesh	Anantapur	Very High	Projected decrease in July rainfall	Low Rainfall	Low NIA
Andhra Pradesh	Mahabubnagar	High	Projected decrease in July rainfall	Low Rainfall	Low NIA
Andhra Pradesh	Kurnool	High	Projected decrease in July rainfall	Low Rainfall	Low NIA
Assam	Karbi-Anglong	Very High	Projected increase in number of drought years	Low Rainfall	Low NIA
Assam	Barpeta	High	Projected decrease in July rainfall	High NSA	Low NIA
Bihar	Kishanganj	Very High	Projected decrease in July rainfall	High NSA	Low NIA
Bihar	Madhubani	Very High	Projected decrease in July rainfall	High NSA	Low groundwater availability
Bihar	Araria	Very High	Projected increase in number of drought years	High NSA	Low NIA
Bihar	Darbhanga	Very High	Projected decrease in July rainfall	High NSA	Low NIA
Bihar	Supaul	Very High	Projected decrease in July rainfall	High NSA	Low groundwater availability
Bihar	Bhagalpur	Very High	Projected decrease in July rainfall	High NSA	Low NIA
Bihar	Gopalganj	High	Projected decrease in July rainfall	High NSA	Low groundwater availability
Bihar	Saran	High	Projected decrease in July rainfall	High NSA	Low NIA
Bihar	Purnea	High	Projected decrease in July rainfall	High NSA	Low NIA
Bihar	Saharsa	High	Projected decrease in July rainfall	High NSA	Low NIA
Bihar	Siwan	High	Projected decrease in July rainfall	High NSA	Low groundwater availability
Bihar	Katihar	High	Projected decrease in July rainfall	High NSA	Low groundwater availability
Bihar	Patna	High	Projected decrease in July rainfall	High NSA	Low NIA
Bihar	Buxar	High	Projected decrease in July rainfall	High NSA	Low groundwater availability
Bihar	Sitamarhi	High	Projected decrease in July rainfall	Flood proneness	Low NIA
Bihar	Nalanda	High	Projected decrease in July rainfall	High NSA	Low groundwater availability
Bihar	Champaran (East)	High	Projected decrease in July rainfall	High NSA	Low NIA
Bihar	Champaran (West)	High	Projected decrease in July rainfall	High NSA	Low NIA

contd.....

State	District	Vulnera-bility	Exposure Factor	Sensitivity Factor	Adaptive Capacity factor
Bihar	Samastipur	High	Projected decrease in July rainfall	High NSA	Low groundwater availability
Bihar	Muzafarpur	High	Projected decrease in July rainfall	High NSA	Low NIA
Bihar	Vaishali	High	Projected decrease in July rainfall	High NSA	Low NIA
Chhattisgarh	Kawardha	High	Projected increase in number of drought years	High NSA	Low NIA
Chhattisgarh	Sarguja	High	Projected increase in number of drought years	High NSA	Low NIA
Chhattisgarh	Rajnandgaon	High	Projected increase in number of drought years	High NSA	Low NIA
Chhattisgarh	Koriya	High	Projected increase in number of drought years	Highly drought prone	Low NIA
Chhattisgarh	Dantewara	High	Projected increase in number of drought years	Highly drought prone	Low NIA
Chhattisgarh	Jashpur	High	Projected increase in number of drought years	High NSA	Low NIA
Chhattisgarh	Durg	High	Projected increase in number of drought years	High NSA	Low groundwater availability
Daman & Diu	Daman & Diu	Very High	Projected rise in min T	Low Rainfall	Low NIA
Gujarat	Patan	Very High	Projected increase in number of drought years	Low Rainfall	Low groundwater availability
Gujarat	Amreli	Very High	Projected rise in min T	Highly drought prone	Low NIA
Gujarat	Surendranagar	Very High	Projected rise in min T	Low Rainfall	Low NIA
Gujarat	Kutch	Very High	Projected decrease in July rainfall	Low Rainfall	Low NIA
Gujarat	Banaskantha	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Gujarat	Mehsana	Very High	Projected increase in number of drought years	High NSA	Low groundwater availability
Gujarat	Ahmedabad	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Gujarat	Bhavnagar	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Gujarat	Rajkot	Very High	Projected increase in number of drought years	Low Rainfall	Low NIA
Gujarat	Jamnagar	Very High	Projected rise in min T	Highly drought prone	Low NIA
Gujarat	Junagadh	Very High	Projected rise in min T	Highly drought prone	Low groundwater availability
Gujarat	Sabarkanta	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Gujarat	Panchmahal	Very High	Projected rise in min T	Highly drought prone	Low NIA
Gujarat	Porbandar	Very High	Projected rise in min T	Highly drought prone	Low NIA
Gujarat	Gandhinagar	High	Projected rise in min T	High NSA	Low groundwater availability

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State	District	Vulnera-bility	Exposure Factor	Sensitivity Factor	Adaptive Capacity factor
Gujarat	Dahod	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Gujarat	Dang	High	Projected rise in min T	High NSA	Low NIA
Gujarat	Bharuch	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Gujarat	Vadodara	High	Projected rise in min T	High NSA	Low groundwater availability
Gujarat	Narmada	High	Projected increase in number of drought years	High NSA	Low NIA
Haryana	Kaithal	High	Projected increase in number of drought years	Low Rainfall	Low groundwater availability
Haryana	Fatehabad	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Haryana	Jhajjar	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Haryana	Sirsa	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Haryana	Bhiwani	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Haryana	Panipet	High	Projected increase in number of drought years	Low Rainfall	Low groundwater availability
Haryana	Jind	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Haryana	Hissar	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Haryana	Mahendragarh	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Himachal Pradesh	Kullu	High	Projected rise in min T	Low Rainfall	Low NIA
Himachal Pradesh	Shimla	High	Projected increase in number of drought years	Low Rainfall	Low NIA
Himachal Pradesh	Chamba	High	Projected increase in number of drought years	Highly drought prone	Low NIA
Himachal Pradesh	Bilaspur	High	Projected increase in number of drought years	Highly drought prone	Low NIA
Jammu & Kashmir	Rajouri	High	Projected increase in number of drought years	Highly drought prone	Low NIA
Jharkhand	Godda	Very High	Projected decrease in July rainfall	High NSA	Low NIA
Jharkhand	Pakur	Very High	Projected decrease in July rainfall	High NSA	Low NIA
Jharkhand	Sahibganj	Very High	Projected decrease in July rainfall	High NSA	Low NIA
Jharkhand	Bokaro	High	Projected decrease in July rainfall	Low AWC	Low NIA
Jharkhand	Gumla	High	Projected rise in min T	High % area operated by small & marginal farmers	Low NIA

