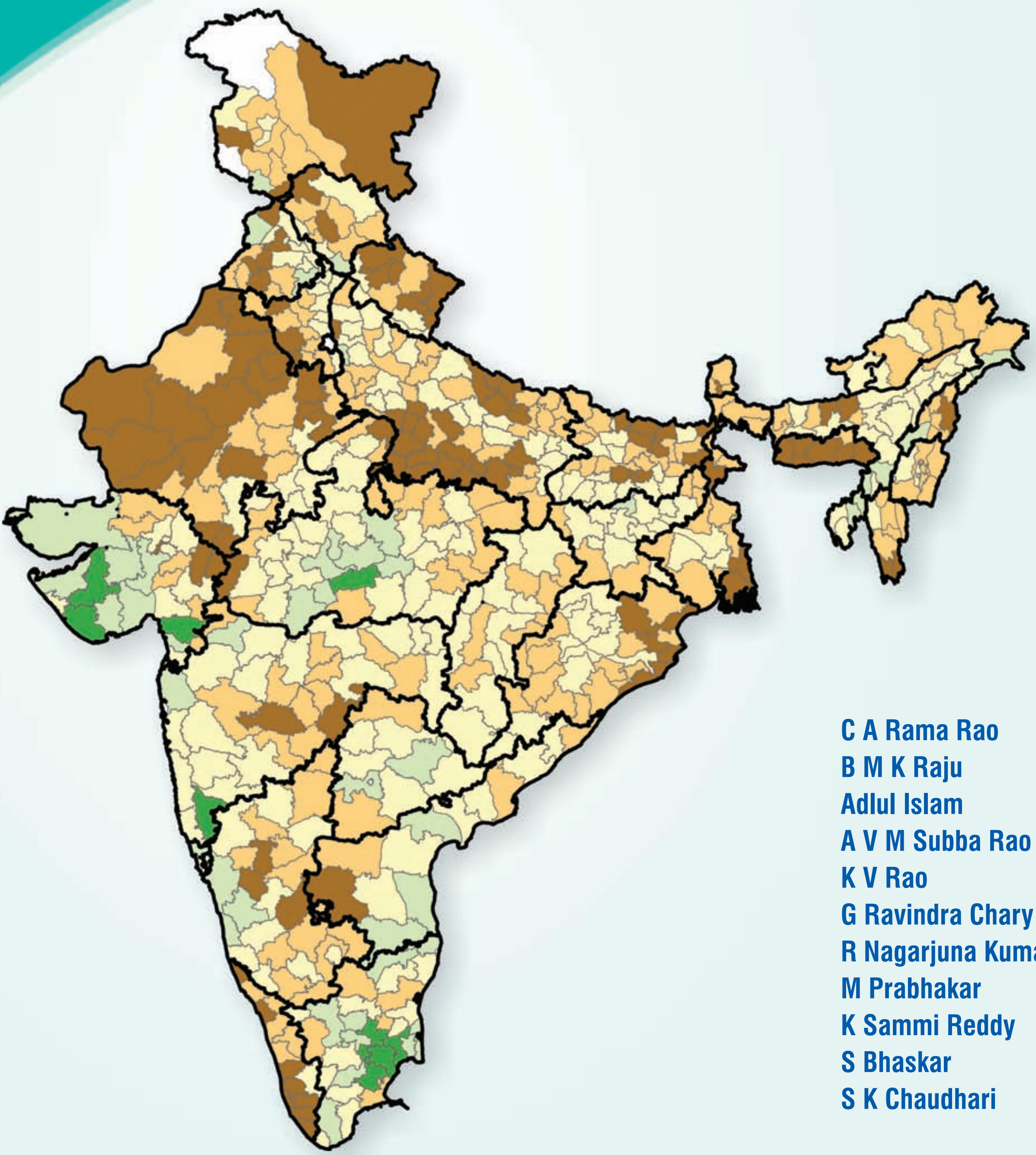
Risk and Vulnerability Assessment of Indian Agriculture to Climate Change



C A Rama Rao
B M K Raju
Adlul Islam
A V M Subba Rao
K V Rao
G Ravindra Chary
R Nagarjuna Kumar
M Prabhakar
K Sammi Reddy
S Bhaskar
S K Chaudhari

National Innovations in Climate Resilient Agriculture
ICAR - Central Research Institute for Dryland Agriculture
Hyderabad, India

NICRA

Participants at the First Stakesholders' Consultation Meeting on 20 July 2018
at National Agricultural Science Complex, New Delhi

Participants at the Second Stakesholders' Consultation Meeting on 19 August 2019
at National Agricultural Science Complex, New Delhi

www.nicra-icar.in

National Innovations in Climate Resilient Agriculture (NICRA) is a network project of the Indian Council of Agricultural Research (ICAR) launched in February, 2011. The project aims to enhance resilience of Indian agriculture to climate change and climate variability through strategic research and by promoting adaptation technologies. The project is multi-sectoral and multi-institutional initiative addressing the climate change research and technology needs in various subsectors such as livestock, fisheries, etc. within agriculture.

National Innovations in Climate Resilient Agriculture

ICAR - Central Research Institute for Dryland Agriculture

Santoshnagar, Hyderabad - 500059

Ph : 040-24530177 Fax : 040-24531802 Website : http://www.icar-crida.res.in

E-mail : director.crida@icar.gov.in

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CRIDA

CRIDA is a constituent organization of the Indian Council of Agricultural Research (ICAR), an autonomous body of the Ministry of Agriculture & Farmers' Welfare, 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 and coordinating basic and applied research for a more sustainable rainfed agriculture. It hosts two network projects, viz., All India Coordinated Research Project for Dryland Agriculture (AICRPDA) and All India Coordinated Research Project on Agrometeorology (AICRPAM). It is also coordinating the National Innovations in Climate Resilient Agriculture (NICRA) since 2011. The institute works with many national and international organizations in pursuit of its mandate.

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K Sammi Reddy, S Bhaskar and S K Chaudhari

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Santoshnagar, Hyderabad - 500059

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Website : http://www.icar-crida.res.in
E-mail : director.crida@icar.gov.in

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CONTENTS

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नरेन्द्र सिंह तोमर

NARENDRA SINGH TOMAR

कृषि एवं किसान कल्याण,
ग्रामीण विकास तथा पंचायती राज मंत्री
भारत सरकार
कृषि भवन, नई दिल्ली

**MINISTER OF AGRICULTURE & FARMER WELFARE,
RURAL DEVELOPMENT AND PANCHAYATI RAJ
GOVERNMENT OF INDIA
KRISHI BHAWAN, NEW DELHI**

संदेश

कृषि एवं किसान कल्याण मंत्रालय के अंतर्गत, भारतीय कृषि अनुसंधान परिषद द्वारा राष्ट्रीय जलवायु समुत्थानशील कृषि में नव प्रवर्तन (NICRA) नामक परियोजना वर्ष 2011 में आरंभ की गई। यह "टिकाऊ कृषि पर राष्ट्रीय मिशन" जोकि भारत सरकार की जलवायु परिवर्तन पर राष्ट्रीय कार्य योजना के आठ मिशनों में से एक है, का प्रमुख अंग है। इस परियोजना के अंतर्गत जलवायु परिवर्तन के प्रति भारतीय कृषि की संशोधित संवेदनशीलता मूल्यांकन रिपोर्ट का प्रकाशन करना एक सराहनीय प्रयास है। भारतीय अर्थव्यवस्था में कृषि एक प्रमुख अंग है, इसलिए एक ओर भारत सरकार जलवायु परिवर्तन की समस्याओं को सुलझाने के लिए महत्वपूर्ण कदम उठा रही है, तो दूसरी ओर स्थानीय अनुकूलन संबंधी कार्रवाईयों एवं स्थानीय लाभों पर भी जोर दे रही है।

मुझे यह जानकर खुशी है कि जलवायु परिवर्तन के परिवर्तन के प्रति जोखिम एवं संवेदनशीलता का जिला स्तर पर विश्लेषण करने का प्रयास इस परियोजना के अंतर्गत किया गया है जैसे कि यह विदित है कि विकास संबंधी योजना मुख्यतः जिला स्तर पर तैयार की जाती है, अतः इस प्रकाशन में प्रस्तुत किए गए विश्लेषण और उनके आधार पर प्राप्त परिणाम आसानी से प्रयोग में लाए जा सकते हैं मुझे आशा है कि इस प्रकाशन में दी गई जानकारी भारतीय कृषि को जलवायु परिवर्तन के प्रति अधिक समुत्थानशील बनाने की दिशा में नीति निर्माण तथा कार्यक्रमों एवं अन्य उपायों के लिए अधिक उपयोगी सिद्ध होगी।

मैं इस प्रकाशन से जुड़े सभी सदस्यों को बधाई देता हूं।

12/12/19

(नरेन्द्र सिंह तोमर)

Office: 'G' Wing, Ground Floor, Krishi Bhawan, New Delhi- 110001, Tel.: 011-23782373, 23782327 Fax: 011-23385876
Resi.: 3 Krishna Menon Marg, New Delhi-110001, Ph.: 011-23794697 / 98, Fax: 011-23794696

परशोत्तम रूपाला
PARSHOTTAM RUPALA

सत्यमेव जयते

राज्य मंत्री
कृषि एवं किसान कल्याण
भारत सरकार
Minister of State For
Agriculture & Farmers Welfare
Government of India
D.O. No..................MOS(A&FW)/VIP/2019-20/

सन्देश

राष्ट्रीय जलवायु समुत्थानशील कृषि में नव-प्रवर्तन (निक्रा) नामक परियोजना कृषि एवं किसान कल्याण मंत्रालय के अंतर्गत भारतीय कृषि अनुसंधान परिषद की एक महत्वपूर्ण परियोजना है | यह परियोजना जलवायु परिवर्तन से भारतीय कृषि को अधिक समुत्थानशील बनाने के लिए प्रौद्योगिकियों एवं नीतियों के विकास में कार्यरत है, जो जलवायु परिवर्तन की स्थिति में देश की कृषि समुदाय की टिकाऊ खाद्यान्न सुरक्ष, जीविकोपार्जन एवं खुशहाली को बनाए रखने में सक्षम है | इस परियोजना के अंतर्गत, जलवायु परिवर्तन के प्रति भारतीय कृषि की संशोधित संवेदनशीलता मूल्यांकन रिपोर्ट का प्रकाशन एक सराहनीय प्रयास है जो मुख्य प्राथमिकताओं, लक्षित हस्तक्षेपों एवं निवेशों एवं जोखिमों पर अच्छी जानकारी प्रदान करता है | मैं समझता हूँ, कि यह प्रकाशन नीति निर्माताओं एवं हितधारकों के लिए काफी उपयोगी सिद्ध होगा |

मैं, भारतीय कृषि अनुसंधान परिषद एवं निक्रा में कार्यरत सभी वैज्ञानिकों एवं अन्य सभी व्यक्तियों, जो इस कार्य से जुड़े हुए हैं, को बधाई देता हूँ |

(परशोत्तम रूपाला)

Delhi Office : Room No. 322, 'A' Wing, Krishi Bhawan, Dr. Rajendra Prasad Road, New Delhi-110 001
Tel. : +91-11-23383975/76 **Fax** : +91-11-23383971, **E-mail** : mosrupala@gmail.com
Gujarat Office : Plot No. 219, Sector-20, Gandhinagar-382 020 **Tele.** : 079-23260013

कैलाश चौधरी
KAILASH CHOUDHARY

सत्यमेव जयते

कृषि एवं किसान कल्याण
राज्य मंत्री
भारत सरकार
MINISTER OF STATE FOR AGRICULTURE
& FARMERS WELFARE
GOVERNMENT OF INDIA

संदेश

जलवायु परिवर्तन, जन सामान्य के टिकाऊ स्वास्थ्य और विशेषकर जो कृषि क्षेत्र पर निर्भर हैं, के लिए वैश्विक चुनौती के रूप में उभरा है। जलवायु परिवर्तन के प्रति कृषि को समुत्थानशील बनाने के लिए नीतियों एवं प्रौद्योगिकियों के विकास की अति आवश्यकता है। इस उद्देश्य के लिए वर्ष 2011 के दौरान निक्रा परियोजना का आरंभ किया गया था और जब यह परियोजना अपने योगदानों के लिए विख्यात है। जलवायु परिवर्तन के प्रति भारतीय कृषि की संशोधित संवेदनशीलता मूल्यांकन रिपोर्ट का प्रकाशन करना एक सराहनीय प्रयास है। यह इस परियोजना के अंतर्गत दूसरी कड़ी के रूप में वर्ष 2013 के दौरान किए गए कार्यों का संशोधित एवं विस्तृत विवरण है। यह प्रकाशन कृषि से जुड़े विभिन्न जिलों के सापेक्ष जोखिम एवं अति संवेदनशीलता को उजागर करता है। अतः यह प्रकाशन जलवायु परिवर्तन संबंधित अनुकूलन नीतियों एवं कार्यक्रमों के विकास में अति उपयोगी सिद्ध होगा।

मैं इस नीति से संबंधित प्रकाशन से जुड़े सभी लोगों को बधाई देता हूं।

शुभकामनाओं सहित।

(कैलाश चौधरी)

Office : 199Q, Krishi Bhawan, New Delhi-110 001. Tel. : +91-11-23782343, 23388165 Fax : 23074190

सत्यमेव जयते
त्रिलोचन महापात्र, पीएच.डी.
सचिव, एवं महानिदेशक
TRILOCHAN MOHAPATRA, Ph.D.
SECRETARY & DIRECTOR GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली 110 001

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE AND FARMERS WELFARE
KRISHI BHAVAN, NEW DELHI 110 001
Tel.: 23382629; 23386711 Fax: 91-11-23384773
E-mail: dg.icar@nic.in

FOREWORD

The globe is on path to +1.5^{0}C warming towards the end of this century. The implications of such warming include serious threat to food security, livelihoods and general wellbeing of the world population. India, with a large population dependent on agriculture dominated by small holders, is among the countries more vulnerable to climate change. As the benefits of mitigation efforts take time to be realized, putting emphasis on adaptation is the immediate need in order to minimize the adverse impacts of climate change. Towards making Indian agriculture more resilient to climate change, the Indian Council of Agricultural Research, initiated the National Initiative on Climate Resilient Agriculture during 2011. As part of this project, a district level vulnerability assessment was undertaken to facilitate prioritization and targeting of adaptation and development initiatives. The outputs of this analysis are extensively used by policy makers, donor agencies, ministries concerned with agricultural and rural development, development practitioners such as NGOs, etc.

As vulnerability is dynamic in nature, the vulnerability assessment is also to be undertaken periodically to upgrade policy making on agricultural development in general and agricultural research in particular. Such an assessment has to take into consideration the emerging conceptual and analytical methods along with relevant climatic and non-climatic information. In the context of climate change, the views and conceptualizations of terminology of the IPCC are more relevant and universally accepted. In this context, the IPCC's Fifth Assessment Report departed from its earlier report in the conceptualization of vulnerability. Also, the Fifth Assessment Report is accompanied by more advanced climate projections due to the advances in modelling efforts made through the CMIP-5 group of models. Keeping these developments in view along with the recommendation emerged through an evaluation of NICRA by a third party, the project made efforts to revise the vulnerability analysis done in 2013. The output of this analysis is presented in this document. The document contains information on relative position of districts of the country in relation to climate change risk and its various determinants viz., exposure, vulnerability and hazard which should prove useful to the policy makers and research managers. This report also comprises district level information on a number of indicators which can be found useful by those outside agriculture ambit. By providing information on districts that have relatively high risk and more vulnerable to climate change, this document can be handy in planning for adaptation for vulnerability and risk reduction. Involvement of stakeholder organizations during the process, will add value and acceptability to the output.

I compliment all the scientists and other staff involved and supported this analytical exercise.

(T. MOHAPATRA)

Dated the 9th December, 2019
New Delhi

Acknowledgements

The work that resulted in this document was triggered by, among other things, one of the recommendations of a third party evaluation of NICRA. A document on district level assessment of vulnerability to climate change was first published in 2013 under this project which was well received and was found useful by many stakeholders. Considering the utility of such an analysis and other developments in conceptualization of vulnerability, availability of more advanced climate projections based on IPCC's AR 5 and the very nature of vulnerability to be dynamic, this study is an attempt to take forward and revise the earlier analysis in the light of these developments. This study received support, encouragement and guidance from Dr T. Mohapatra, Director General, ICAR & Secretary, DARE. The progress was also reviewed in HLMC meeting chaired by DG, ICAR. We express our sincere gratitude to DG, ICAR & Secretary, DARE.