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State	District	Vulnera-bility	Exposure Factor	Sensitivity Factor	Adaptive Capacity factor
Jharkhand	West Singbhum	High	Projected rise in min T	High % area operated by small & marginal farmers	Low NIA
Jharkhand	Lohardaga	High	Projected rise in max T	High NSA	Low NIA
Jharkhand	East Singbhum	High	Projected decrease in July rainfall	Low AWC	Low NIA
Jharkhand	Palamu	High	Projected rise in max T	Low Rainfall	Low NIA
Karnataka	Bijapur	Very High	Projected decrease in July rainfall	Low Rainfall	Low groundwater availability
Karnataka	Gulbarga	Very High	Projected decrease in July rainfall	High NSA	Low NIA
Karnataka	Gadag	Very High	Projected decrease in July rainfall	Low Rainfall	Low NIA
Karnataka	Bagalkot	Very High	Projected decrease in July rainfall	Low Rainfall	Low groundwater availability
Karnataka	Raichur	Very High	Projected decrease in July rainfall	High NSA	Low NIA
Karnataka	Chitradurga	Very High	Projected rise in min T	Low Rainfall	Low NIA
Karnataka	Haveri	Very High	Projected rise in max T	High NSA	Low NIA
Karnataka	Bidar	Very High	Projected rise in min T	High NSA	Low NIA
Karnataka	Davanagere	Very High	Projected rise in max T	Low Rainfall	Low groundwater availability
Karnataka	Bangalore (Rural)	Very High	Projected decrease in July rainfall	Low Rainfall	Low NIA
Karnataka	Tumkur	Very High	Projected decrease in total rainfall	Low Rainfall	Low NIA
Karnataka	Koppal	Very High	Projected decrease in July rainfall	Low Rainfall	Low NIA
Karnataka	Dharwad	Very High	Projected decrease in total rainfall	High NSA	Low NIA
Karnataka	Chamarajanagar	Very High	Projected decrease in July rainfall	Low Rainfall	Low groundwater availability
Karnataka	Kolar	High	Projected decrease in July rainfall	Low Rainfall	Low NIA
Karnataka	Bellary	High	Projected decrease in July rainfall	Low Rainfall	Low groundwater availability
Karnataka	Belgaum	High	Projected increase in number of drought years	Low Rainfall	Low groundwater availability
Karnataka	Mysore	High	Projected increase in number of drought years	Low Rainfall	Low groundwater availability
Karnataka	Mandya	High	Projected decrease in July rainfall	Low Rainfall	Low groundwater availability
Madhya Pradesh	Jhabua	Very High	Projected rise in min T	Low Rainfall	Low NIA
Madhya Pradesh	Rajgarh	Very High	Projected rise in min T	High NSA	Low groundwater availability
Madhya Pradesh	Mandsaur	Very High	Projected rise in min T	High NSA	Low groundwater availability

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State	District	Vulnera-bility	Exposure Factor	Sensitivity Factor	Adaptive Capacity factor
Madhya Pradesh	Shajapur	Very High	Projected rise in min T	High NSA	Low groundwater availability
Madhya Pradesh	Dindori	Very High	Projected rise in min T	Low AWC	Low NIA
Madhya Pradesh	Ratlam	Very High	Projected rise in min T	High NSA	Low NIA
Madhya Pradesh	Dhar	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Madhya Pradesh	Sidhi	Very High	Projected increase in number of drought years	Highly drought prone	Low NIA
Madhya Pradesh	Vidisha	Very High	Projected rise in min T	High NSA	Low groundwater availability
Madhya Pradesh	Shivpuri	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Madhya Pradesh	Ujjain	Very High	Projected rise in min T	High NSA	Low groundwater availability
Madhya Pradesh	Bhind	Very High	Projected rise in min T	High NSA	Low groundwater availability
Madhya Pradesh	Barwani	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Madhya Pradesh	Shahdol	Very High	Projected rise in min T	High NSA	Low NIA
Madhya Pradesh	Rewa	High	Projected rise in min T	High NSA	Low NIA
Madhya Pradesh	Mandla	High	Projected increase in number of drought years	High NSA	Low NIA
Madhya Pradesh	Dewas	High	Projected increase in number of drought years	High NSA	Low groundwater availability
Madhya Pradesh	Neemuch	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Madhya Pradesh	Khargone (West Nimar)	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Madhya Pradesh	Betul	High	Projected increase in number of drought years	Low Rainfall	Low NIA
Madhya Pradesh	Guna	High	Projected rise in min T	High NSA	Low groundwater availability
Madhya Pradesh	Sehore	High	Projected increase in number of drought years	High NSA	Low groundwater availability
Madhya Pradesh	Umaria	High	Projected increase in number of drought years	High NSA	Low NIA
Madhya Pradesh	Damoh	High	Projected increase in number of drought years	High NSA	Low groundwater availability
Madhya Pradesh	Panna	High	Projected rise in min T	High NSA	Low groundwater availability
Madhya Pradesh	Satna	High	Projected rise in min T	High NSA	Low groundwater availability
Madhya Pradesh	Chhatarpur	High	Projected rise in min T	High NSA	Low groundwater availability
Madhya Pradesh	Datia	High	Projected rise in min T	High NSA	Low groundwater availability
Madhya Pradesh	Chhindwara	High	Projected increase in number of drought years	High NSA	Low NIA

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State	District	Vulnera-bility	Exposure Factor	Sensitivity Factor	Adaptive Capacity factor
Madhya Pradesh	Katni	High	Projected rise in min T	High NSA	Low groundwater availability
Maharashtra	Solapur	Very High	Projected increase in number of drought years	Low Rainfall	Low NIA
Maharashtra	Beed	Very High	Projected rise in min T	Low Rainfall	Low NIA
Maharashtra	Ahmednagar	Very High	Projected increase in number of drought years	Low Rainfall	Low NIA
Maharashtra	Osmanabad	Very High	Projected rise in min T	High NSA	Low NIA
Maharashtra	Latur	Very High	Projected rise in min T	High NSA	Low NIA
Maharashtra	Nandurbar	Very High	Projected rise in min T	Low Rainfall	Low NIA
Maharashtra	Sangli	Very High	Projected rise in min T	Low Rainfall	Low NIA
Maharashtra	Buldhana	Very High	Projected increase in number of drought years	High NSA	Low NIA
Maharashtra	Dhule	Very High	Projected rise in min T	Low Rainfall	Low NIA
Maharashtra	Nasik	Very High	Projected rise in min T	Low Rainfall	Low NIA
Maharashtra	Jalna	Very High	Projected rise in min T	High NSA	Low NIA
Maharashtra	Amravati	Very High	Projected increase in number of drought years	High NSA	Low NIA
Maharashtra	Akola	High	Projected increase in number of drought years	High NSA	Low NIA
Maharashtra	Aurangabad	High	Projected rise in min T	Low Rainfall	Low NIA
Maharashtra	Jalgaon	High	Projected rise in min T	High NSA	Low NIA
Maharashtra	Parbhani	High	Projected rise in min T	High NSA	Low NIA
Maharashtra	Washim	High	Projected rise in min T	High NSA	Low NIA
Orissa	Nuapada	High	Projected increase in number of drought years	High NSA	Low NIA
Punjab	Faridkot	Very High	Projected decrease in July rainfall	Low Rainfall	Low density of livestock
Punjab	Moga	High	Projected rise in min T	Low Rainfall	Low density of livestock
Punjab	Kapurthala	High	Projected rise in min T	Low Rainfall	Low density of livestock
Punjab	Mansa	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Punjab	Firozpur	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Barmer	Very High	Projected decrease in July rainfall	Low Rainfall	Low NIA
Rajasthan	Jaisalmer	Very High	Projected decrease in July rainfall	Low Rainfall	Low NIA
Rajasthan	Jodhpur	Very High	Projected decrease in July rainfall	Low Rainfall	Low NIA
Rajasthan	Bikaner	Very High	Projected decrease in July rainfall	Low Rainfall	Low NIA
Rajasthan	Nagaur	Very High	Projected rise in min T	Low Rainfall	Low NIA
Rajasthan	Jalore	Very High	Projected decrease in July rainfall	Low Rainfall	Low groundwater availability

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State	District	Vulnera-bility	Exposure Factor	Sensitivity Factor	Adaptive Capacity factor
Rajasthan	Churu	Very High	Projected rise in min T	Low Rainfall	Low NIA
Rajasthan	Pali	Very High	Projected rise in min T	Low Rainfall	Low NIA
Rajasthan	Tonk	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Ajmer	Very High	Projected rise in min T	Low Rainfall	Low NIA
Rajasthan	Sirohi	Very High	Projected rise in min T	Highly drought prone	Low groundwater availability
Rajasthan	Dungarpur	Very High	Projected rise in min T	Low Rainfall	Low NIA
Rajasthan	Rajsamand	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Banswara	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Hanumangarh	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Sikar	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Bhilwara	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Jhunjhunu	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Sawai Madhopur	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Udaipur	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Jaipur	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Jhalawar	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Chittorgarh	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Dausa	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Bharatpur	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Ganganagar	High	Projected decrease in July rainfall	Low Rainfall	Low groundwater availability
Rajasthan	Bundi	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Dholpur	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Alwar	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Karauli	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Rajasthan	Baran	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Tamil Nadu	Perambalur	Very High	Projected decrease in July rainfall	High NSA	Low NIA

contd.....

State	District	Vulnera-bility	Exposure Factor	Sensitivity Factor	Adaptive Capacity factor
Tamil Nadu	Ariyalur	Very High	Projected decrease in July rainfall	High NSA	Low NIA
Tamil Nadu	Salem	Very High	Projected decrease in July rainfall	Highly drought prone	Low groundwater availability
Tamil Nadu	Namakkal	Very High	Projected decrease in July rainfall	Low Rainfall	Low groundwater availability
Tamil Nadu	Dharmapuri	Very High	Projected decrease in July rainfall	Low Rainfall	Low NIA
Tamil Nadu	Ramanathapuram	Very High	Projected decrease in July rainfall	Low Rainfall	Low groundwater availability
Tamil Nadu	Villupuram	High	Projected decrease in July rainfall	Low Rainfall	Low groundwater availability
Tamil Nadu	Thiruvannamalai	High	Projected decrease in July rainfall	Low Rainfall	Low groundwater availability
Tamil Nadu	Karur	High	Projected decrease in July rainfall	Low Rainfall	Low groundwater availability
Tamil Nadu	Thiruvarur	High	Projected decrease in July rainfall	High NSA	Low groundwater availability
Tamil Nadu	Dindigul	High	Projected decrease in July rainfall	Low Rainfall	Low groundwater availability
Uttar Pradesh	Mahoba	Very High	Projected rise in min T	High NSA	Low groundwater availability
Uttar Pradesh	Chitrakut	Very High	Projected rise in min T	High NSA	Low NIA
Uttar Pradesh	Banda	Very High	Projected rise in min T	High NSA	Low groundwater availability
Uttar Pradesh	Hamirpur	Very High	Projected rise in min T	High NSA	Low groundwater availability
Uttar Pradesh	Ballia	Very High	Projected decrease in July rainfall	High NSA	Low groundwater availability
Uttar Pradesh	Bahraich	Very High	Projected rise in min T	High NSA	Low NIA
Uttar Pradesh	Kaushambi	Very High	Projected rise in min T	High NSA	Low groundwater availability
Uttar Pradesh	Mathura	Very High	Projected rise in min T	Low Rainfall	Low groundwater availability
Uttar Pradesh	Deoria	Very High	Projected decrease in July rainfall	High NSA	Low groundwater availability
Uttar Pradesh	Shravasti	Very High	Projected rise in min T	High NSA	Low groundwater availability
Uttar Pradesh	Jhansi	Very High	Projected rise in min T	High NSA	Low groundwater availability
Uttar Pradesh	Siddharth Nagar	Very High	Projected rise in min T	High NSA	High poverty
Uttar Pradesh	Bagpat	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Uttar Pradesh	Lalitpur	High	Projected rise in min T	High NSA	Low groundwater availability
Uttar Pradesh	Budaun	High	Projected decrease in July rainfall	High NSA	Low groundwater availability
Uttar Pradesh	Gonda	High	Projected rise in min T	High NSA	Low groundwater availability

contd.....

State	District	Vulnera-bility	Exposure Factor	Sensitivity Factor	Adaptive Capacity factor
Uttar Pradesh	Balrampur	High	Projected rise in min T	High NSA	Low NIA
Uttar Pradesh	Ghazipur	High	Projected rise in max T	High NSA	Low groundwater availability
Uttar Pradesh	Sonbhadra	High	Projected rise in min T	Low Rainfall	Low NIA
Uttar Pradesh	Fatehpur	High	Projected rise in min T	High NSA	Low groundwater availability
Uttar Pradesh	Mau	High	Projected decrease in July rainfall	High NSA	Low groundwater availability
Uttar Pradesh	Rae-Bareily	High	Projected rise in min T	High NSA	Low groundwater availability
Uttar Pradesh	Basti	High	Projected decrease in July rainfall	High NSA	Low groundwater availability
Uttar Pradesh	Kushi Nagar	High	Projected decrease in July rainfall	High NSA	High poverty
Uttar Pradesh	Shahjahanpur	High	Projected decrease in July rainfall	High NSA	Low groundwater availability
Uttar Pradesh	Jalaun	High	Projected rise in min T	High NSA	Low groundwater availability
Uttar Pradesh	Agra	High	Projected rise in min T	Low Rainfall	Low groundwater availability
Uttar Pradesh	Jaunpur	High	Projected rise in max T	High NSA	Low groundwater availability
Uttar Pradesh	Faizabad	High	Projected rise in min T	Highly drought prone	Low groundwater availability
Uttar Pradesh	Maharajganj	High	Projected decrease in July rainfall	High NSA	High poverty
Uttarakhand	Bageshwar	Very High	Projected increase in number of drought years	Low Rainfall	Low NIA
Uttarakhand	Tehri Garwal	Very High	Projected rise in min T	Highly drought prone	Low NIA
Uttarakhand	Chamoli	Very High	Projected increase in number of drought years	Highly drought prone	Low NIA
Uttarakhand	Almora	High	Projected rise in min T	Low Rainfall	Low NIA
Uttarakhand	Pithoragarh	High	Projected increase in number of drought years	Low AWC	Low NIA
Uttarakhand	Champawat	High	Projected decrease in July rainfall	Highly drought prone	Low NIA
Uttarakhand	Rudraprayag	High	Projected rise in min T	Highly drought prone	Low NIA
West Bengal	Malda	Very High	Projected decrease in July rainfall	High NSA	Low NIA

End notes

1. The approach to methodology for assessing vulnerability were finalized in a brainstorming workshop conducted for the purpose.