We are immensely thankful to Dr K. Alagudundaram, Deputy Director General (NRM and Agricultural Engineering), ICAR for his support and guidance throughout this study and for his key role in organizing the consultation meetings with stakehodlers.

The approach, methodology, intermediate and final results were shared in two consultation meetings with different stakeholders representing various Ministries/Departments of Government of India such as MoAFW (DACFW, NRAA), MoWR, MoEFCC, MoES (IMD, IITM), DST, like NIRDPR, MANAGE, international research organizations such as ICRISAT, IFPRI, IWMI, ILRI, ICAR institutes like NIAP, academic institutions such as IEG, MSE, IISc, NGOs involved in agricultural and rural development such as WASSAN, AFPRO, etc. We acknowledge the inputs and observations of all of them.

The work was also reviewed in annual workshop of NICRA and received useful inputs from the Expert Members of NICRA, especially from Dr B Venkateswarlu, Former Vice-Chancellor, VNMKV. We place on record our gratitude to experts. We are also thankful to all scientists and experts who were involved in assigning weights to the indicators and dimensions of risk.

We are thankful to Dr K S Kavi Kumar, Madras School of Economics, Dr N H Ravindranath, IISc, Dr Prem Narain and Dr V K Bhatia, Former Directors, ICAR-IASRI, Dr Rajender Parshad, ICAR-IASRI, Dr G K Jha, ICAR-IARI and Dr B S Kulkarni, Professor (Retired), ANGRAU for their valuable inputs.

We acknowledge the hard work of project staff viz., Ms N Swapna, Ms Y L Meghana, and Dr G Samba Siva in processing all the data and of Ms C Kanaka Durga in word processing.

Authors

List of Abbreviations

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ACU	Adult Cattle Unit
AFPRO	Action for Food Production
AR	Assessment Report
CGWB	Central Ground Water Board
CMIP-5	Coupled Model Inter-comparison Project -5
CO_2	Carbon Dioxide
CoP	Conference of the Parties
DACFW	Department of Agriculture, Cooperation and Farmers' Welfare
DDP	District Domestic Product
DES	Directorate of Economics and Statistics
DST	Department of Science and Technology
FAI	Fertilizer Association of India
GCM	Global Circulation Model
GDP	Gross Domestic Product
GoI	Government of India
HLMC	High Level Monitoring Committee
IARI	Indian Agricultural Research Institute
IASRI	Indian Agricultural Statistics Research Institute
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
IEG	Institute of Economic Growth
IFPRI	International Food Policy Research Institute
IISc	Indian Institute of Science
IITM	Indian Institute of Tropical Meteorology
ILRI	International Livestock Research Institute
IMD	India Meteorological Department
INDC	Intended Nationally Determined Contribution
INR	Indian Rupee
IPCC	Intergovernmental Panel on Climate Change

List of Abbreviations

IWMI	International Water Management Institute
MANAGE	National Institute of Agricultural Extension and Management
Max T	Maximum Temperature
Min T	Minimum Temperature
MoAFW	Ministry of Agriculture & Farmers' Welfare
MoES	Ministry of Earth Sciences
MoEF	Ministry of Environment and Forests
MoEFCC	Ministry of Environment, Forest and Climate Change
MoWR	Ministry of Water Resources
MSE	Madras School of Economics
NBSSLUP	National Bureau of Soil Survey & Land Use Planning
NDMA	National Disaster Management Authority
NGO	Non-Governmental Organization
NIA	Net Irrigated Area
NIAP	National Institute of Agricultural Economics & Policy Research
NICRA	National Innovations on Climate Resilient Agriculture
NIRDPR	National Institute of Rural Development and Panchayati Raj
NRAA	National Rainfed Area Authority
NSA	Net Sown Area
PRECIS	Providing Regional Climates for Impacts Studies
RBI	Reserve Bank of India
RCP	Representative Concentration Pathways
SRES	Special Report on Emission Scenarios
TERI	The Energy and Resources Institute
UNDP	United Nations Development Programme
WASSAN	Watershed Support Services and Activities Network
WRCP	World Climate Research Program

1 Background

Climate change has emerged as a challenge to livelihoods and wellbeing of the people world over (Sani and Chalchisa, 2016). According to the Assessment Report (AR) 5 of the Intergovernmental Panel on Climate Change (IPCC), the global surface temperature is likely to increase by 1.5^{0}C by 2100 relative to the period 1850-1900 (IPCC, 2013). The frequency of extreme events is also projected to increase in future. The projections with respect to precipitation are, however, more uncertain. The national governments as well as international agencies concerned with climate change have now recognized that adaptation is as important as mitigation as the benefits of latter will take decades to be realized. In the context of developing countries adaptation is even more important. Intensified adaptation efforts are needed in spite of the Paris Agreement arrived at CoP 21 to limit warming to 1.5^{0}C (Runhaar et al., 2018). Adaptation requires resources in terms of investments and interventions. However, considering climate and climate change are spatially variable, not all regions are equally impacted by climate change and vary with their capacities to adapt and shocks to adapt to. Globally, temperatures are projected to rise at higher latitudes but no region is expected to witness fall in temperature. Trends in rainfall are more variable spatially.

India is one of the countries that are more vulnerable to climate change (Cruz et al., 2007). The Coupled Model Intercomparison Project (CMIP) 5 projections for India show that the average climate is likely to be warmer by 1.7 to 2.0^{0}C for 2030s and by 3.3 – 4.8^{0}C for 2080s compared to the pre-industrial times (Chaturvedi et al., 2012). The precipitation is likely to increase by 5 to 6 per cent and 6 to 14 per cent, for 2030s and 2080s, respectively. Agriculture, being a biological production process, is obviously affected by climate and hence the projected change in climate will have implications to sustainability of agricultural production and of livelihoods of those dependent on agriculture. As climate change aggravates all other problems such as land degradation, market volatility, rising input costs, slowing response to added inputs that hinder agricultural growth, it is recognized as a potent threat to sustainability of agriculture. Developing countries such as India, with their relatively higher dependence on agriculture for livelihoods, are more likely to suffer from such an impending climate change.

There is emerging evidence that the productivity of crops, livestock and fish is likely to be affected with implications to food security, livelihoods and sustainability in agriculture. Both the changes in mean climate and the variability therein will affect growth and productivity of crops and livestock. It can be broadly generalized that rising temperature and declining rainfall will adversely affect agricultural productivity, though there can be certain exceptions such as rising temperature in the temperate hill regions may help improve productivity of crops. In India, several studies have projected declining crop yields, in the absence of adaptation, in response to changing climate characterized by rising temperature. The impacts of rising temperature on crop yields are stronger than positive impacts of the rising atmospheric CO_2 levels (Jayaraman, 2011), the latter being referred to as carbon fertilization effect. The negative effects of temperature on farm revenue outweigh the smaller positive effects of increasing precipitation (Kumar and Parikh, 2001).

Adaptation is a necessary response to deal with climate change in agriculture and in other sectors such as infrastructure, urban planning, public health (Wamsler, 2015). The adaptation response can be effective through either mainstreaming or integrating into the existing development programmes or through developing dedicated climate change focussed programmes. Both ways need information on what to adapt to and how to adapt. More specifically, information on what future climate is going to look like in terms of changes in temperature, rainfall patterns, etc. as well as the conditions or features of the system of interest that predispose to the climate change impacts. Such an analysis, which can be a useful initial step in adaptation planning, is referred to as vulnerability analysis.

In order to develop technologies and strategies for enhancing resilience of Indian agriculture to climate change, the Indian Council of Agriculture (ICAR), Ministry of Agriculture & and Farmers' Welfare (MoAFW), Government of India (GoI) initiated the project 'National Initiative on Climate Resilient Agriculture' (NICRA) during 2011, the second phase of which, commencing from 2017, is called 'National Innovations in Climate Resilient Agriculture (NICRA). A district level analysis of vulnerability of agriculture to climate change (Rama Rao et al., 2013, 2016) is an important output of the initial phase of NICRA, which is being used by many different stakeholders in planning and locating various adaptation efforts.

1.1. Need for revising the vulnerability analysis

Vulnerability is essentially a dynamic concept, *ex ante* in nature (Ionescu et al., 2008) and responds to development efforts. It is a concept with origins in social sciences. However, the word vulnerability is used to denote different things by researchers in many different domains of research such as development economics, disaster management, geography, etc. However, the concept and definitions of vulnerability as given by the IPCC are most frequently adopted in the context of climate change. Following this, the vulnerability assessment done in NICRA during 2013 (Rama Rao e al., 2013, 2016) adopted the definition and framework of vulnerability analysis given by the IPCC in its 3rd and 4th Assessment Reports. Vulnerability, as per IPCC (2001, 2007) was viewed as residual impact, as conceptualized in Fussel and Klein (2006), on a system of interest due to exposure after accounting for adaptation. Thus, vulnerability is seen as residual impact and framed as a resultant of sensitivity, exposure and adaptive capacity. The first two dimensions of vulnerability determine the potential impact which will be moderated by adaptation, a manifestation of adaptive capacity. In this framework, 'sensitivity' is referred to as the ability or propensity of the system to be adversely or positively affected by an external shock such as climate change which is referred to as 'exposure'. Adaptive capacity, which is a precursor to adaptation, refers to the ability of the system to respond to climate change to avoid or minimize the impact and is a function of factors such as wealth, technology, education, skills, infrastructure, access to resources, etc (McCarthy, et al., 2001). Such a framework warrants inclusion of a range of non-climatic socio-economic information in the vulnerability analysis. Most of such socioeconomic variables change over time in response to the development efforts of government in various sectors. Also, the 'exposure' dimension of vulnerability entails capturing future climate projections based on different global and/or regional climate models. Such climate models also evolve over time with the advances made in understanding the physical basis of global and regional climate and in the ability to model such understanding. Thus, the relative vulnerability of districts, which is the unit of analysis in the analysis, was assessed through a number of indicators selected to capture the three dimensions of vulnerability. In particular, the sensitivity and adaptive capacity were captured through agro-climatic and socio-economic indicators. On the other hand, the exposure was captured by considering the climate projections obtained through the regional climate model, PRECIS, which was found more appropriate to be used in Indian conditions (MoEF, 2012). However, most of the indicators used in the analysis would have changed over time that can potentially alter the relative vulnerability of districts to climate change. Further, the IPCC in its 5th Assessment Report adopted a different conceptualization of vulnerability incorporating many elements of vulnerability that have evolved over time and to make such an analysis more policy relevant. This report was also accompanied by climate projections from more advanced global climate models of CMIP-5 that report projections based on what are called Representative Concentration Pathways (RCP) that take into consideration the mitigation actions.

Further, the progress in NICRA was evaluated by an independent agency as part of the monitoring mechanism of the project. The evaluation, among other things, while appreciating the appropriateness and utility of the district level vulnerability analysis as one of the important outcomes of the project, also recommended to revisit the analysis, perhaps, because of the reasons mentioned above. Therefore, we attempted to revise the analysis by adopting the conceptualization and framework of vulnerability as given in the AR 5 of the IPCC and by using the more recent data on agro-climatic and socio-economic indicators. As far as climate projections that are essential to be included in the analysis, we used a sub-set of CMIP-5 global climate models to capture the future climate.

2 Conceptual shift from AR 4 to AR 5: Vulnerability as a Determinant of Risk

The literature on vulnerability and its assessment is continually evolving drawing on works in different fields. The dynamic trait of vulnerability and its components is not adequately addressed in the Third and Fourth Assessment Reports of the IPCC. The recent literature suggests that the risks due to climate change are also a result of complex interactions among social and ecological systems and the hazards arising out of climate change rather than being externally generated alone. Various facets of these interactions have to be carefully differentiated to understand risk to inform policy making for risk management. The AR 5 framework emphasizes these aspects as well as that the very components of vulnerability and risk will also interact with the contextual factors of development pathways and the climate systems (Oppenheimer et al., 2014). Also, inclusion of 'exposure' as a component of vulnerability as in AR 4 framework, may trigger decisions that may potentially lead to maladaptation given the uncertainty associated with climate projections.

2.1. Vulnerability – a component of risk assessment

The AR5 proposes a different framework where in vulnerability is placed as one of the determinants of risk, the other two being 'exposure' and 'hazard'. The definitions given in AR 5 for risk and its components (Oppenheimer, et al., 2014) are given below:

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Impacts: The term impacts is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts.

Hazard: The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts.

Risk: The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur.

Risk = (Probability of Events or Trends) × Consequences

Risk results from the interaction of vulnerability, exposure, and hazard.

The AR4 and AR5 definitions and frameworks view the terms 'vulnerability' and 'exposure' differently. Exposure in the AR 4 terminology is related to climate related shocks that a system is exposed to whereas the AR 5 describes it being related to the individuals, systems, etc. being exposed to the 'hazard', a concept introduced in AR 5 framework. Vulnerability, as per AR 5, is more a predisposition to an external shock and whether it will lead to risk depends on whether the vulnerable system is located (exposure) in a place where the 'hazards' are likely to occur. A highly vulnerable system may not suffer risk due to climate change or a less vulnerable system may face risk if it is placed where severe hazard incidence is possible. In terms of AR 4 terminology, vulnerability as viewed in AR 5 is independent of 'exposure' (Sharma and Ravindranath, 2019; Sharma et al., 2018). Thus, the relationship between these three components of risk are more explicit and policy relevant. The AR 5 vulnerability framework is closer to the disaster management conceptualization which is considered more appropriate in the context of climate change.

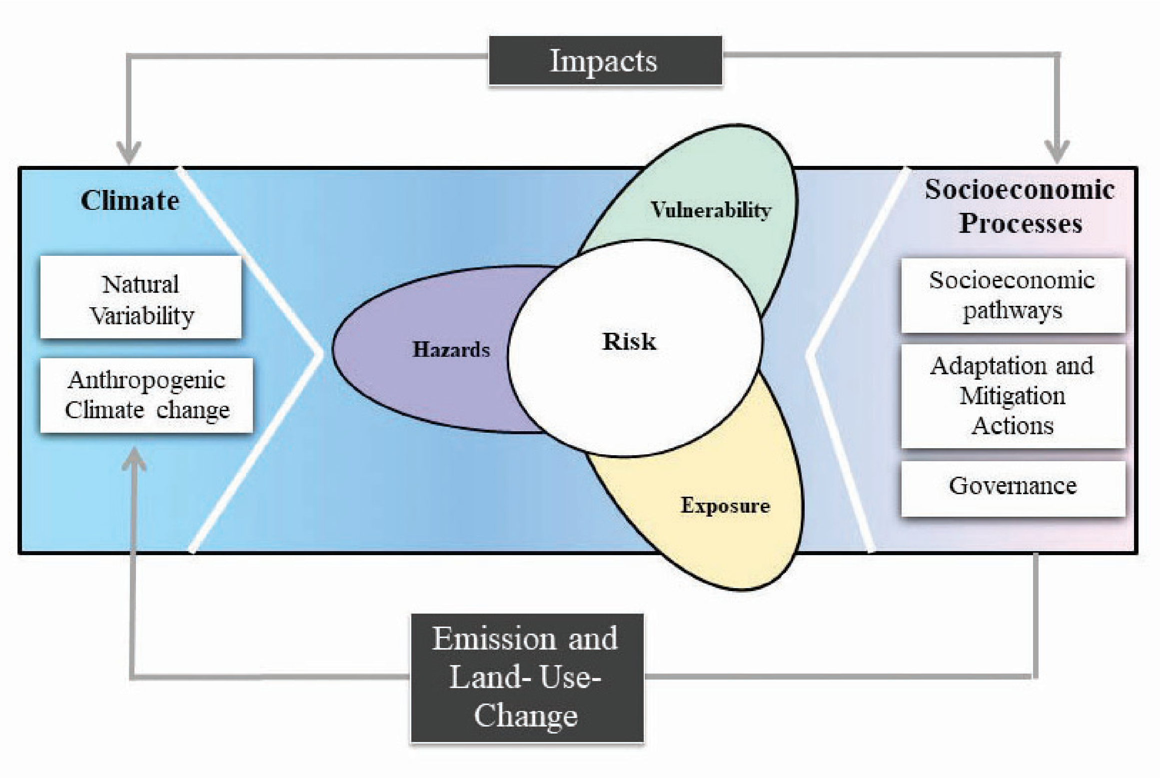


Fig 1. IPCC's AR 5 framework of risk assessment
(Adapted from Oppenheimer et al., 2014)

The AR 5 risk conceptualization furthers the risk analysis by identifying two kinds of risk: key risks and emergent risks. Key risks are potentially severe consequences arising when systems with high vulnerability interact with severe hazards. Different criteria are suggested to categorize a risk as key which are based on the magnitude of the risk, high vulnerability of a particular group of population, criticality of the sector in the economy. Emergent risks are those that are not direct consequences of climate change hazard but are results of responses to climate change. For example, migration of population from a region due to climate change related hazards may increase the vulnerability and thus risk of receiving regions; similarly increased groundwater extraction during a drought may increase the vulnerability and risk in future. Thus, emergent risks are a result of spatial linkages and temporal dynamics related to responses to changing climate. Thus AR 5 framework places more emphasis on identifying and managing risk and thus views vulnerability as a determinant. Such conceptualization and framework will be more relevant to policy making.

The difference in conceptual framing of vulnerability as given in the AR 4 and AR 5 of IPCC is summarized in figure 2.

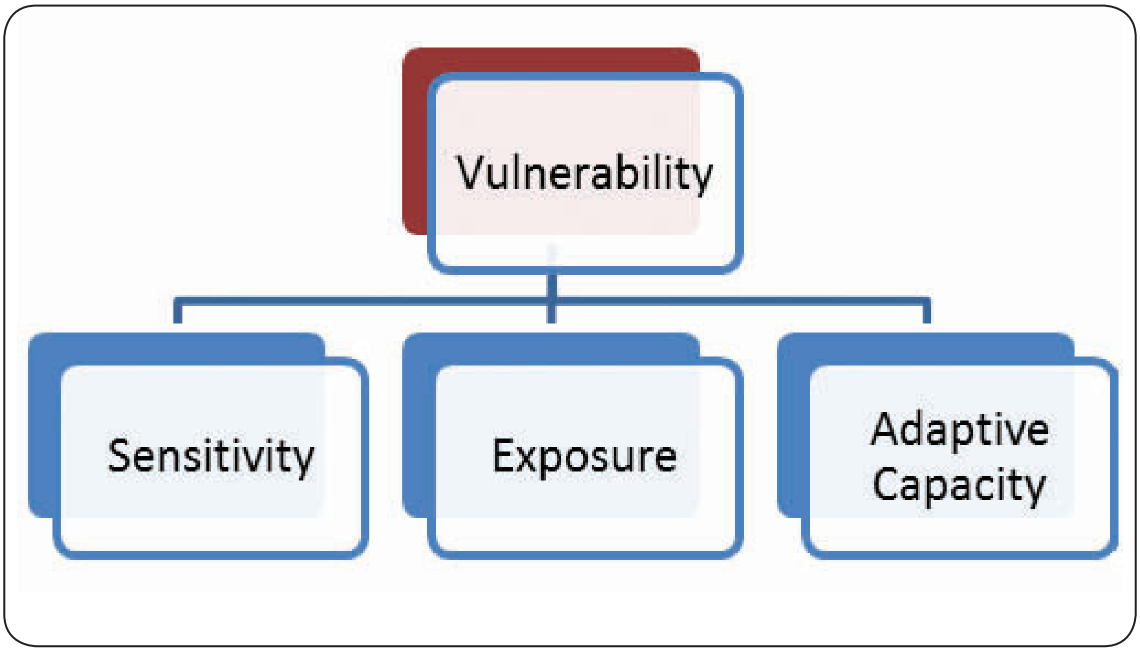


Fig 2a. Framework of vulnerability as given by IPCC, 2007

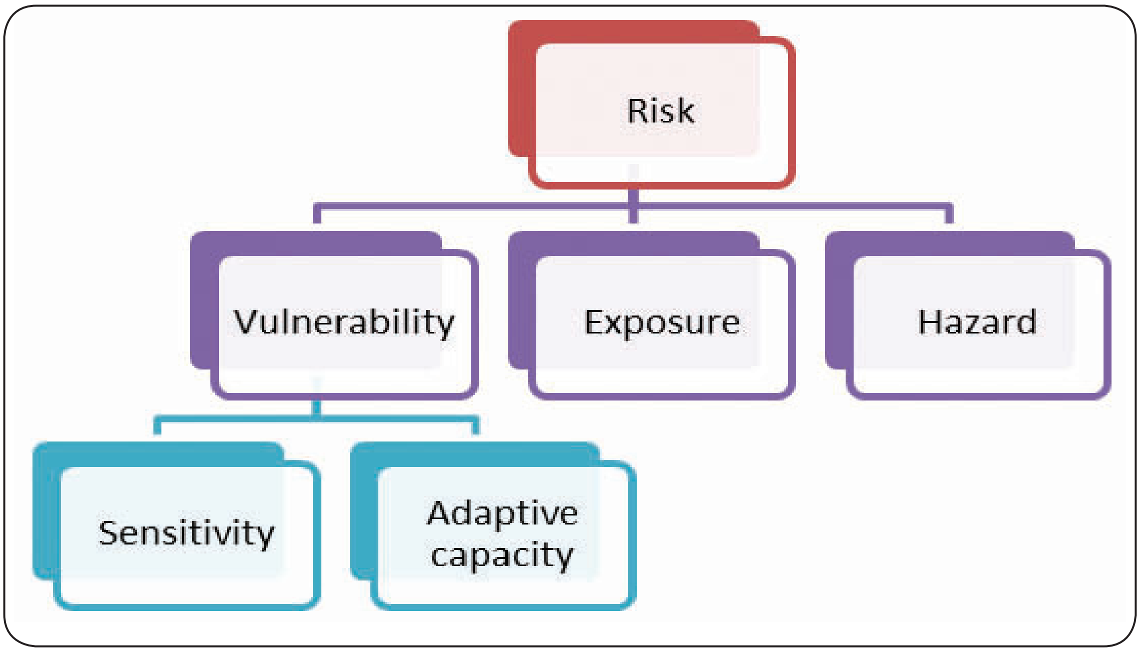


Fig 2b. Framework of vulnerability and risk as given by IPCC, 2014

3 Approach and Methodology

3.1. Approaches and types of vulnerability assessment

Vulnerability is postulated differently depending on the context of analysis. 'Outcome vulnerability is conceptualized as 'end point' analysis where in the impact of climate change is examined on productivity or production of a particular crop or animal species either through simulation modelling or through physical experimentation. This is also referred to as biophysical impact assessment or first generation vulnerability assessment. Such 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). As the purpose of such assessment was to identify strategies that reduce vulnerability of the systems or populations concerned, vulnerability assessments became more policy oriented.

The socio-economic approach to vulnerability assessment proposes that the attributes of the system or entity of interest predispose it to the adverse impacts of an external shock (climate change or variability) (Adger and Kelly, 1999) and thus it is referred to as 'starting point analysis'. In this case, vulnerability is regarded as a pre-existing condition (Jurgilevech et al., 2017) in terms of health, education, wealth, etc. of the individuals and the differential endowments of individuals are responsible for varying vulnerability.

The integrated approach combines both these approaches integrating bio-physical and socio-economic dimensions of vulnerability. As the vulnerability assessments evolved, more non-climatic data became a part of such assessments.

Current vulnerability analyses the current risks to the system of interest whereas *future vulnerability* assessments are concerned with future risks. Vulnerability assessment is considered static or dynamic whether the temporal changes in the predisposing conditions and/or risk are considered in the analysis.

The present analysis can be referred as the current vulnerability to future climate change as the objective is to inform the decision making process 'currently' to help minimize future climate change risk. Vulnerability is important in managing risk arising out of climate change because the other two determinants, hazard and exposure, are relatively more difficult to change in ways that reduce risk. For example, altering exposure requires shifting people or systems from the locations where they are currently existing. Similarly, preparing for and adapting to projected climate change hazard has to deal with the uncertainties associated with climate projections, especially considering the fact that adaptation is essentially local in nature. On the other hand, strengthening or altering those features underlying the susceptibility of the system to climate change hazard, is relatively better and pragmatic approach to vulnerability reduction or risk reduction.

There are different approaches and methods to assessment of vulnerability and risk analysis ranging from indicator-based methods to more participatory local level assessments (Cardona et al., 2012). However, the choice of method is determined by the purpose of analysis, availability of data and resources including human resources. 'Indicator method' is one of the frequently used methods because of its transparency and attractiveness to policy makers. The method is particularly useful when the purpose is to identify regions with different levels of vulnerability and risk so that investments and interventions can be better prioritized and targeted. Therefore, the indicator method was adopted.

3.2. Selection of Indicators

Indicators are the variables that are closely associated with the phenomenon or concept that is intended to be quantified or measured, but difficult to be measured. In other words, the (relative) values of indicators, when viewed individually or in the form of an aggregate index, will help understand the relative position of the system or unit of interest vis-à-vis other units with respect to the phenomenon that the indicators are associated with. Thus, indicators or indicator method is more useful in planning development interventions and if tracked over time, can be a useful tool of monitoring and evaluation of any programme, as observed by Crane et al. (2017) in case of vulnerability.

In this analysis, we chose indicators that reflect the three dimensions of risk, i.e., hazard, exposure and vulnerability by considering the definitions and meanings mentioned in section 2.1. The choice of indicators was guided by review of literature (e.g. Esteves et al., 2013, 2016; Ravindranath et al., 2011; O'Brien et al., 2004, 2007; Rama Rao et al., 2013; Upgupta et al., 2015), theoretical considerations of what underlie different determinants of risk and stakeholder consultation.

Hazard refers to the occurrence of climate shock in the context of climate change. In this analysis, hazard was represented in two forms: future climate hazard and historic hazard. The future climate hazard was captured in terms of agriculturally relevant indicators derived from the climate projections from a subset of CMIP-5 global climate models[1].

3.2.1. Multi-model ensemble of climate projections for RCP 4.5 at 0.5^0 X 0.5^0 grids for India

In this study, the IPCC' Fifth Assessment Report's climate change projections based on RCP's were used. Bias corrected and spatially disaggregated (BCSD) projections from the World Climate Research Program's (WRCP's) CMIP 5 multi-model dataset were used to generate multi-model ensemble climate change scenarios. Climate change projections of 30 GCM from 21 modelling centres/ groups were used. As different GCMs have multiple runs, we used 61 projections (runs) for RCP 4.5, for generating climate change scenarios.

Though delta change method is the most commonly used method for generating future climate scenarios, it does not consider variability or change in time series behaviour in the future. Therefore, the hybrid-delta ensemble method that considers inter-annual variability for each month was used (Islam *et al*. 2012a, b; Tohver *et al*. 2014). This method uses quantile mapping approach (Wood *et al*. 2002) to re-map the observations onto the bias corrected GCM data (historical and future time series) to produce the historic and future GCM projected rainfall and temperature data corresponding to the non-exceedance probability of observed rainfall and temperature data. Using the hybrid-delta ensemble method, we generated multi-model ensemble climate change scenarios for four different RCPs and three future periods (2020s, 2030s, 2050s, and 2080s). However, in this analysis, results pertaining to RCP4.5 for the period of 2030s (2020-49) are only used. The names of GCMs used and the number of runs are presented in Annexure I. The climate projections for RCP 4.5 for the period 2020-49 are used to derive the indicators of future hazard[2] (Table 1).

1 The IITM, Pune has recently provided the climate projections from the CORDEX project to be used for Indian conditions. However, they were not available when this exercise began.

2 We constructed two sets of future hazard indicators using climate projections based on RCP 4.5 and RCP 6.0 for the period 2040-69. However, a recommendation emerged on presentation of draft results in a meeting of stakeholders held on 20 July 2018 that the climate projections for RCP 4.5 for the period 2020-49 be used.

Table 1. Indicators of future hazard included in computation of risk index

S. No.	Indicator	Measurement (unit)	Rationale	Relationship with future hazard
1	Change in annual rainfall	Change (%) in annual rainfall during 2020-49 relative to the baseline (1976-2005)	Increase in rainfall is favourable to agricultural productivity	Inverse
2	Change in June rainfall	Change (%) in June rainfall during 2020-49 relative to the baseline (1976-2005)	An increase in rainfall enables sowing of crops in right time	Inverse
3	Change in July rainfall	Change (%) in July rainfall during 2020-49 relative to the baseline (1976-2005)	An increase in July rainfall enables sowing of crops in right time and better establishment of crop stand	Inverse
4	Change in number of rainy days	Change (%) in number of rainy days during 2020-49 relative to the baseline (1976-2005)	Increase in number of rainy days implies a better distribution of rainfall	Inverse
5	Change in maximum temperature	Change in maximum temperature (^{0}C) during 2020-49 relative to the baseline (1976-2005)	An increase in maximum temperature implies adverse effects on crop yields	Direct
6	Change in minimum temperature	Change in minimum temperature (^{0}C) during 2020-49 relative to the baseline (1976-2005)	An increase in minimum temperature implies adverse effects on yields, especially for rabi crops like wheat	Direct
7	Change in incidence of unusually hot days	Change in frequency of days during March to May when maximum temperature exceeds the normal by at least 4^{0}C during 2020-49 relative to the baseline (1976-2005)	An increase in frequency will imply adverse yield effects	Direct
8	Change in incidence of unusually cold days	Change in frequency of days during December to February when minimum temperature falls below the normal by at least 4^{0}C during 2020-49 relative to the baseline (1976-2005)	An increase in frequency will imply adverse yield effects	Direct
9	Change in frequency of occurrence of frost	Change in frequency of occurrence of frost during 2020-49 relative to the baseline (1976-2005)	An increase in frequency will imply adverse yield effects	Direct
10	Change in drought proneness	Change in drought proneness during 2020-49 relative to the baseline (1976-2005)	Increase in drought proneness means higher yield risk	Direct
11	Change in incidence of dry spells of >= 14 days	Change in dry spell score[3] computed for dry spells during June to October during 2020-49 relative to the baseline (1976-2005)	Higher the number of dry spells, less is productivity	Direct

3. Dry spell score is computed as follows: Score = $\sum$[Exp{(Length of dry spell/14)-1}] for dry spells of >= 14 days. A dry spell of less than 14 days is expected not to adversely affect the crop in general and a dry spell of more than 42 days will not allow the crop to yield anything significant. Accordingly, the values were truncated at these two points.

S. No.	Indicator	Measurement (unit)	Rationale	Relationship with future hazard
12	Change in 99 percentile of daily rainfall	Change during 2020-49 relative to the baseline (1976-2005)	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
13	Change in number of events with >100 mm in 3 days	Change in the number of events during 2020-49 relative to the baseline (1976-2005)	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
14	Change in average highest rainfall in a single day as % to annual normal	Change during 2020-49 relative to the baseline (1976-2005)	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
15	Change in average highest rainfall in 3 consecutive days as % to annual normal	Change during 2020-49 relative to the baseline (1976-2005)	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

Source of data: All these indicators are computed using the daily data on rainfall, maximum temperature and minimum temperature as obtained from a subset of CMIP-5 group of global climate models for RCP 4.5 for the period 2020-49. These data are downscaled to 0.5^0 X 0.5^0 grids. Using the data at grid level, the district level estimates are arrived at by taking weighted average with the areas of the Thiessen Polygons in a district. Thus, indicators reflecting change in average climate and in extreme events in temperature and rainfall are derived from the projections and included.

Hazard is also represented as the historical incidence of extreme events as presented in table 2.

Table 2. Indicators of historical hazard included in computation of risk index

S. No.	Indicator	Measurement (unit)	Rationale	Relationship with hazard	Source of data
1	Drought proneness	Index computed by combining the probability of occurrence of severe and moderate droughts with respective weights of 2:1 and expressed as %	Incidence of more frequent droughts implies a more risky agriculture and hence more hazard	Direct	Derived from rainfall data for 1976-2005 of IMD at grid level (0.5^0 X 0.5^0)
2	Flood proneness	Geographical area prone to flood incidence (%)	Larger area susceptible to flood incidence implies more area prone to hazard	Direct	National Seismic Advisor, GoI-UNDP
3	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 attendant problems and hence more hazard	Direct	NDMA web site http://ndma.gov.in

Exposure refers to presence of people, systems, assets, etc. in the locations where the hazards are likely to occur exposing them to the impact risk. Thus, five different indicators are selected to represent exposure (Table 3).