2. We have included SC/ST population in adaptive capacity because of the consideration that the lack of facilities for health, education, alternative employment opportunities are the factors that are responsible for their poor adaptive capacity and these can be addressed through various policies.

3. Consideration by a group of experts of a broader list of indicators obtained through review of literature and causal relationship with vulnerability led to this final set of indicators included in the analysis.

4. Though there are more recent outputs of improved climate projections from CMIP 5 (Chaturvedi et al., 2012), the availability of data at the scale required is highly limited so far. As and when these recent data sets are available, one can use those data sets. Also see the section on 'Scope and Limitations'.

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6. We have included the number of markets from which the informaion is collected and disseminated by AGMARKNET as a proxy for the number of all agricultural markets in the districts as the information on the latter is not available.

7. From 2010 onwards, HDI is being computed as a geometric mean of the component indices. Before 2010, it was calculated as a simple average of the component indices.

8. The approach and the findings were discussed in a consultation meeting of stakeholders represented by relevant government organizations such as Ministry of Agriculture, Ministry of Earth Sciences, Ministry of Water Resources, National Rainfed Area Authority, India Meteorological Department, subject matter experts from organizations such as Indian Agricultural Research Institute, Indian Institute of Science, The Energy and Resources Institute, MS Swaminathan Research Foundation, National Remote Sensing Centre, ICRISAT, NIRD and development and donor agencies such as DFID, GIZ, AFPRO.

9. For details see Kaushalya et al (2013)

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Relative rankings of districts based on exposure, sensitivity, adaptive capacity and vulnerability indices

State	District	Rank based on			
		Exposure	Sensitivity	Adaptive Capacity	Vulnerability
A & N Islands	A & N Islands	546	528	453	537
Andhra Pradesh	Chittoor	1	279	267	18
Andhra Pradesh	Anantapur	492	120	421	56
Andhra Pradesh	Mahabubnagar	108	275	347	116
Andhra Pradesh	Kurnool	507	243	370	187
Andhra Pradesh	Kadapa	538	217	271	312
Andhra Pradesh	Medak	515	297	307	339
Andhra Pradesh	Adilabad	474	374	425	340
Andhra Pradesh	Prakasam	561	266	275	434
Andhra Pradesh	Rangareddy	520	294	160	467
Andhra Pradesh	Guntur	536	208	94	477
Andhra Pradesh	Srikakulam	547	305	185	482
Andhra Pradesh	Visakhapatnam	567	351	362	503
Andhra Pradesh	Warangal	500	339	157	512
Andhra Pradesh	Nellore	541	284	76	541
Andhra Pradesh	East Godavari	564	283	124	547
Andhra Pradesh	Nizamabad	560	329	134	549
Andhra Pradesh	Karimnagar	553	343	119	557
Andhra Pradesh	Vizianagaram	569	342	276	558
Andhra Pradesh	Khammam	562	409	269	559
Andhra Pradesh	Nalgonda	568	296	166	560
Andhra Pradesh	West Godavari	565	237	44	564
Andhra Pradesh	Krishna	570	209	74	565
Arunachal Pradesh	Tawang	43	557	506	384
Arunachal Pradesh	East Kameng	92	564	551	388
Arunachal Pradesh	Upper Subansiri	97	572	555	406
Arunachal Pradesh	West Siang	147	570	540	446
Arunachal Pradesh	Upper Siang	150	566	531	451
Arunachal Pradesh	West Kameng	84	568	505	466
Arunachal Pradesh	Dibang valley	53	571	476	496
Arunachal Pradesh	Tirap	460	569	549	502
Arunachal Pradesh	Lower Subansiri	174	560	487	504
Arunachal Pradesh	Lohit	122	561	465	510
Arunachal Pradesh	Changlang	61	567	391	538
Arunachal Pradesh	Kurung Kumey	175	565	401	551
Arunachal Pradesh	Papum Pare	148	562	343	562
Arunachal Pradesh	East Siang	312	559	238	569
Assam	Karbi-Anglong	77	451	552	109

contd.....

State	District	Rank based on			
		Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Assam	Barpeta	364	330	410	216
Assam	N C Hills	71	538	529	288
Assam	Hailakandi	239	397	363	365
Assam	Dhemaji	333	420	376	399
Assam	Nalbari	393	365	303	416
Assam	Kamrup	291	362	258	419
Assam	Dhubri	442	358	301	423
Assam	Morigaon	51	404	205	432
Assam	Golaghat	293	432	326	448
Assam	Karimganj	431	456	355	483
Assam	Nagaon	180	408	203	487
Assam	Kokrajhar	385	477	353	490
Assam	Goalpara	456	402	255	501
Assam	Bongaigaon	451	423	292	505
Assam	Lakhimpur	328	436	237	515
Assam	Sonitpur	331	455	273	516
Assam	Dibrugarh	357	443	248	520
Assam	Tinsukia	436	493	325	527
Assam	Jorhat	448	463	281	532
Assam	Sibsagar	444	471	227	546
Assam	Cachar	571	498	385	571
Assam	Darrang	572	405	212	572
Bihar	Kishanganj	47	194	427	27
Bihar	Madhubani	63	169	414	29
Bihar	Araria	5	314	399	43
Bihar	Darbhanga	200	78	278	45
Bihar	Supaul	13	233	260	61
Bihar	Bhagalpur	38	218	282	77
Bihar	Gopalganj	245	135	234	127
Bihar	Saran	272	175	288	129
Bihar	Purnea	24	316	310	132
Bihar	Saharsa	115	228	274	134
Bihar	Siwan	211	137	201	150
Bihar	Katihar	21	319	286	153
Bihar	Patna	227	125	175	164
Bihar	Buxar	125	152	176	167
Bihar	Sitamarhi	206	176	202	175
Bihar	Nalanda	250	136	177	178
Bihar	Champaran(East)	309	230	266	186
Bihar	Champaran(West)	374	338	450	194
Bihar	Samastipur	261	174	199	195
Bihar	Muzafarpur	240	232	235	207

contd.....