Table 3. Indicators of exposure included in computation of risk index

S. No.	Indicator	Measurement (unit)	Rationale	Relationship with hazard	Source of data
1	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	DES, DACFW, GoI; Agricultural Census-2010-11 DACFW, GoI; (Mostly data for 2014-15, 2015-16, 2016-17 was used)
2	Rural population density	Number of rural people per sq km of geographical area	Higher density is an indication of more number of people at risk. It also implies high population pressure on land resources and since the livelihoods of rural population are heavily dependent on agriculture, it means higher exposure	Direct	GoI, Census, 2011

S. No.	Indicator	Measurement (unit)	Rationale	Relationship with hazard	Source of data
3	Small and marginal farmers	Number of small and marginal farmers in relation to total number of farmers (%)	Higher number implies more number being exposed. 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 risky.	Direct	Agricultural Census 2010-11 (DACFW, GoI)
4	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 and more of them implies higher exposure.	Direct	GoI - Census, 2011
5	Cross-bred cattle	Per cent cross-bred cattle in relation to total small and large ruminant livestock population expressed in terms of Adult Cattle Units (ACU)	Cross-bred cattle are more productive, require more investments in feed, fodder and management and more sensitive to climate change. Higher the number, more is the exposure	Direct	Livestock Census, 2012

As indicated earlier, vulnerability is considered as an internal trait of the system that predisposes the system to an external hazard. Any characteristic of the system that helps adapt to or deal with hazard better help reduce the adverse impacts or risk due to hazard. Vulnerability is a function of sensitivity and adaptive capacity where the former denotes the system's propensity to be affected and the latter the ability to adapt to the hazard. In this analysis, the indicators selected are categorized into different capital endowments which determine the ability of the system to deal with the hazard. Thus, fifteen indicators related to five different dimensions of capital endowment - natural, human, social, physical and financial - are selected to capture vulnerability (Table 4).

Table 4. Indicators of vulnerability included in computation of risk index

S. No.	Dimension/ Indicator	Measurement (unit)	Rationale	Relationship with vulnerability	Source of data
Natural capital					
1	Annual rainfall	Average annual rainfall (mm)	Higher the rainfall, better is for crop growth (over a wide range except in extremely higher levels). An upper tab of 1500 mm rainfall (Mandal et al., 1999) was considered as cut-off as the demand to meet the potential evapotranspiration for the cropping season is well within 1500 mm for 99.8% of the total geographical Area (NRAA, 2012)	Inverse	Average of 1976-2005 computed from rainfall data set of IMD at grid level (0.5^0 X 0.5^0)

S. No.	Dimension/ Indicator	Measurement (unit)	Rationale	Relationship with vulnerability	Source of data
2	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)
3	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).
4	Ground water availability	Availability of ground water (ha m/km^2)	Groundwater availability reflects the scope to exploit ground water resources for irrigation.	Inverse	CGWB (2011)
5	Livestock density[4]	Number of livestock (small and large ruminants) expressed in terms of ACU per km^2 of geographical area	This is an indicator of diversification of agriculture and livelihoods and hence enhances the ability to cope with.	Inverse	Livestock census, 2012
Human capital					
6	Literacy	Percent people who are literate	Higher literacy enables people to adapt better and also enhances their ability to diversify livelihoods	Inverse	GoI, Census, 2011
Social capital					
7	Gender gap	Difference between total literacy and female literacy	A lower gap indicates better gender equity	Direct	GoI Census, 2011
8	Self-help groups	Per cent villages in the district with self-help groups	A higher % include prevalence of farmers' organizations and thus help higher ability to adapt	Inverse	GoI Census, 2011
Physical capital					
9	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.	Inverse	DES, DAC FW, GoI, Agricultural Census -2010 -11, DACFW, GoI (Mostly data for 2014-15, 2015-16 and 2016-17 was used)

4. Whether to include livestock as natural capital or financial capital can be debated and there is less consensus on such things (Crane et al., 2017).

S. No.	Dimension/ Indicator	Measurement (unit)	Rationale	Relationship with vulnerability	Source of data
10	Road connectivity	Villages that have all weather roads (%)	This is indicator of market access as well as of better integration with the economy and the associated spread effects of development.	Inverse	GoI, Census, 2011
11	Rural Electrification	Number of rural households having electricity as source of lighting in relation to total households in rural areas (%)	This is an indicator of overall development that positively influences the ability to adapt.	Inverse	GoI, Census 2011
12	Market access	Number of regulated wholesale agricultural markets per one lakh farm holdings	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.	Inverse	For markets: Directorate of Marketing & Inspection, DACFW, GoI; For holdings: Agricultural Census 2010-11, DACFW, GoI
13	Fertiliser use	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.	Inverse	For Fertiliser use data: FAI; for gross sown area: DES and Ag census 2010-11, DACFW, GoI
Financial capital					
14	Income	Per capita income[5] in the district, Rs/year	A higher per capita income implies better adaptive capacity.	Inverse	Computed from State level data (TE 2015-16) from RBI and district level data from Planning Commission web sites
15	Income inequity	Difference between percent workforce dependent on agriculture and share of agriculture in district domestic product (DDP)[6]	Higher income inequity implies low productivity	Direct	Census, 2011 for work force and RBI and Planning Commission web sites for agricultural DDP

5. The district level data on this indicator is available for 2005-06 only. The indicator was estimated for TE 2015-16 assuming the growth rate in per capita income of state for all the districts in that state considering the state level data for 2005-06 and TE 2015-16.

6. The district level data on agricultural DDP and total DDP were estimated by following similar procedure as in case of per capita income.

3.3. Computation of indices of risk and its determinants

In order to compute the indices of hazard, exposure and vulnerability and finally of risk, a database of all the indicators for the 573 rural districts of India (excluding the Union Territories of Andaman & Nicobar Islands, Lakshadweep) was created. The indicators were normalized to bring all the indicators to a common scale and to make them unit-free by computing Z-scores in case of indicators related to exposure, vulnerability and historical hazard. The Z-scores are computed as follows:

$Z_i = (X_i – \mu) / \sigma$ when the indicator is positively related to the respective index,

$Z_i = - (X_i – \mu) / \sigma$ when the indicator is inversely related to the respective index,

where X_i and Z_i are actual and normalized values of the indicators for i^{th} district, μ and σ are mean and standard deviation, respectively.

As mentioned earlier, the indicators related to future hazard are expressed in terms of changes from the baseline climate. Thus, any change in the indicator values will increase or decrease the degree of hazard depending on the indicator and zero change indicates that climate change is going to be neither better nor worse as far as the indicator in question is concerned. It would then be appropriate that the normalized value retains the sign of the actual value which the Z-score normalization does not allow. Even the 'min-max' normalization adopted in a number of studies including Rama Rao et al (2013, 2016) does not retain the sign of the actual indicator. Therefore, the following normalization formula was adopted in case of indicators related to future hazard:

when the indicator is positively related to the respective index: $Z_i = X_i / (X_{Max} – X_{Min})$ when the indicator includes 0 in its range, or $Z_i = X_i / |X|_{Max}$ when the indicator has only positive or only negative values;

when the indicator is inversely related to the respective index: $Z_i = -X_i / (X_{Max} – X_{Min})$ when the indicator includes 0 in its range, or $Z_i = - X_i / |X|_{Max}$ when the indicator has only positive or only negative values.

where X_i, and Z_i are actual value and normalized value of the indicator for i^{th} district and X_{Max} and X_{Min} are maximum and minimum values of indicator, respectively.

In order to obtain the indices, the normalized indicators have to be aggregated. While computing such aggregate indices, it is possible that the extreme values of indicators will unduly affect the index. This issue was addressed by (i) the upper values were specified based on certain considerations such as crop response as in case of rainfall (1500 mm), (ii) 99 percentile in case of rural population density, net per capita income, livestock density, fertiliser use, (iii) log transformation of indicator values in case market density/access, (iv) use of exponential function to capture the impact of dry spells, and (v) the future hazard indicators were truncated at 1 and 99 percentile values. Moderating extreme values of indicators not only allows better discrimination in rest of the data but also reduces the unduly large influence on the resulting aggregate index when combined with other indicators.

After normalizing the indicators, they were aggregated into the indices of historical hazard, future hazard, exposure, vulnerability and finally of risk. Weights to indicators of each determinant of risk were obtained through expert consultation wherein 20 experts from different disciplines of agricultural research such as agronomy, soil and water conservation, soil science, agrometeorology, crop physiology, pest management, agricultural economics, agricultural statistics, agricultural extension, were involved. The whole process, right from the approach, methodology, indicator selection, weighting, etc., was presented and discussed in two consultation meetings with representatives from different stakeholder organizations comprising development departments of the government (e.g. DACFW, MoWR, NRAA, NIRDPR, MANAGE), other ministries or departments concerned with climate change (e.g. MoEFCC, IMD, IITM), national and international research organizations (e.g. NIAP, ICRISAT, IFPRI, IWMI), academic institutions (e.g. IISc, IEG, MSE), NGOs (e.g. WASSAN), and other agencies such as TERI in addition to representatives from the ICAR. Table 5 presents the weights of different indicators in each of the four determinants of risk.

Table 5a. Weights given to different indicators of Exposure

Indicator	Weight (%)
Net sown area	40
Rural population density	15
Small and marginal farmers	20
SC/ST population	15
Cross-bred cattle	10

Table 5b. Weights given to different indicators of Historical Hazard

Indicator	Weight (%)
Drought proneness	55
Flood proneness	25
Cyclone proneness	20

Table 5c. Weights given to different indicators of Future Hazard

Future hazard	
Indicator	Weight (%)
Change in annual rainfall	10
Change in June rainfall	5
Change in July rainfall	15
Change in number of rainy days	5
Change in maximum temperature	6
Change in minimum temperature	6
Change in incidence of unusually hot days	5
Change in incidence of unusually cold days	3
Change in frequency of occurrence of frost	2
Change in drought proneness	12
Change in incidence of dry spells of >= 14 days	11
Change in 99 percentile rainfall	5
Change in number of events with >100 mm in 3 days	5
Change in average highest rainfall in a single day as % to annual normal	5
Change in average highest rainfall in three consecutive days as % to annual normal	5

Table 5d. Weights given to different indicators of Vulnerability

Vulnerability	
Indicator	Weight (%)
Annual rainfall	12
Degraded and waste land	5
Available water holding capacity of soil	8
Ground water availability	10
Livestock density	8
Literacy	3
Gender gap	3
Self-help groups	3
Net irrigated area	20
Road connectivity	4
Electrification	3
Market access	4
Fertiliser use	5
Income	4
Income inequity	8

The indices of determinants of risk viz., hazard, exposure and vulnerability were then combined to build an index of risk with the weights as given in table 6.

Table 6. Weights assigned to different components of risk

Risk determinant	Weight
Historical Hazard	20
Future Hazard	20
Exposure	20
Vulnerability	40

The results obtained through this process were found to agree with those obtained by applying weights derived through factor analysis and were also presented to various stakeholders. Figure 3 summarizes the whole process of building district level risk index.

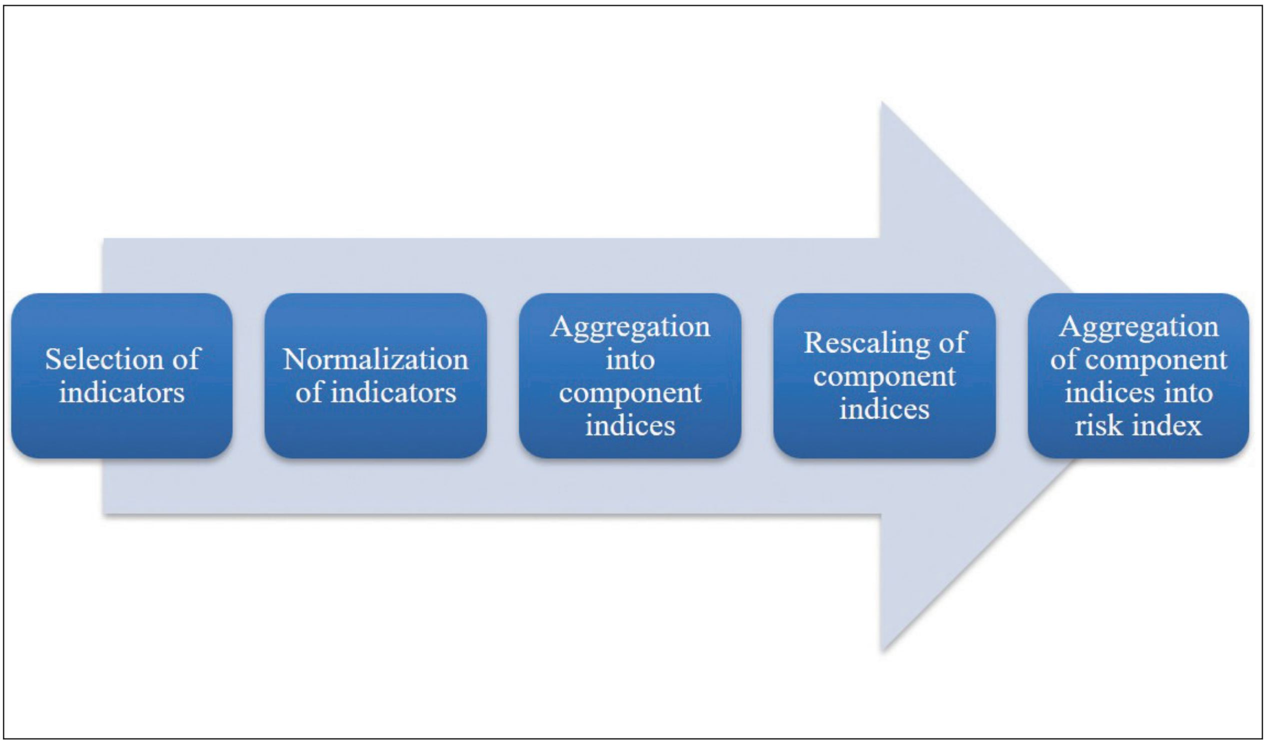


Fig 3. Process of building indices of risk and its components

3.4. Categorization of districts

Based on the index values, the districts were categorized as shown in table 7.

Table 7. Categorization of districts based on indices of components of risk

Index value	Category		
	Exposure, Vulnerability and Historical Hazard	Future Hazard	Risk
> 1.5. SD	Very High	More unfavourable	Very High
0.5 SD to 1.5 SD	High	Moderately unfavourable	High
- 0.5 SD to + 0.5 SD	Medium	No Hazard	Medium
- 1.5 SD to - 0.5 SD	Low	Moderately favourable	Low
< - 1.5 SD	Very Low	More favourable	Very Low

It is to be mentioned here that the index values are relative in nature and can only be used to order the districts. A high index for risk results from higher values of any or some of the determinants. The index values in case of vulnerability, exposure and historical hazard are centred around mean which means that values nearer to average represent the 'average situation' and those away from the mean represent better or worse situation owing to the normalization method used. On the other hand, the index values for future hazard are centred around zero in the sense that values near zero mean climate change is 'neutral' and those away from zero mean a worsening or improving climate, and accordingly chose nomenclature for describing future hazard as above. Further, the distribution of districts into different categories changes with the number of categories or with the threshold values of each category, the choice of which is subjective. For example, if we were to make three or seven categories of risk, the number of districts will change in all the categories. The relative ranking (Annexure II) of districts with respect to risk or its determinants is more important for policy considerations.

4 Findings

The status of the districts in the country with respect to different indicators of hazard, exposure and vulnerability is presented in this section. The results of aggregation of the indicators into the indices of hazard, exposure and vulnerability and finally of risk are also presented. The relative ranking of all the districts based on all the indices is presented as Annexure II. As mentioned earlier, this relative ranking may as well be used by decision makers for prioritizing, targeting and allocation of resources.

4.1. Exposure Indicators

Net Sown Area: Net sown area, expressed in terms of per cent of geographical area under cultivation, showed variability across the country. The area under cultivation exceeded 80 per cent of geographical area in 40 districts of which 24 are in Punjab and Uttar Pradesh. Sixty to eighty per cent of geographical area is cultivated in 151 districts predominantly located in the states of Uttar Pradesh, Bihar, Maharashtra, Gujarat, Madhya Pradesh, Haryana and Rajasthan. Relatively less area (< 20%) is cultivated in 92 districts majority of which are in the north-eastern states and in Himalayan states of Jammu and Kashmir and Uttarakhand (Fig E1).

Rural population density: This indicates the pressure on land resources. Population density is more than 800/ km^2 in 66 districts many of which are located in Bihar and Uttar Pradesh. Population pressure is relatively low (<200/ km^2) in the north-eastern states and in the states such as Madhya Pradesh, Chhattisgarh (Fig E2).

Small and marginal farmers: Indian agriculture is dominated by small holdings. About 85 per cent of holdings in the country are less than 2 ha in size. Together, small and marginal farmers operate about 45 per cent of the net sown area in the country. The dominance of small holdings is conspicuous throughout the country with 358 districts having more than 80 per cent of small and marginal farmers. The average farm size, which is inversely related to the proportion of small and marginal holdings, is relatively high in states of Rajasthan and Arunachal Pradesh where they constitute less than 20 per cent of total holdings (Fig E3).

SC/ST population: The population belonging to scheduled castes and schedules tribes ranged between 20 and 40 per cent in 277 out of 573 districts. They constituted more than 80 per cent in 40 districts many of which are located in north-eastern states (Fig E4).

Cross-bred cattle: Cross-bred cattle, though more productive, are more susceptible to climate change and variability. The proportion of cross-bred cattle is high (>40%) in 73 districts. In a majority of districts, cross-bred cattle accounted for less than 10 per cent of total large and small ruminant population (Fig E5).

4.2. Vulnerability indicators

Annual Rainfall: Annual rainfall is one of the important determinants of agricultural production. A wide variation exists with respect to rainfall in the country. The annual rainfall is less than 500 mm in 28 districts largely located in Rajasthan, Haryana and Punjab. The rainfall ranged between 500 - 700 mm in 59 districts. One hundred and ninety five districts largely located in eastern and north-eastern states, Kerala and Maharashtra receive more than 1300 mm rainfall annually (Fig V1).

Area under degraded and waste land: Degraded lands are low in productivity as the physical, chemical, physiographical and biological conditions of soils are not favourable to health crop or vegetation growth. Abiotic stress conditions induced by climate change can make agricultural production even more difficult and risky. More than 60 per cent of geographical area under degraded and waste lands in 131 districts located in Rajasthan, Uttar Pradesh, Maharashtra, Karnataka, Kerala and north-eastern states (Fig V2).

Available water holding capacity (AWC) of the soil: AWC indicates the amount of water that the plant can take from the soil and is a function of soil texture and depth. It is less than 60 mm in 164 districts many of which are located in Bihar, Chhattisgarh, Jammu and Kashmir, Arunachal Pradesh and Assam. About 154 districts in Uttar Pradesh, Madhya Pradesh, Maharashtra and Haryana, soils can hold more than 125 mm of water (Fig V3).

Groundwater availability: Groundwater is the most dominant source of irrigation in the country and is one of the most yield stabilizing factor. Low groundwater availability is a potent constraint to stable agricultural production. Availability of groundwater is less than 20 ha m/ km^2 in as many as 390 districts of the country. It exceeded 40 ha m/ km^2 in 42 districts only most of which are in Uttar Pradesh, Punjab and Assam (Fig V4).

Livestock population: This is an indicator of adaptive capacity as livestock provides an alternative source of income during the periods of climatic shock such as drought. Higher livestock numbers are thus associated with better adaptive capacity. In 259 districts of the country, livestock density is less than 100 ACU/km^2 of geographical area. The density is more than 300 ACU/km^2 in 25 districts only (Fig V5).

Literacy: Adaptation to climate change requires ability to access information and knowledge from a variety of sources and as such an important determinant of adaptive capacity and vulnerability. Literacy levels in a majority of districts (372) in the country ranged between 60 to 80 per cent. However, 45 districts still have literacy levels between 40 to 60 per cent (Fig V6).

Gender Gap: Measured as the difference between total literacy and female literacy, this is an indicator of gender equity. The need for higher female literacy also assumes importance given the current trends in feminization of agriculture partly as a result of migration of male earning members of the household. Relatively wide gender gap (15 - 20%) is noticed in 17 districts only. Many of them are in Rajasthan (Fig V7).

Self-help groups: Social capital is an important enabling mechanism to access information, financial capital and technology. Self-help groups are an important form of social capital in rural India. Measured as per cent of villages in the district having self-help groups, social capital is more than 80 per cent in 248 districts. Less than 40 per cent of villages have self-help groups in 133 districts (Fig V8).

Net Irrigated Area: Irrigation is the single most important yield enhancing and stabilizing factor in agriculture. Less than 20 per cent of the net sown area is irrigated in 145 districts. Many of these districts are located in the states of Maharashtra, Odisha, Assam, Jharkhand, Chhattisgarh, etc. On the other hand, more than 80 per cent of net sown area has access to irrigation in 122 districts in Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, etc (Fig V9).

Road connectivity: A better transport infrastructure, of which road connectivity is a part, is critical to connect farmers to markets. Investments in infrastructure creation resulted in as many as 149 out 0f 573 districts having almost all (>95%) villages connected by paved roads. However, there is some work left in this regard in 105 districts where less than half of villages are connected by paved roads (Fig V10).

Rural electrification: This is another aspect of infrastructure development which is associated with better adaptive capacity. Less than 20 per cent of households have electricity for lighting in 81 districts of the country. They are mostly in Bihar, Uttar Pradesh, Jharkhand and Odisha (Fig V11).

Market density: Access to markets and improved marketing facilities is important to translate higher productivity into better profits. The number of regulated markets in each district can be an indicator of marketing facilities. Expressed as number of markets per lakh farmers, market density varied from less than 2 in 219 districts to more than 8 in 91 districts (Fig V12).

Fertilizer Use: This indicator is taken as a proxy for technology adoption as well as input supply infrastructure for agriculture though it is strongly influenced by cropping pattern and irrigation. Thus, higher fertiliser use can be related to better adaptive capacity of farmers. Less than 100 kg of fertiliser nutrients were applied per ha of gross sown area in as many as 251 districts where as it exceeded 300 kg/ha in 46 districts. Districts with low fertilizer use are observed in Rajasthan, Madhya Pradesh, Odisha, Assam, Jharkhand, Arunachal Pradesh, etc (Fig V13).

Per capita Income: This is an obvious indicator of adaptive capacity and is inversely related to vulnerability. High per capita income allows investments necessary to deal with climate change. Bihar and Uttar Pradesh host 55 of 57 districts with a per capita income of less than INR 15,000. It ranged between INR 15000 - 30000 in 191 districts with Uttar Pradesh, Rajasthan, Madhya Pradesh, Odisha, Assam, Jharkhand, etc. (Fig V14).

Income inequity: This is measured as the difference between the per cent workforce dependent on agriculture and the per cent contribution to district domestic product. A higher value indicates more dependence on agriculture and hence is associated with higher vulnerability. The inequity ranged between 40 - 60 per cent in 286 districts of the country and is more than 60 per cent in 24 districts some of which are located in Maharashtra, Gujarat, Chhattisgarh, Uttarakhand, etc (Fig V15).

4.3. Historical Hazard

Drought proneness: Drought is an important climate related hazard in India. The incidence of drought is more than 15 per cent in 48 districts of the country out of which 26 are located in Rajasthan and Gujarat. Since this indicator is expressed in terms of severe drought which is equivalent to two moderate droughts, it follows that the probability of occurrence of drought is 30 per cent in these 48 districts (Fig HH 1).

Flood proneness: Districts with larger areas subjected to flooding face high hazard. More than 60 per cent of area is prone to flood incidence in 39 districts and another 58 districts have flood prone area in the range of 30 – 60 per cent. Many of these flood prone districts are in Bihar, Uttar Pradesh, Punjab and West Bengal (Fig HH2).

Cyclone proneness: This indicator is computed considering five parameters viz., number of cyclones crossing the district, number severe cyclones crossing the district, probable rainfall for a day, probable maximum winds in know and probable maximum storm surge. High and very high cyclone proneness is observed in 46 districts largely located in Andhra Pradesh, Gujarat, Odisha, West Bengal and Tamil Nadu (Fig HH3).

4.4. Future Hazard Indicators

As mentioned earlier, these are derived from the climate projections for the period 2020-49 for the RCP 4.5. The daily projections on rainfall, maximum temperature and minimum temperature for 2020-49 are converted into agriculturally relevant indicators and are expressed in terms of change with respect to baseline period 1976-2005. The information on the status of these 15 indicators for the baseline period is presented in figures in Annexure III.

Change in annual rainfall: Projections indicate no considerable change in annual rainfall with 396 districts expected to receive 3 – 6 per cent more rainfall compared to 1976-2005 baseline. However, rainfall is expected to increase by more than 6 per cent in 57 districts of which 21 are in Gujarat, 8 in Madhya Pradesh, 5 in Uttar Pradesh, 4 in Rajasthan and 3 in Tamil Nadu (Fig FH1).

Change in rainfall during June: Climate projections indicate a marginal decline in rainfall during June in 27 districts. Nine of these 27 districts are in Karnataka, 7 in Maharashtra and 4 in Kerala. On the other hand, June rainfall in 45 districts is expected to increase by more than 6 per cent. In most districts (501), marginal increase in rainfall is expected (Fig FH2).

Change in rainfall during July: Rainfall during July is critical to the beginning of the agricultural season in the country. In most of the districts (471), July rainfall is projected to increase marginally by up to five per cent. It is expected to decline marginally in 12 districts (6 in Karnataka, 2 in Kerala) only (Fig FH3).

Change in number of rainy days: Number of rainy days is an indicator of temporal distribution of rainfall. Fewer rainy days are projected for 48 districts. Rainy days are expected to increase by more than three in 12 districts of Gujarat, four districts of Rajasthan, two each in Maharashtra and Mizoram (Fig FH4).

Change in maximum temperature: Maximum temperature is expected to increase by 1 to 1.3^{0}C in 256 districts, by 1.3 to 1.6^{0}C in 157 districts. Highest increase of more than 1.9^{0}C is projected for three districts in Himachal Pradesh, two in Jammu and Kashmir and one each in Madhya Pradesh and Maharashtra (Fig FH5).

Change in minimum temperature: As with maximum temperature, minimum temperature is also projected to increase in all the districts of the country. The increase ranged from $<1.3^{0}$C in 199 districts to $>1.6^{0}$C in 89 districts. Many of the latter are in the states of Madhya Pradesh (15), Jammu and Kashmir (13), Himachal Pradesh (12), Rajasthan (10), Uttar Pradesh (8) and Uttarakhand (8) (Fig FH6).

Change in incidence of unusually hot days: Number of days with abnormally high maximum temperature during March to May is expected to increase by more than one in 54 districts. A majority of these districts are in the Himalayan states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, north-eastern states and in Punjab (Fig FH7).

Change in incidence of unusually cold days: Frequency of days with lower than normal minimum temperature during December to February is projected to increase, though marginally, in 526 districts. Noticeable increase in such conditions is projected to occur in 29 districts (Chhattisgarh (8), Uttar Pradesh (8), Madhya Pradesh (7), Maharashtra (4), and one each in Odisha and Rajasthan (Fig FH8).

Change in occurrence of frost: The number of days when the minimum temperature goes below 0^{0}C remain about the same in 548 districts and to decrease by more than 10 days in 11 districts of Jammu and Kashmir (Fig FH9).

Change in drought proneness: The incidence of drought, expressed in terms of severe drought equivalents, is projected to increase in about 302 districts and to decrease in 144 districts. Many of the districts where drought incidence is projected to increase are in Uttar Pradesh (38), Madhya Pradesh (25), Bihar (22), Rajasthan (19), Tamil Nadu (19), Maharashtra (18), Assam (14), Odisha (13), and Uttarakhahnd (10) (Fig FH10).

Change in incidence of Dry Spells: Expressed as a score computed based on the number of dry spells of at least 14 days duration, incidence of dry spells is projected to in 119 districts. It is expected to remain as in the baseline situation in 85 districts (Fig FH11).

Change in 99 percentile of daily rainfall: An increase in the value of this indicator is associated with increase in extreme rainfall hazard. The 99 percentile rainfall is expected to increase by 4mm 20 districts (Gujarat (8), Meghalaya (3), Daman & Diu (3)). It is projected to increase by 2 to 4 mm in 283 districts many of which are in Madhya Pradesh, Bihar, Maharashtra, Gujarat, Jharkhand, Odisha, Assam, Tamil Nadu, etc (Fig FH12).

Change in number of events with more than 100 mm rainfall in three consecutive days: The incidence of this extreme rainfall event is expected to increase in all the districts. The frequency of such events is expected to increase by more than 1.5 in Arunachal Pradesh (6 districts), Kerala (4), Meghalaya (4), Sikkim (3), Gujarat (2), Assam (2), Maharashtra (2), one each in Bihar and Uttarakhand (Fig FH13).

Change in mean maximum rainfall in single event: The amount of rainfall in one single event expressed as per cent to annual rainfall is expected to increase marginally in most of the districts except in 55 districts where it is projected to decrease marginally. Many of these 55 districts are in Gujarat (11), Maharashtra (10), Rajasthan (9), Madhya Pradesh (7) and Tamil Nadu (6) (Fig FH14).

Change in mean maximum rainfall in three consecutive days: This is also an indicator of extreme rainfall event and is expressed as the amount of maximum rainfall received in three consecutive days in relation to the annual rainfall. Any increase in this is associated with increase in the possible flood hazard. It is projected to increase by more than 0.4 per cent in 25 districts and by 0.2 to 0.4 per cent in 174 districts (Fig FH15).

4.5. Risk and its determinants

Exposure: Exposure summarizes the five indicators of who and what are being exposed to the hazard of climate change. 'Very high' exposure can be seen in 50 districts most of which are in Uttar Pradesh, Bihar, Kerala and West Bengal. About 127 districts are found to have 'high' exposure. 'Low' and 'very low' exposure is observed in 192 districts (Fig E6 and Table 8).

Vulnerability: This is an aggregation of 15 indicators and indicates the predisposition to the hazard. Vulnerability is found to be 'high' and 'very high' in 171 and 22 districts, respectively. Many of them are in the states of Rajasthan, Maharashtra, Jharkhand, Odisha, Arunachal Pradesh, Chhattisgarh, Madhya Pradesh, Karnataka, etc. Districts with 'low' and 'very low' vulnerability are in Uttar Pradesh, Haryana, Punjab, Tamil Nadu, West Bengal, Gujarat, etc (Fig V16 and Table 9).

Historical Hazard: Computed based on the historical incidence of three hazards of drought, flood and cyclone, 'very high' historical hazard is observed in 46 districts and 'high' historical hazard in 128 districts. Districts that experience more than one of the three hazards are likely to suffer more. For example, districts on the coast suffer from both flood and cyclone and some districts in Gujarat suffer from both drought and cyclone. Thus, districts with relatively higher historical hazard are in the states of Gujarat, Rajasthan, Uttar Pradesh, Tamil Nadu, Punjab, Haryana, West Bengal, etc (Fig HH4 and Table 10).

Future Hazard: Computed as an aggregate of a number of agriculturally relevant indicators computed using climate projections for RCP 4.5, future climate is likely to be 'more unfavourable' in 126 districts and 'moderately unfavourable' 199 districts. Thus, climate change implies a worsening situation in many of the districts in the country (Fig FH16 and Table 11).

Climate Change Risk: Risk is the resultant of interaction among exposure, vulnerability and hazard. The analysis indicated 'very high' risk for 109 districts in Uttar Pradesh (22), Rajasthan (17), Bihar (10), Kerala (8), Uttarakhand (7), Odisha (6), Punjab (5), and the remaining in the states of West Bengal, Karnataka, Haryana, Gujarat, Mizoram, Assam, Himachal Pradesh, etc. Most of the 201 districts with 'high' risk are in Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Karnataka, Rajasthan, Bihar, Odisha, Maharashtra, etc. These districts have to be given high priority while planning for measures for protecting agriculture and farmers from the adverse impacts of climate change (Fig R1 and Table 12).