State	District	Rank based on			
		Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Bihar	Vaishali	119	231	187	213
Bihar	Begusarai	162	188	148	233
Bihar	Lakhisarai	223	277	263	240
Bihar	Jahanabad	396	249	247	255
Bihar	Banka	204	350	372	260
Bihar	Bhojpur	237	200	118	323
Bihar	Jamui	380	410	457	330
Bihar	Madhepura	20	320	114	334
Bihar	Sheikhpura	220	278	159	351
Bihar	Aurangabad	308	333	220	385
Bihar	Khagaria	176	223	60	404
Bihar	Sivhar	273	257	100	411
Bihar	Rohtas	277	302	138	412
Bihar	Bhabhua(kaimur)	265	355	215	435
Bihar	Gaya	340	372	206	479
Bihar	Nawadha	354	368	186	494
Bihar	Monghyr	257	364	112	528
Chhattisgarh	Kawardha	154	369	485	148
Chhattisgarh	Sarguja	130	442	532	151
Chhattisgarh	Rajnandgaon	177	378	491	160
Chhattisgarh	Koriya	83	496	545	174
Chhattisgarh	Dantewara	324	553	572	193
Chhattisgarh	Jashpur	207	480	544	204
Chhattisgarh	Durg	75	331	321	221
Chhattisgarh	Mahasamund	137	379	398	264
Chhattisgarh	Bilaspur	99	412	395	302
Chhattisgarh	Bastar	383	542	567	305
Chhattisgarh	Kanker	373	501	524	331
Chhattisgarh	Korba	228	527	500	372
Chhattisgarh	Raigadh	231	479	449	376
Chhattisgarh	Janjgir	219	360	253	397
Chhattisgarh	Raipur	96	429	279	436
Chhattisgarh	Dhamtari	255	377	222	449
Dadra & Nagar Haveli	Dadra & Nagar Haveli	274	416	289	460
Daman & Diu	Daman & Diu	186	72	230	51
Goa	Goa	391	472	231	539
Gujarat	Patan	29	17	375	6
Gujarat	Amreli	109	12	254	8
Gujarat	Surendranagar	81	61	361	15
Gujarat	Kutch	321	65	386	21
Gujarat	Banaskantha	151	37	245	22
Gujarat	Mehsana	19	39	105	34

contd.....

State	District	Rank based on			
		Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Gujarat	Ahmedabad	67	56	151	47
Gujarat	Bhavnagar	155	60	188	50
Gujarat	Rajkot	158	45	168	54
Gujarat	Jamnagar	544	35	298	55
Gujarat	Junagadh	376	43	153	81
Gujarat	Sabarkanta	70	123	181	102
Gujarat	Panchmahal	112	256	335	107
Gujarat	Porbandar	566	36	285	111
Gujarat	Gandhinagar	31	53	50	123
Gujarat	Dahod	195	271	369	131
Gujarat	Dang	116	517	564	173
Gujarat	Bharuch	466	173	268	184
Gujarat	Vadodara	48	214	145	200
Gujarat	Narmada	36	390	379	230
Gujarat	Kheda	439	94	96	272
Gujarat	Anand	278	66	17	407
Gujarat	Surat	39	341	73	472
Gujarat	Valasad	145	396	193	476
Gujarat	Navsari	33	359	83	489
Haryana	Kaithal	315	13	34	124
Haryana	Fatehabad	518	7	46	142
Haryana	Jhajjar	484	28	79	143
Haryana	Sirsa	517	25	78	161
Haryana	Bhiwani	531	77	216	162
Haryana	Panipet	123	22	21	169
Haryana	Jind	427	21	36	183
Haryana	Hissar	512	48	95	215
Haryana	Mahendragarh	542	62	136	223
Haryana	Kurukshetra	313	15	8	262
Haryana	Faridabad	419	33	26	290
Haryana	Gurgaon	501	52	49	320
Haryana	Rewari	489	75	63	324
Haryana	Karnal	243	32	9	327
Haryana	Sonipet	341	34	20	329
Haryana	Rohtak	407	79	38	360
Haryana	Panchkula	390	269	123	427
Haryana	Ambala	478	69	18	462
Haryana	Yamunanagar	416	126	16	523
Himachal Pradesh	Kullu	275	334	470	139
Himachal Pradesh	Shimla	156	363	456	188
Himachal Pradesh	Chamba	267	407	501	196
Himachal Pradesh	Bilaspur	27	411	397	226

contd.....

State	District	Rank based on			
		Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Himachal Pradesh	Kinnaur	493	281	354	245
Himachal Pradesh	Hamirpur	218	401	415	309
Himachal Pradesh	Mandi	249	447	440	364
Himachal Pradesh	Una	302	352	284	373
Himachal Pradesh	Kangra	453	414	334	457
Himachal Pradesh	Sirmaur	197	509	351	495
Himachal Pradesh	Solan	352	494	314	522
Himachal Pradesh	Lahaul & Spiti	557	400	200	561
Jammu & Kashmir	Rajouri	69	417	459	211
Jammu & Kashmir	Doda	247	427	503	231
Jammu & Kashmir	Udhampur	85	461	490	246
Jammu & Kashmir	Pulwama	153	207	130	285
Jammu & Kashmir	Budgam	105	226	129	287
Jammu & Kashmir	Poonch	128	394	396	289
Jammu & Kashmir	Anantnag	82	292	162	321
Jammu & Kashmir	Srinagar	202	255	103	381
Jammu & Kashmir	Kathua	395	357	304	393
Jammu & Kashmir	Kupwara	336	353	243	415
Jammu & Kashmir	Kargil	117	478	270	498
Jammu & Kashmir	Leh(Ladakh)	299	434	209	525
Jammu & Kashmir	Baramulla	356	448	229	529
Jammu & Kashmir	Jammu	498	366	111	552
Jharkhand	Godda	111	367	547	60
Jharkhand	Pakur	132	474	568	96
Jharkhand	Sahibganj	98	426	539	115
Jharkhand	Bokaro	54	444	516	140
Jharkhand	Gumla	329	518	571	168
Jharkhand	West Singbhum	428	499	570	170
Jharkhand	Lohardaga	280	506	563	205
Jharkhand	East Singbhum	399	437	542	209
Jharkhand	Palamu	217	453	519	220
Jharkhand	Giridish	320	445	517	242
Jharkhand	Dumka	414	497	560	243
Jharkhand	Garhwa	238	462	509	256
Jharkhand	Chtra	271	508	541	281
Jharkhand	Ranchi	310	428	475	298
Jharkhand	Dhanbad	368	430	483	306
Jharkhand	Deoghar	290	433	466	311
Jharkhand	Hazaribag	198	483	460	368
Jharkhand	Koderma	307	476	446	390
Karnataka	Bijapur	4	91	424	7
Karnataka	Gulbarga	7	203	461	11

contd.....