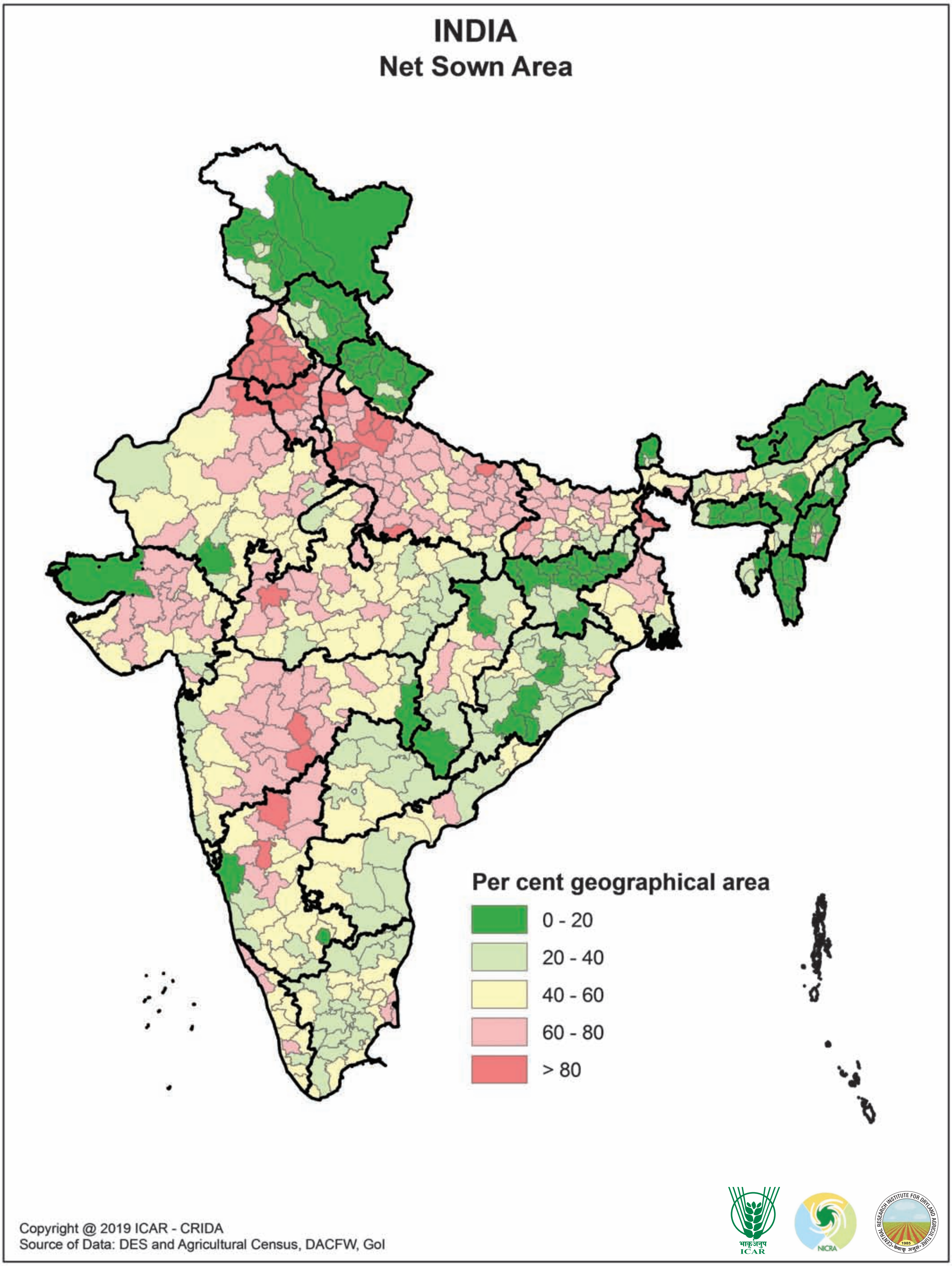

INDIA
Net Sown Area
Per cent geographical area
0 - 20
20 - 40
40 - 60
60 - 80
> 80
Copyright @ 2019 ICAR - CRIDA
Source of Data: DES and Agricultural Census, DACFW, GoI

Fig. E1

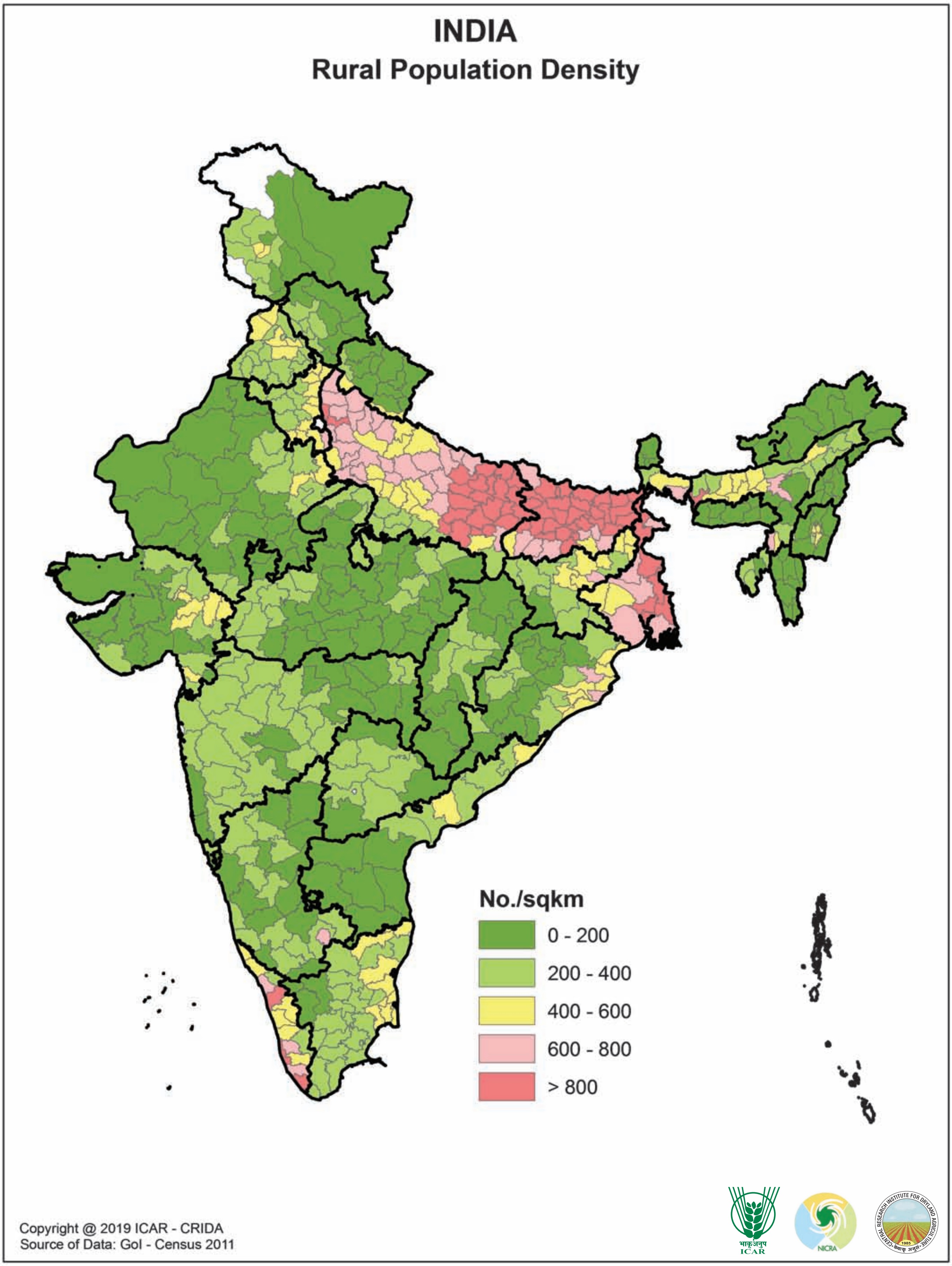

INDIA
Rural Population Density
No./sqkm
0 - 200
200 - 400
400 - 600
600 - 800
> 800
Copyright @ 2019 ICAR - CRIDA
Source of Data: GoI - Census 2011
ICAR
NICRA

Fig. E2

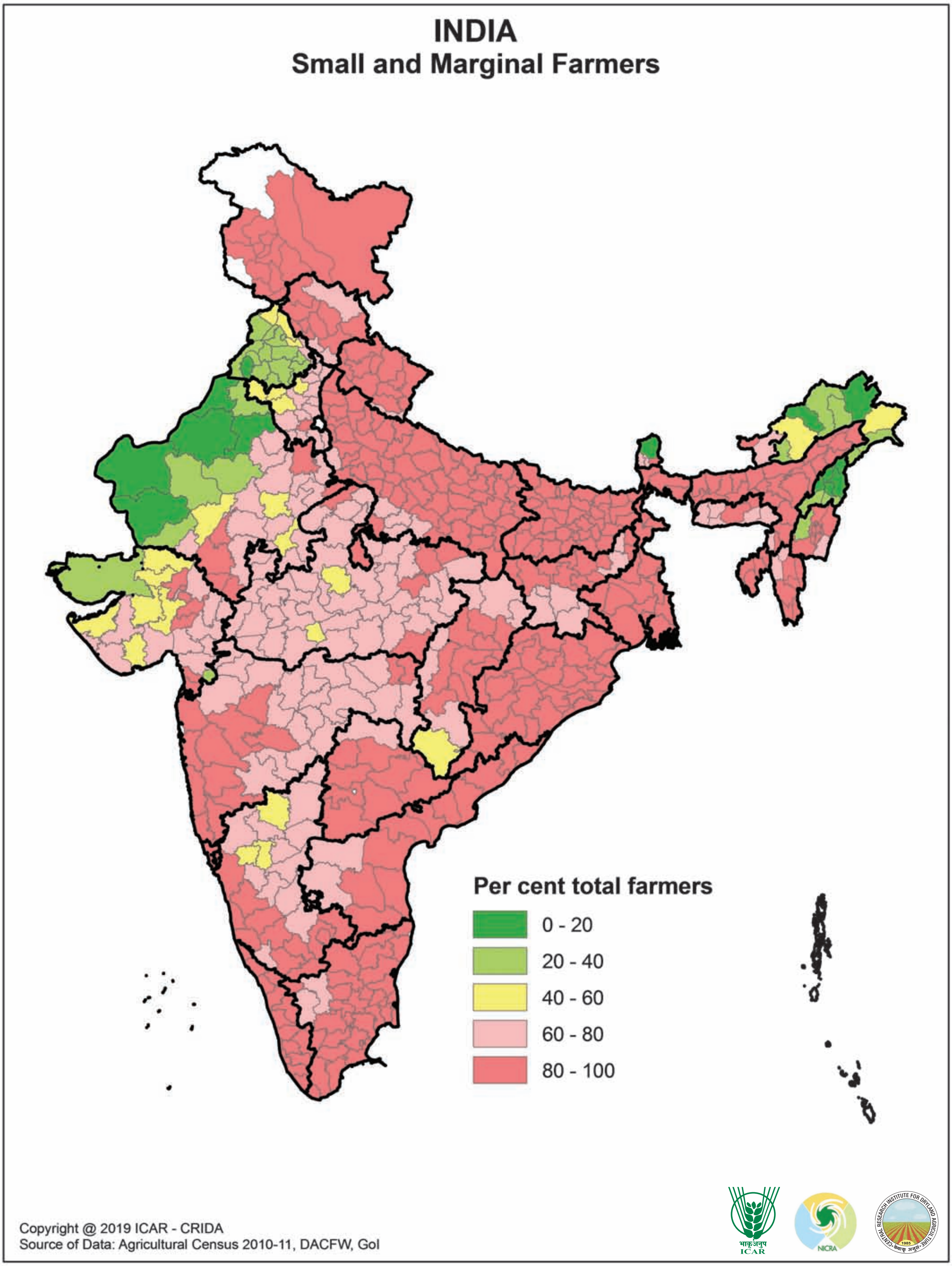

INDIA
Small and Marginal Farmers
Per cent total farmers
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Copyright @ 2019 ICAR - CRIDA
Source of Data: Agricultural Census 2010-11, DACFW, GoI