State	District	Rank based on			
		Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Karnataka	Gadag	11	122	389	13
Karnataka	Bagalkot	3	108	244	16
Karnataka	Raichur	28	139	404	17
Karnataka	Chitradurga	88	131	411	24
Karnataka	Haveri	64	181	400	32
Karnataka	Bidar	161	156	435	35
Karnataka	Davanagere	103	140	287	69
Karnataka	Bangalore (Rural)	216	192	327	89
Karnataka	Tumkur	365	183	359	90
Karnataka	Koppal	129	224	319	100
Karnataka	Dharwad	179	248	346	108
Karnataka	Chamarajanagar	78	259	315	112
Karnataka	Kolar	516	180	367	146
Karnataka	Bellary	164	240	296	149
Karnataka	Belgaum	66	219	179	179
Karnataka	Mysore	74	272	224	199
Karnataka	Mandya	62	198	125	227
Karnataka	Bangalore (Urban)	185	273	137	356
Karnataka	Hassan	221	391	241	444
Karnataka	Chikmagalur	276	502	313	519
Karnataka	Uttara Kannada	337	519	352	524
Karnataka	Kodagu / Coorgu	241	533	251	556
Karnataka	Udupi	510	486	194	566
Karnataka	Dakshina Kannada	504	464	116	568
Karnataka	Shimoga	289	526	128	570
Kerala	Thiruvanathapuram	495	189	226	254
Kerala	Malappuram	260	307	242	310
Kerala	Kollam	437	270	240	314
Kerala	Kozhikode	424	298	261	333
Kerala	Wayanad	104	392	322	348
Kerala	Kasaragod	418	268	196	350
Kerala	Kannur	330	332	264	363
Kerala	Kottayam	246	317	170	396
Kerala	Alappuzha	296	205	70	403
Kerala	Idukki	425	385	306	438
Kerala	Palakkad	100	349	142	439
Kerala	Thrissur	190	322	87	486
Kerala	Pathanamthitta	491	381	250	497
Kerala	Ernakulam	359	376	171	511
Madhya Pradesh	Jhabua	529	254	533	58
Madhya Pradesh	Rajgarh	65	212	328	64
Madhya Pradesh	Mandsaur	270	160	364	71

contd.....

State	District	Rank based on			
		Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Madhya Pradesh	Shajapur	143	229	371	74
Madhya Pradesh	Dindori	149	469	569	80
Madhya Pradesh	Ratlam	389	146	341	82
Madhya Pradesh	Dhar	304	184	344	85
Madhya Pradesh	Sidhi	72	383	507	86
Madhya Pradesh	Vidisha	49	324	428	88
Madhya Pradesh	Shivpuri	254	287	443	99
Madhya Pradesh	Ujjain	348	190	342	101
Madhya Pradesh	Bhind	300	166	311	103
Madhya Pradesh	Barwani	339	261	413	105
Madhya Pradesh	Shahdol	76	419	522	114
Madhya Pradesh	Rewa	210	328	447	135
Madhya Pradesh	Mandla	89	470	553	136
Madhya Pradesh	Dewas	110	295	356	137
Madhya Pradesh	Neemuch	214	250	320	147
Madhya Pradesh	Khargone(West Nimar)	253	263	337	154
Madhya Pradesh	Betul	114	373	472	157
Madhya Pradesh	Guna	172	306	374	159
Madhya Pradesh	Sehore	73	325	358	166
Madhya Pradesh	Umaria	86	460	526	171
Madhya Pradesh	Damoh	55	399	452	177
Madhya Pradesh	Panna	173	389	477	180
Madhya Pradesh	Satna	159	321	357	189
Madhya Pradesh	Chhatarpur	196	345	417	202
Madhya Pradesh	Datia	209	197	190	210
Madhya Pradesh	Chhindwara	140	371	439	218
Madhya Pradesh	Katni	121	380	437	222
Madhya Pradesh	Seoni	126	440	480	248
Madhya Pradesh	Morena	322	236	208	258
Madhya Pradesh	Sheopur Kalan	394	326	368	265
Madhya Pradesh	Raisen	152	388	409	266
Madhya Pradesh	Bhopal	44	313	197	268
Madhya Pradesh	Khandwa(East Nimar)	194	337	330	277
Madhya Pradesh	Tikamgarh	266	327	317	278
Madhya Pradesh	Indore	409	148	139	292
Madhya Pradesh	Sagar	170	386	394	295
Madhya Pradesh	Narsinghpur	107	361	283	349
Madhya Pradesh	Jabalpur	91	375	277	362
Madhya Pradesh	Gwalior	263	315	195	374
Madhya Pradesh	Harda	32	441	252	418
Madhya Pradesh	Balaghat	193	513	393	471
Madhya Pradesh	Hoshangabad	41	458	132	531

contd.....

State	District	Rank based on			
		Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Maharashtra	Solapur	2	121	299	12
Maharashtra	Beed	192	132	429	30
Maharashtra	Ahmednagar	35	104	297	31
Maharashtra	Osmanabad	40	210	378	42
Maharashtra	Latur	201	196	423	48
Maharashtra	Nandurbar	87	318	473	63
Maharashtra	Sangli	52	158	257	72
Maharashtra	Buldhana	286	234	408	76
Maharashtra	Dhule	379	201	387	83
Maharashtra	Nasik	141	225	331	95
Maharashtra	Jalna	472	221	407	106
Maharashtra	Amravati	268	282	418	113
Maharashtra	Akola	349	252	381	128
Maharashtra	Aurangabad	458	245	390	141
Maharashtra	Jalgaon	281	222	312	145
Maharashtra	Parbhani	519	262	431	165
Maharashtra	Washim	488	299	426	182
Maharashtra	Nanded	496	312	406	239
Maharashtra	Pune	90	310	210	283
Maharashtra	Hingoli	526	308	380	293
Maharashtra	Yavatmal	551	354	451	354
Maharashtra	Wardha	459	346	345	355
Maharashtra	Satara	146	348	246	361
Maharashtra	Nagpur	372	347	308	367
Maharashtra	Raigad	318	465	382	443
Maharashtra	Thane	222	473	360	453
Maharashtra	Gondia	199	446	305	464
Maharashtra	Ratnagiri	181	516	392	468
Maharashtra	Gadchiroli	295	546	469	478
Maharashtra	Bhandara	378	413	280	480
Maharashtra	Sindhudurg	256	500	349	493
Maharashtra	Kolhapur	235	424	214	508
Maharashtra	Chandrapur	486	492	373	518
Manipur	Churachandpur	314	491	546	251
Manipur	Chandel	188	534	557	273
Manipur	Ukhrul	163	531	535	303
Manipur	Senapati	327	521	512	370
Manipur	Tamenglong	417	558	566	391
Manipur	Imphal East	269	449	340	447
Manipur	Imphal West	476	452	293	526
Manipur	Thoubal	401	406	152	540
Manipur	Bishnupur	386	487	223	548

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State	District	Rank based on			
		Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Meghalaya	South Garo Hills	400	511	554	294
Meghalaya	West Garo Hills	412	512	521	366
Meghalaya	East Garo Hills	490	495	511	371
Meghalaya	West Khasi Hills	215	541	492	431
Meghalaya	Jaintia Hills	182	547	444	484
Meghalaya	East Khasi Hills	229	548	366	536
Meghalaya	Ri-Bhoi	422	549	388	543
Mizoram	Champhai	157	505	498	316
Mizoram	Saiha	465	514	536	352
Mizoram	Lawngtlai	506	529	561	359
Mizoram	Mamit	226	550	528	378
Mizoram	Serchhip	332	515	486	400
Mizoram	Lunglei	446	530	518	409
Mizoram	Kolasib	30	551	448	417
Mizoram	Aizawl	142	525	430	442
Nagaland	Mon	441	539	530	402
Nagaland	Tuensang	477	543	520	437
Nagaland	Wokha	167	554	495	452
Nagaland	Phek	294	544	455	488
Nagaland	Zunheboto	351	552	468	500
Nagaland	Kohima	136	556	433	514
Nagaland	Mokokchung	406	555	458	534
Nagaland	Dimapur	95	485	182	535
Orissa	Nuapada	347	438	537	197
Orissa	Kalahandi	338	459	525	253
Orissa	Bolangir	461	425	514	261
Orissa	Phulbani (Kandhamal)	342	537	565	279
Orissa	Keonjhar	470	398	484	284
Orissa	Gajapati	535	431	543	297
Orissa	Nabarangpur	503	510	559	315
Orissa	Puri	101	300	167	332
Orissa	Mayurbhanj	388	457	488	341
Orissa	Kendrapara	508	311	316	344
Orissa	Sundargarh	361	503	502	358
Orissa	Malkangiri	549	524	562	382
Orissa	Deogarh	433	523	510	395
Orissa	Bhadrak	420	291	169	401
Orissa	Jagatsingpur	559	177	172	408
Orissa	Baragarh	468	418	402	410
Orissa	Koraput	537	535	558	413
Orissa	Sonepur	303	439	377	422
Orissa	Dhenkanal	445	454	436	424

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State	District	Rank based on			
		Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Orissa	Jharsuguda	469	468	454	429
Orissa	Rayagada	528	545	556	430
Orissa	Nayagarh	454	450	419	433
Orissa	Sambalpur	421	520	471	455
Orissa	Balasore (Baleshwar)	521	303	183	456
Orissa	Boudh	523	507	479	470
Orissa	Jajpur	462	336	184	473
Orissa	Angul	530	504	481	475
Orissa	Ganjam	545	382	295	513
Orissa	Khurda	522	435	221	550
Orissa	Cuttack	483	393	131	553
Pondicherry	Pondicherry	487	288	13	567
Punjab	Faridkot	513	2	23	91
Punjab	Moga	524	1	15	121
Punjab	Kapurthala	455	3	19	156
Punjab	Mansa	555	9	39	225
Punjab	Firozpur	539	6	28	229
Punjab	Sangrur	527	5	11	274
Punjab	Muktsar	550	31	55	280
Punjab	Bathinda	540	18	32	291
Punjab	Jalandhar	525	4	2	336
Punjab	Fathegarh Sahib	499	10	3	345
Punjab	Shahid Bhagat Singh Nagar	440	44	14	414
Punjab	Patiala	514	26	6	421
Punjab	Hoshiarpur	443	93	29	425
Punjab	Amritsar	415	51	7	445
Punjab	Ludhiana	532	11	1	458
Punjab	Rupnagar	377	161	30	485
Punjab	Gurdaspur	502	80	10	506
Rajasthan	Barmer	169	16	550	1
Rajasthan	Jaisalmer	68	24	527	2
Rajasthan	Jodhpur	134	8	474	3
Rajasthan	Bikaner	166	23	508	4
Rajasthan	Nagaur	311	20	489	5
Rajasthan	Jalore	463	29	442	9
Rajasthan	Churu	509	47	504	10
Rajasthan	Pali	297	74	464	14
Rajasthan	Tonk	183	96	434	19
Rajasthan	Ajmer	236	85	420	20
Rajasthan	Sirohi	127	83	365	23
Rajasthan	Dungarpur	168	171	467	25
Rajasthan	Rajsamand	205	92	383	26

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State	District	Rank based on			
		Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Rajasthan	Banswara	252	211	482	33
Rajasthan	Hanumangarh	554	49	416	40
Rajasthan	Sikar	552	30	329	41
Rajasthan	Bhilwara	288	143	422	44
Rajasthan	Jhunjhunu	556	27	294	52
Rajasthan	Sawai Madhopur	301	112	338	57
Rajasthan	Udaipur	346	186	432	59
Rajasthan	Jaipur	497	55	265	62
Rajasthan	Jhalawar	144	179	336	67
Rajasthan	Chittorgarh	160	191	350	68
Rajasthan	Dausa	475	73	256	75
Rajasthan	Bharatpur	410	64	192	92
Rajasthan	Ganganagar	534	67	249	118
Rajasthan	Bundi	326	119	232	119
Rajasthan	Dholpur	413	98	219	126
Rajasthan	Alwar	494	58	149	138
Rajasthan	Karauli	480	167	324	144
Rajasthan	Baran	292	193	218	190
Rajasthan	Kota	285	199	108	342
Sikkim	South	113	522	412	440
Sikkim	North	18	563	462	441
Sikkim	West	283	540	403	517
Sikkim	East	232	532	290	545
Tamil Nadu	Perambalur	16	154	323	28
Tamil Nadu	Ariyalur	8	172	272	39
Tamil Nadu	Salem	15	114	135	70
Tamil Nadu	Namakkal	12	213	198	78
Tamil Nadu	Dharmapuri	34	264	318	84
Tamil Nadu	Ramanathapuram	479	130	333	104
Tamil Nadu	Villupuram	6	247	115	158
Tamil Nadu	Thiruvannamalai	10	280	146	176
Tamil Nadu	Karur	17	285	173	192
Tamil Nadu	Thiruvarur	56	103	67	206
Tamil Nadu	Dindigul	138	241	204	217
Tamil Nadu	Thanjavur	22	113	42	234
Tamil Nadu	Coimbatore	80	144	101	235
Tamil Nadu	Vellore	23	289	161	238
Tamil Nadu	Cuddalore	9	238	59	257
Tamil Nadu	Erode	25	265	110	263
Tamil Nadu	Thoothukudi	558	102	211	269
Tamil Nadu	Nagapattinam	165	182	99	307
Tamil Nadu	Madurai	14	258	57	322