Fig. E3

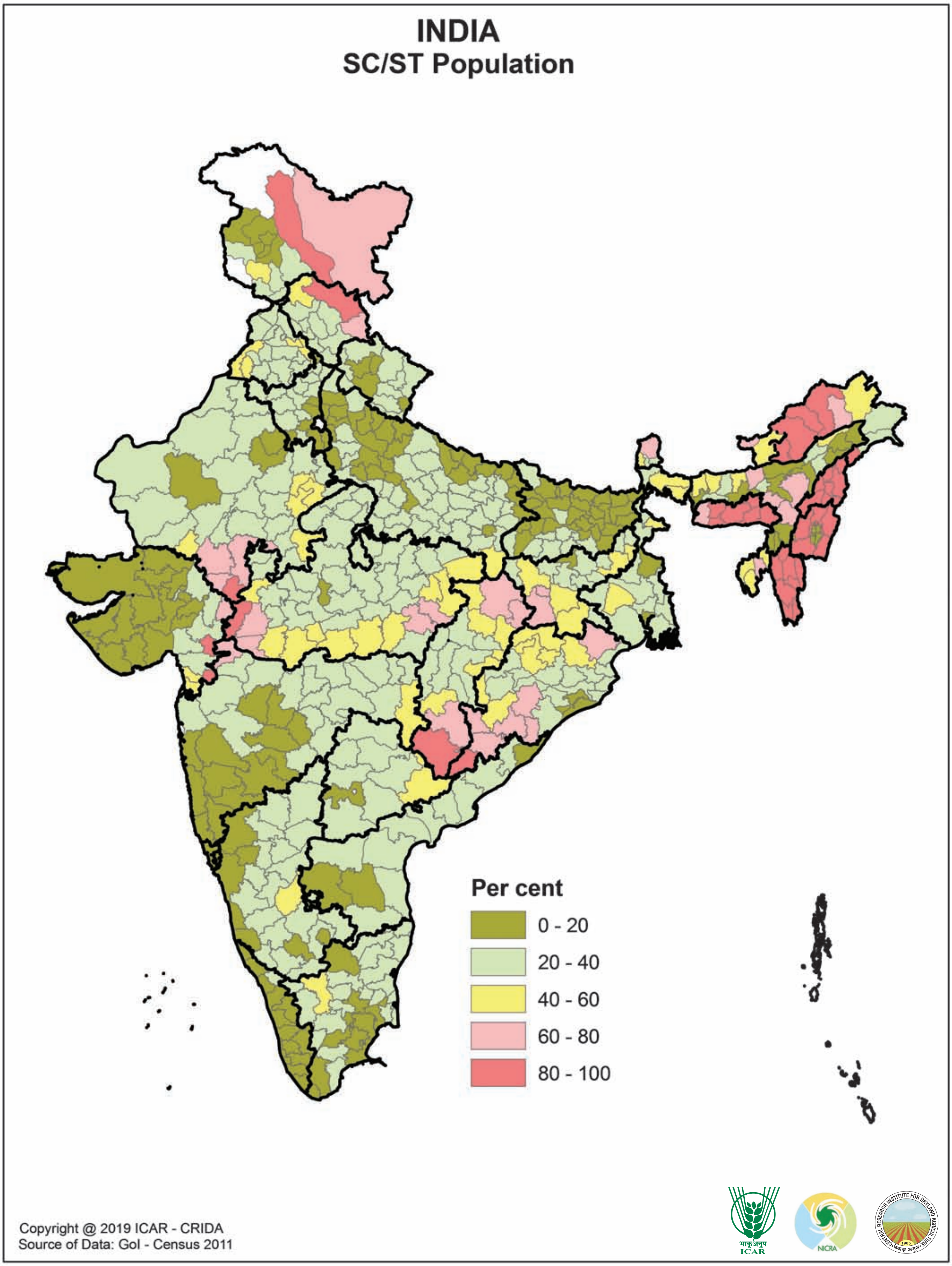
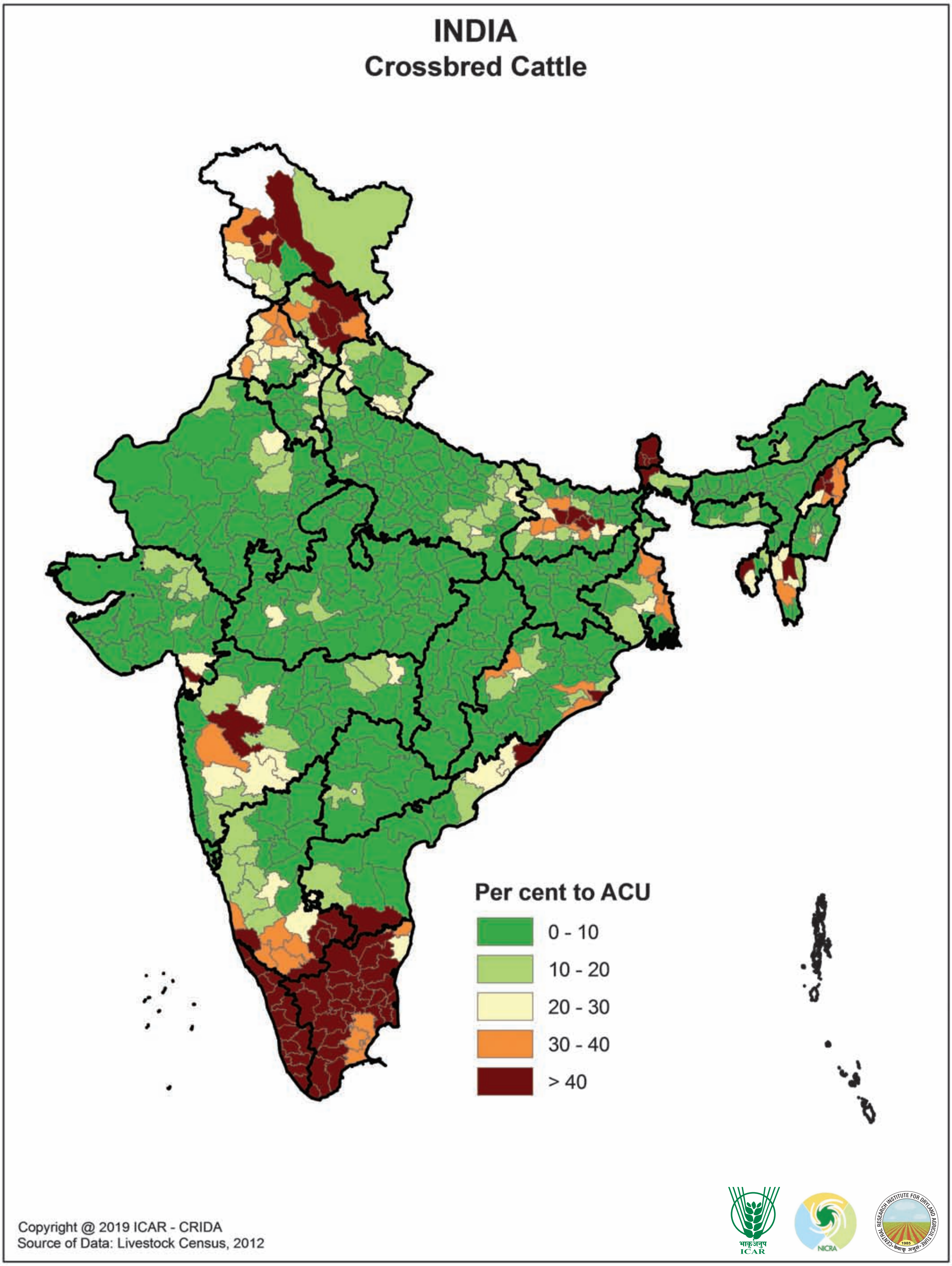

INDIA
SC/ST Population
Per cent
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Copyright @ 2019 ICAR - CRIDA
Source of Data: GoI - Census 2011

Fig. E4


INDIA
Crossbred Cattle
Per cent to ACU
0 - 10
10 - 20
20 - 30
30 - 40
> 40
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Source of Data: Livestock Census, 2012

Fig. E5

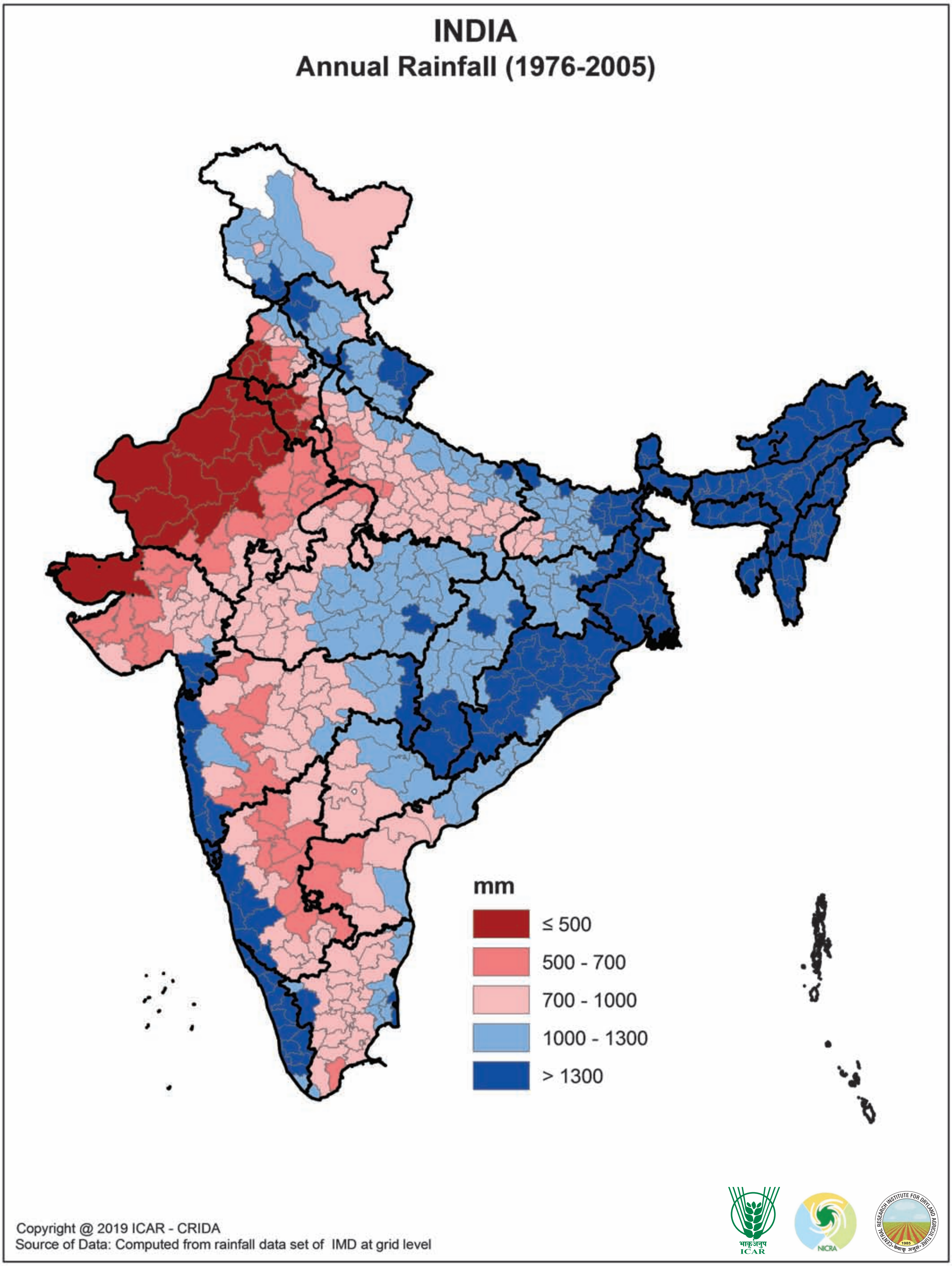

INDIA
Annual Rainfall (1976-2005)
mm
≤ 500
500 - 700
700 - 1000
1000 - 1300
> 1300
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed from rainfall data set of IMD at grid level
NICRA

Fig. V1

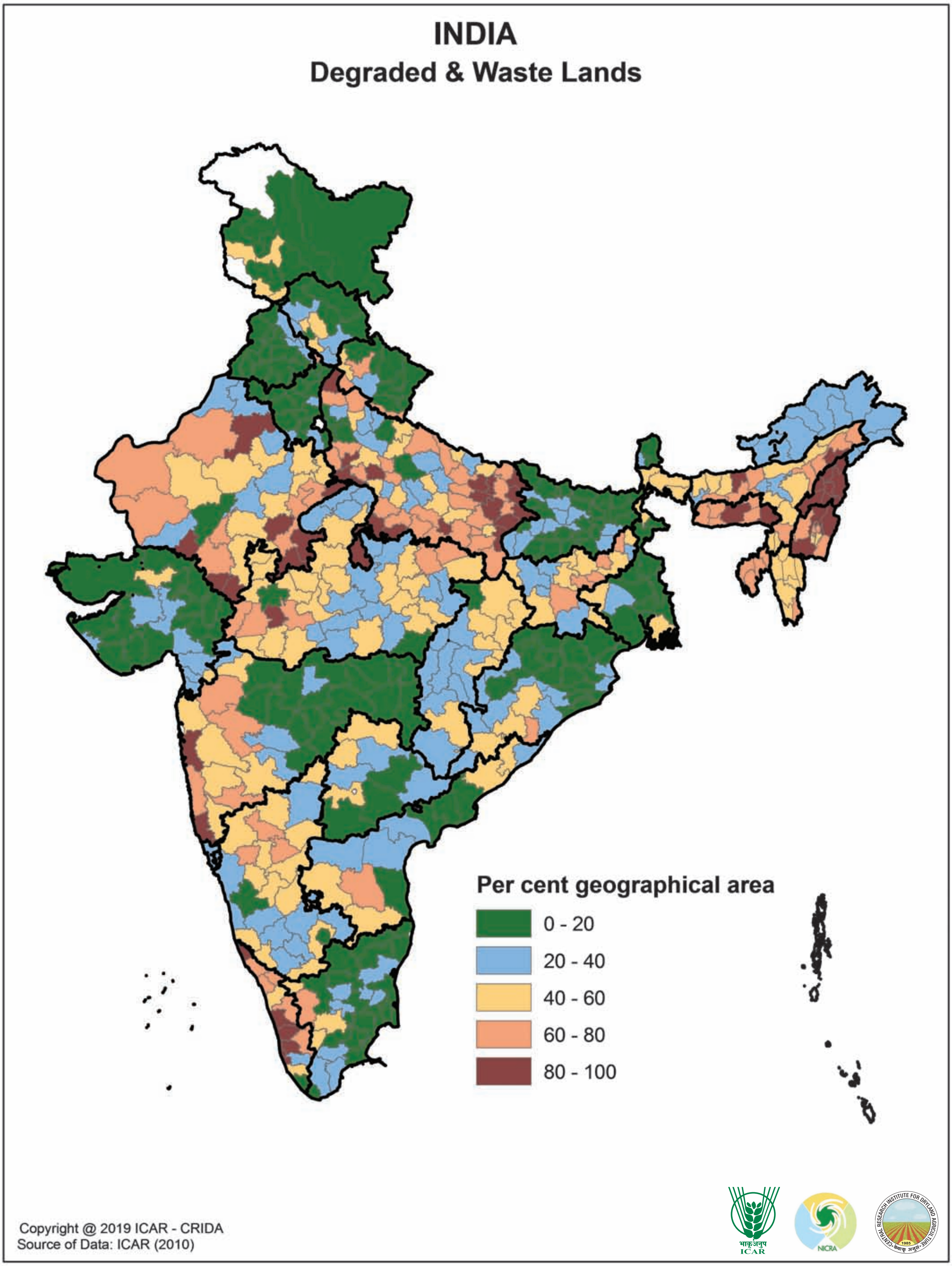

INDIA
Degraded & Waste Lands
Per cent geographical area
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Copyright @ 2019 ICAR - CRIDA
Source of Data: ICAR (2010)

Fig. V2

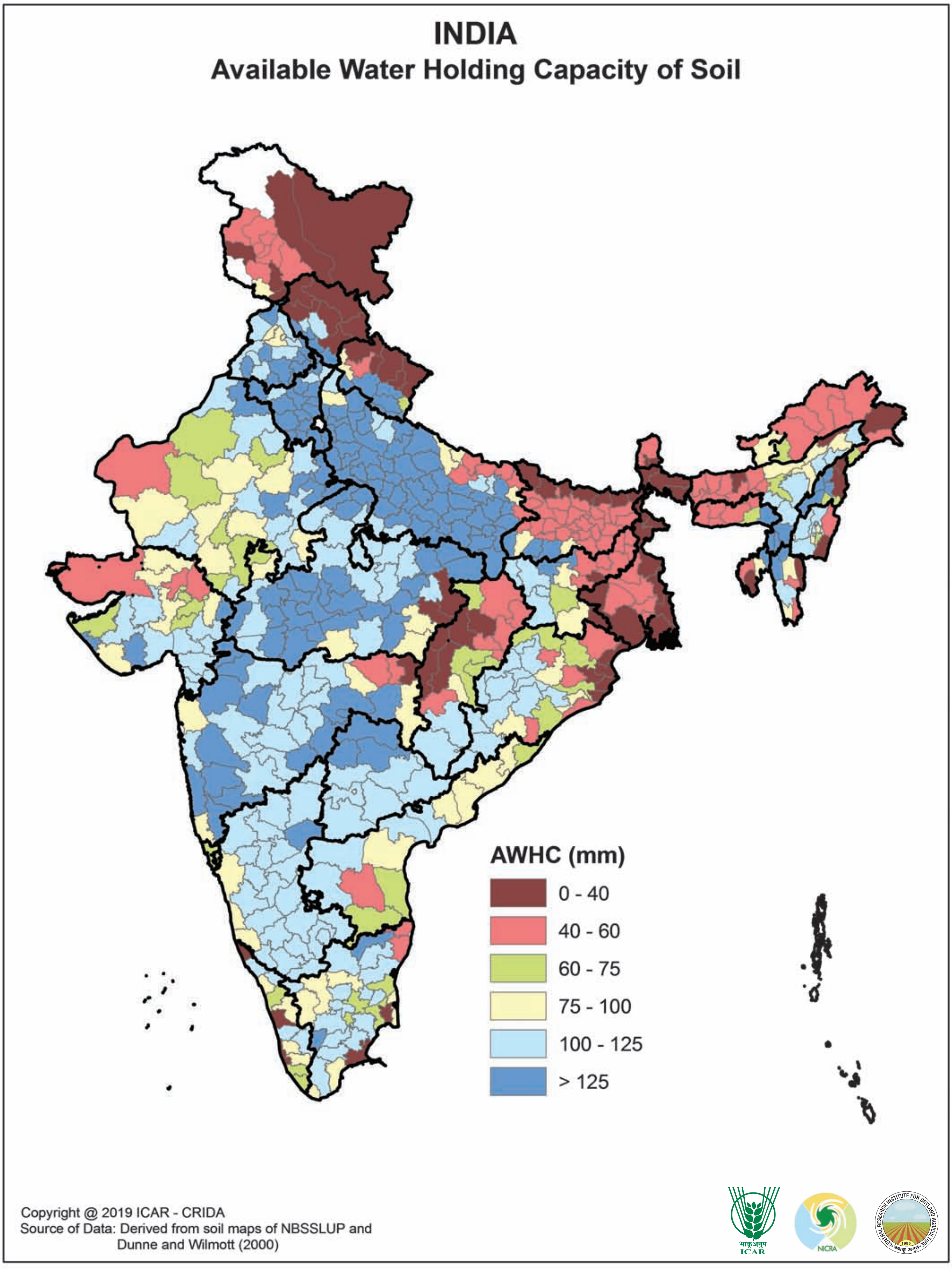
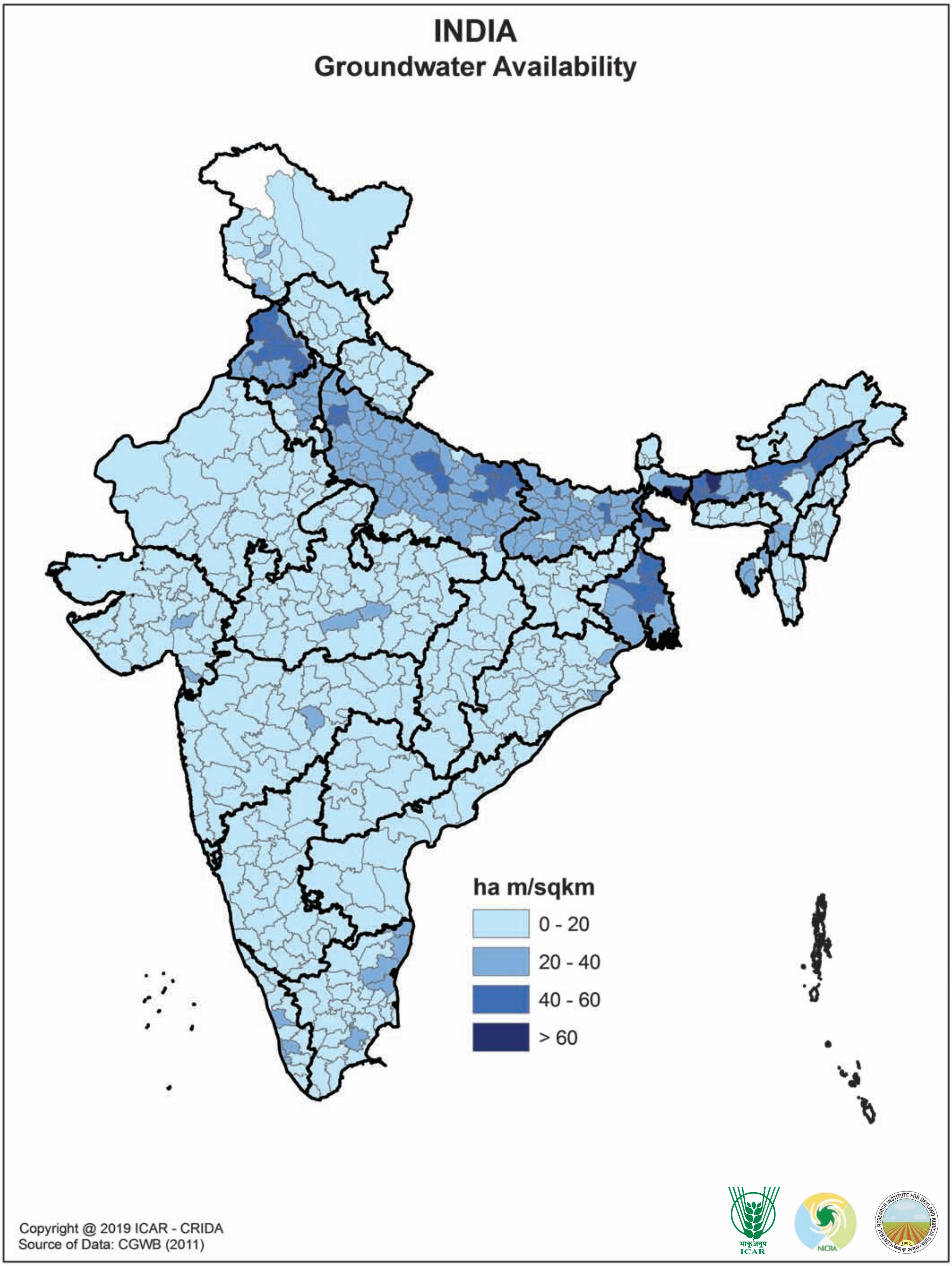