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State	District	Rank based on			
		Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Tamil Nadu	Thiruchirappalli	26	251	68	325
Tamil Nadu	Kanyakumari	548	141	133	387
Tamil Nadu	Pudukkottai	42	290	71	394
Tamil Nadu	Theni	533	220	163	405
Tamil Nadu	Sivagangai	225	276	97	426
Tamil Nadu	The Nilgiris	102	490	332	461
Tamil Nadu	Virudhunagar	563	244	191	481
Tamil Nadu	Thirunelveli	543	165	62	492
Tamil Nadu	Thiruvallur	133	286	37	507
Tamil Nadu	Kancheepuram	50	309	24	521
Tripura	Dhalai	408	481	405	459
Tripura	South Tripura	230	421	225	499
Tripura	North Tripura	467	475	300	533
Tripura	West Tripura	375	415	127	554
Uttar Pradesh	Mahoba	350	187	478	36
Uttar Pradesh	Chitrakut	224	301	534	37
Uttar Pradesh	Banda	233	142	438	38
Uttar Pradesh	Hamirpur	335	155	441	46
Uttar Pradesh	Ballia	79	50	154	49
Uttar Pradesh	Bahraich	435	111	348	65
Uttar Pradesh	Kaushambi	244	115	291	73
Uttar Pradesh	Mathura	457	19	90	87
Uttar Pradesh	Deoria	171	46	107	93
Uttar Pradesh	Shravasti	382	267	445	97
Uttar Pradesh	Jhansi	203	170	302	98
Uttar Pradesh	Siddharth Nagar	402	101	236	110
Uttar Pradesh	Bagpat	316	14	41	117
Uttar Pradesh	Lalitpur	131	293	384	120
Uttar Pradesh	Budaun	345	76	165	122
Uttar Pradesh	Gonda	367	86	189	125
Uttar Pradesh	Balrampur	323	235	339	133
Uttar Pradesh	Ghazipur	124	95	120	152
Uttar Pradesh	Sonbhadra	139	387	493	155
Uttar Pradesh	Fatehpur	248	163	213	172
Uttar Pradesh	Mau	106	89	85	181
Uttar Pradesh	Rae-Bareily	259	124	156	185
Uttar Pradesh	Basti	343	107	147	191
Uttar Pradesh	Kushi Nagar	319	118	150	201
Uttar Pradesh	Shahjahanpur	370	87	121	203
Uttar Pradesh	Jalaun	360	206	233	212
Uttar Pradesh	Agra	482	38	65	214
Uttar Pradesh	Jaunpur	366	71	88	219

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State	District	Rank based on			
		Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Uttar Pradesh	Faizabad	387	54	61	224
Uttar Pradesh	Maharajganj	242	153	164	228
Uttar Pradesh	Mirzapur	187	274	259	232
Uttar Pradesh	Hardoi	362	128	155	236
Uttar Pradesh	Kanpur (Dehat)	404	147	178	244
Uttar Pradesh	Aligarh	213	63	43	247
Uttar Pradesh	Pratapgarh	191	178	144	249
Uttar Pradesh	Sant Ravidas Nagar	282	70	58	250
Uttar Pradesh	Sant Kabir Nagar	334	164	158	259
Uttar Pradesh	Hathras	473	42	51	267
Uttar Pradesh	Farrukhabad	369	84	75	275
Uttar Pradesh	Azamgarh	178	127	89	276
Uttar Pradesh	Allahabad	212	168	122	282
Uttar Pradesh	Muzaffarnagar	426	41	33	296
Uttar Pradesh	Unnao	306	150	117	299
Uttar Pradesh	Jyotiba Phulenagar	325	110	81	300
Uttar Pradesh	Gorakhpur	234	138	91	301
Uttar Pradesh	Varanasi	298	40	22	304
Uttar Pradesh	Etah	481	97	93	313
Uttar Pradesh	Saharanpur	447	57	40	317
Uttar Pradesh	Auraiya	452	134	126	318
Uttar Pradesh	Kannauj	429	99	80	319
Uttar Pradesh	Bareilly	432	105	86	326
Uttar Pradesh	Ambedkar Nagar	305	133	84	335
Uttar Pradesh	Sitapur	353	151	102	338
Uttar Pradesh	Sultanpur	392	145	98	343
Uttar Pradesh	Etawah	381	157	104	347
Uttar Pradesh	Kheri	464	204	140	353
Uttar Pradesh	Firozabad	411	90	47	369
Uttar Pradesh	Bijnor	262	185	72	375
Uttar Pradesh	Pilibhit	438	162	92	377
Uttar Pradesh	Barabanki	189	227	82	379
Uttar Pradesh	Mainpuri	485	117	64	380
Uttar Pradesh	Gautam Buddh Nagar	363	88	31	383
Uttar Pradesh	Bulandshahar	405	109	48	386
Uttar Pradesh	Chandauli	355	239	109	389
Uttar Pradesh	Moradabad	397	149	66	392
Uttar Pradesh	Lucknow	258	159	54	398
Uttar Pradesh	Rampur	450	195	77	428
Uttar Pradesh	Kanpur City	284	216	53	450
Uttar Pradesh	Ghaziabad	344	68	5	469
Uttar Pradesh	Meerut	287	116	4	530

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State	District	Rank based on			
		Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Uttarakhand	Bageshwar	45	335	496	53
Uttarakhand	Tehri Garwal	279	344	538	66
Uttarakhand	Chamoli	46	395	515	79
Uttarakhand	Almora	118	403	513	130
Uttarakhand	Pithoragarh	59	467	523	163
Uttarakhand	Champawat	264	466	548	198
Uttarakhand	Rudraprayag	60	422	463	208
Uttarakhand	Uttarkashi	93	488	494	270
Uttarakhand	Pauri Garhwal	358	489	499	346
Uttarakhand	Haridwar	384	246	52	491
Uttarakhand	Dehardun	430	482	239	544
Uttarakhand	Nainital	251	536	262	555
Uttarakhand	Udham Singh Nagar	398	340	35	563
West Bengal	Malda	37	129	174	94
West Bengal	Purulia	471	384	497	237
West Bengal	Dinajpur (Uttar)	57	202	113	241
West Bengal	Murshidabad	120	106	69	252
West Bengal	Nadia	135	59	25	271
West Bengal	Dinajpur (Dakshin)	58	323	207	286
West Bengal	24-Paraganas (South)	403	260	217	308
West Bengal	Howrah	423	82	56	328
West Bengal	Cooch Behar	184	215	106	337
West Bengal	24-Paraganas (North)	317	100	45	357
West Bengal	Midnapore	511	242	141	420
West Bengal	Birbhum	449	304	143	454
West Bengal	Jalpaiguri	208	356	180	463
West Bengal	Darjeeling	94	484	309	465
West Bengal	Hooghly	371	81	12	474
West Bengal	Bankura	505	370	228	509
West Bengal	Burdwan	434	253	27	542

Note: Ranks are given based on the index value. A district with rank 1 in vulnerability, has highest vulnerability and the one with 572 the least vulnerability. Similar interpretaion applies to the three components of vulnerability.

NICRA

Participants at the workshop on 'Vulnerability Assessment-Sharing Experiences' on 3rd March 2011 at CRIDA, Hyderabad

Participants at the 'Stakeholders' Consultation Meeting on 1st October 2012 at National Agricultural Science Complex, New Delhi.

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National Initiative on Climate Resilient Agriculture (NICRA) is a network project of the Indian Council of Agricultural Research (ICAR) launched in February, 2011 with an objective of enhancing resilience of Indian agriculture to climate change and variability. The project envisages developing technologies and strategies for enhancing adaptation and mitigation through genetic improvement, better input and natural resource management and policy options in the crop, livestock and fish production systems. The project consists of four components viz. Strategic Research, Technology Demonstration, Capacity Building and Sponsored/Competitive Grant sub-projects.

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