INDIA
Available Water Holding Capacity of Soil
AWHC (mm)
0 - 40
40 - 60
60 - 75
75 - 100
100 - 125
> 125
Copyright @ 2019 ICAR - CRIDA
Source of Data: Derived from soil maps of NBSSLUP and
Dunne and Wilmott (2000)

Fig. V3



INDIA
Groundwater Availability
ha m/sqkm
0 - 20
20 - 40
40 - 60
> 60
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Source of Data: CGWB (2011)

Fig. V4

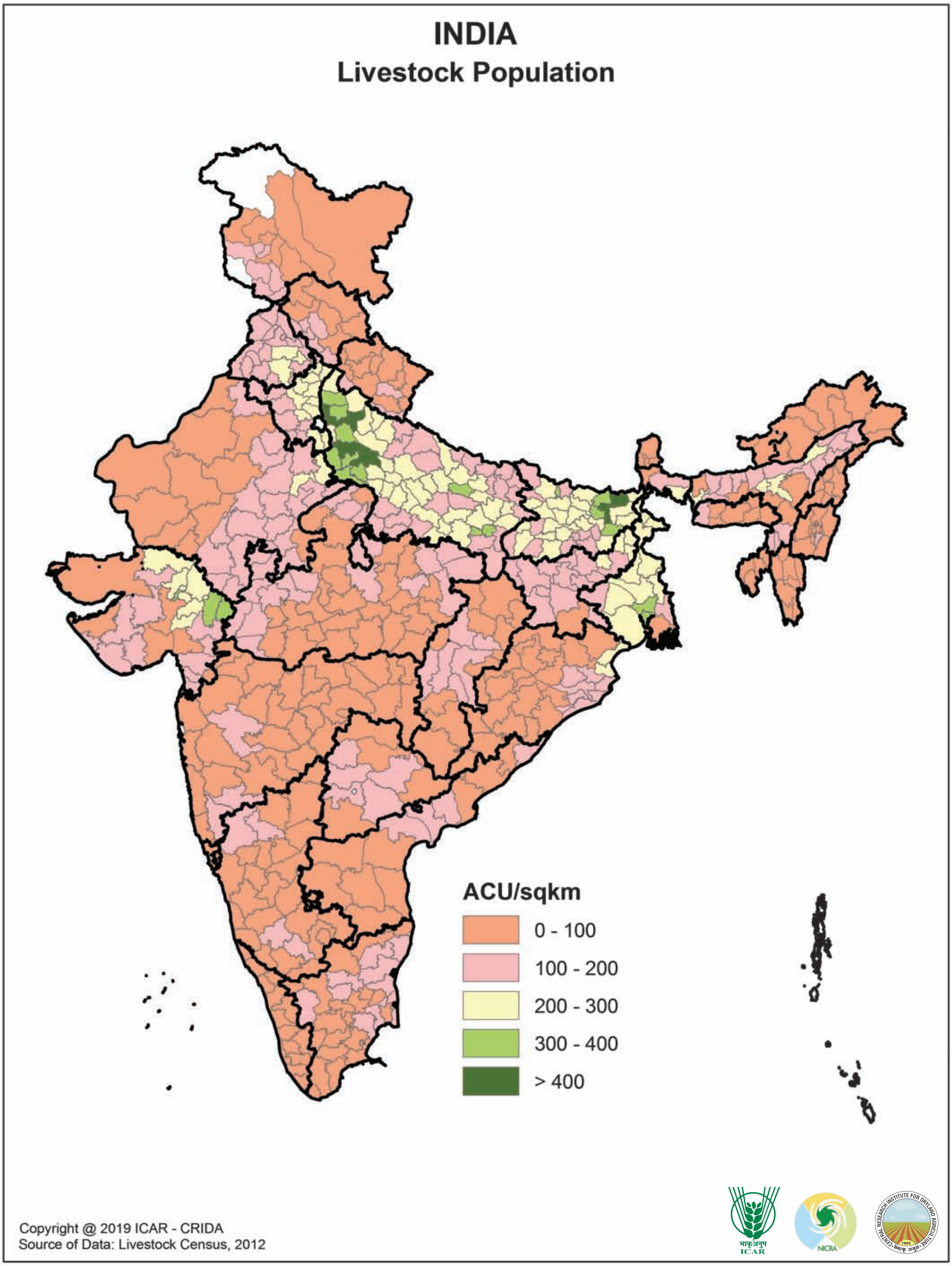
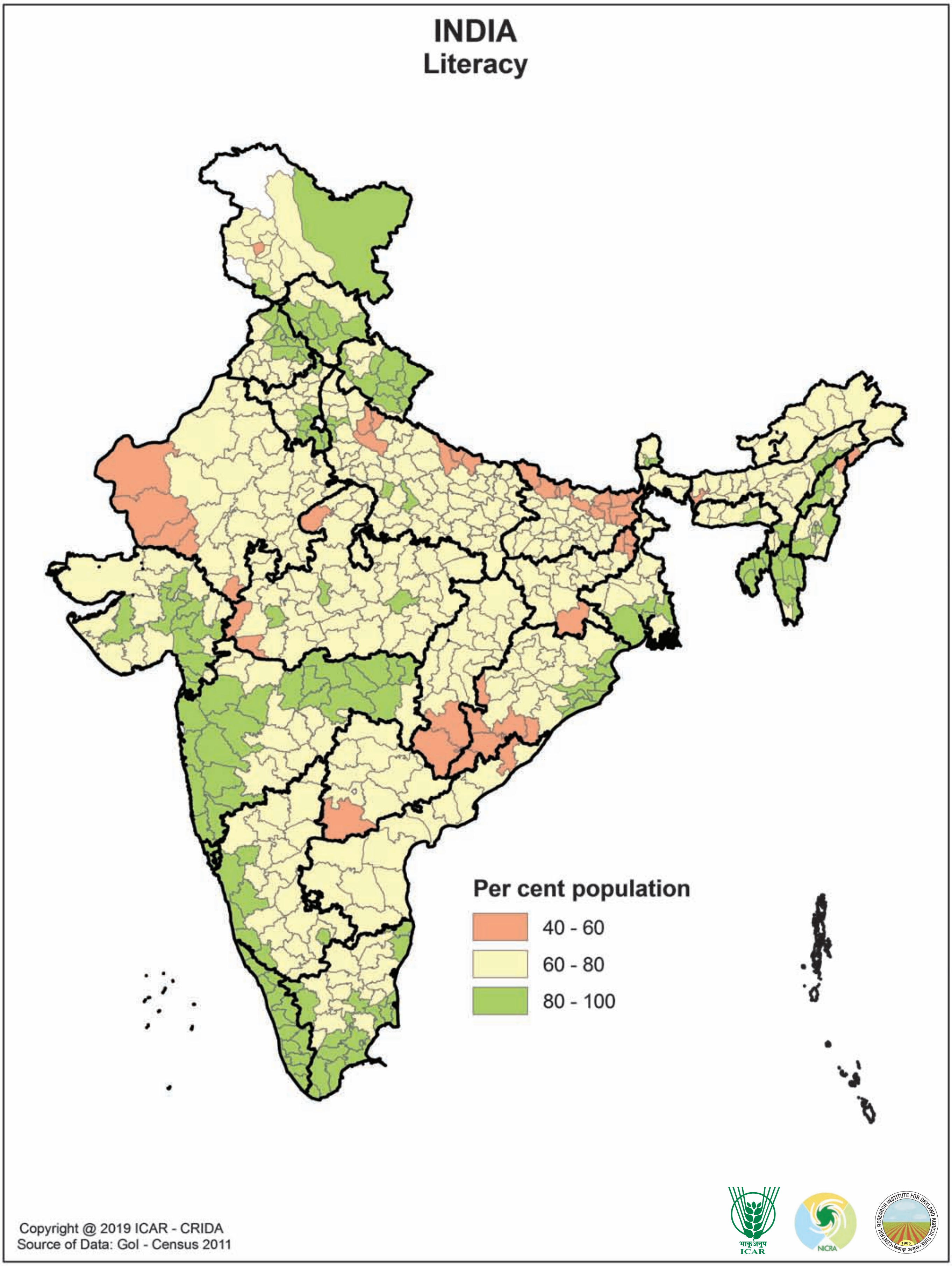

INDIA
Livestock Population
ACU/sqkm
0 - 100
100 - 200
200 - 300
300 - 400
> 400
Copyright @ 2019 ICAR - CRIDA
Source of Data: Livestock Census, 2012

Fig. V5


INDIA
Literacy
Per cent population
40 - 60
60 - 80
80 - 100
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Source of Data: GoI - Census 2011
ICAR
NICRA

Fig. V6

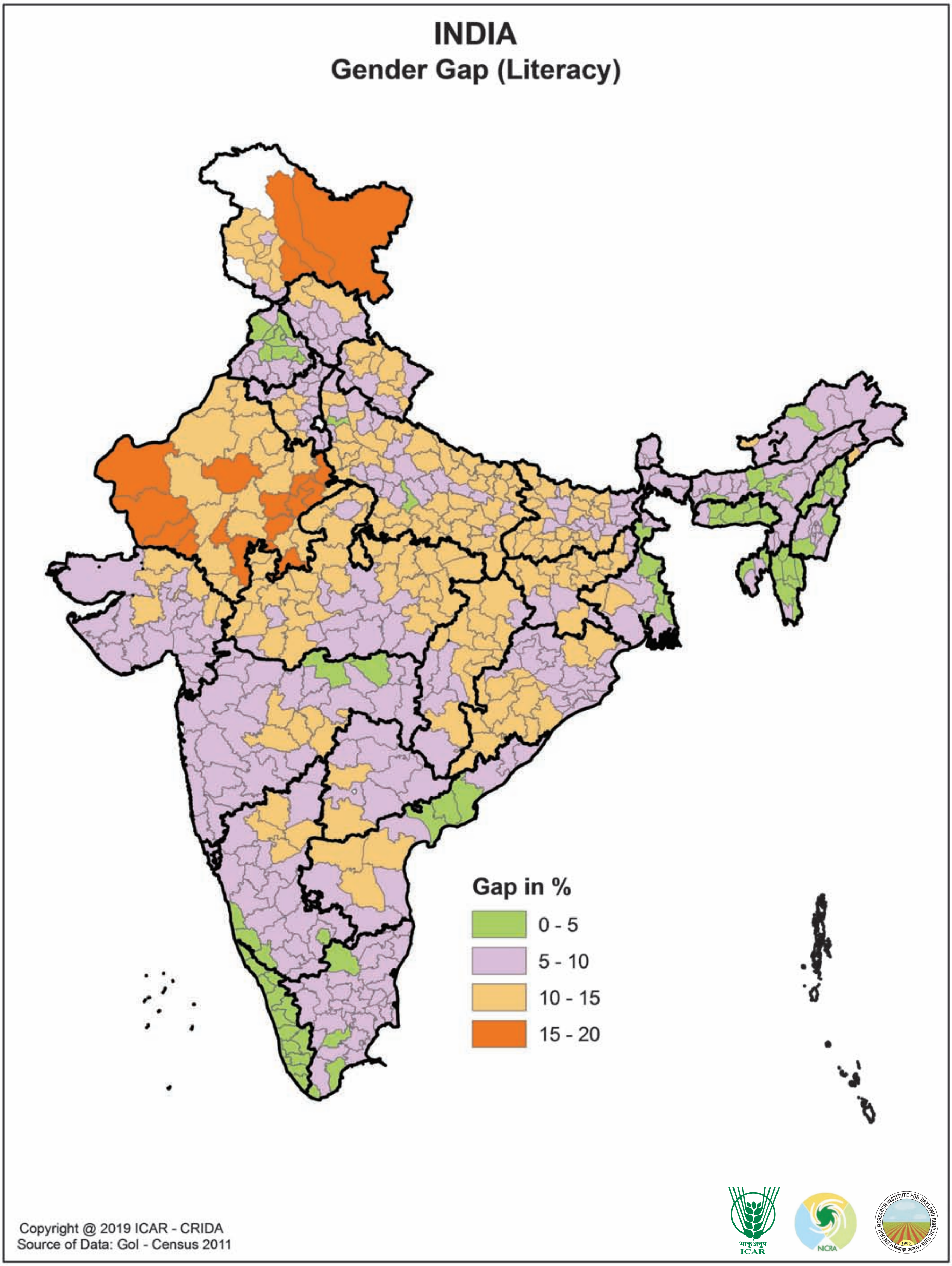

INDIA
Gender Gap (Literacy)
Gap in %
0 - 5
5 - 10
10 - 15
15 - 20
Copyright @ 2019 ICAR - CRIDA
Source of Data: GoI - Census 2011

Fig. V7

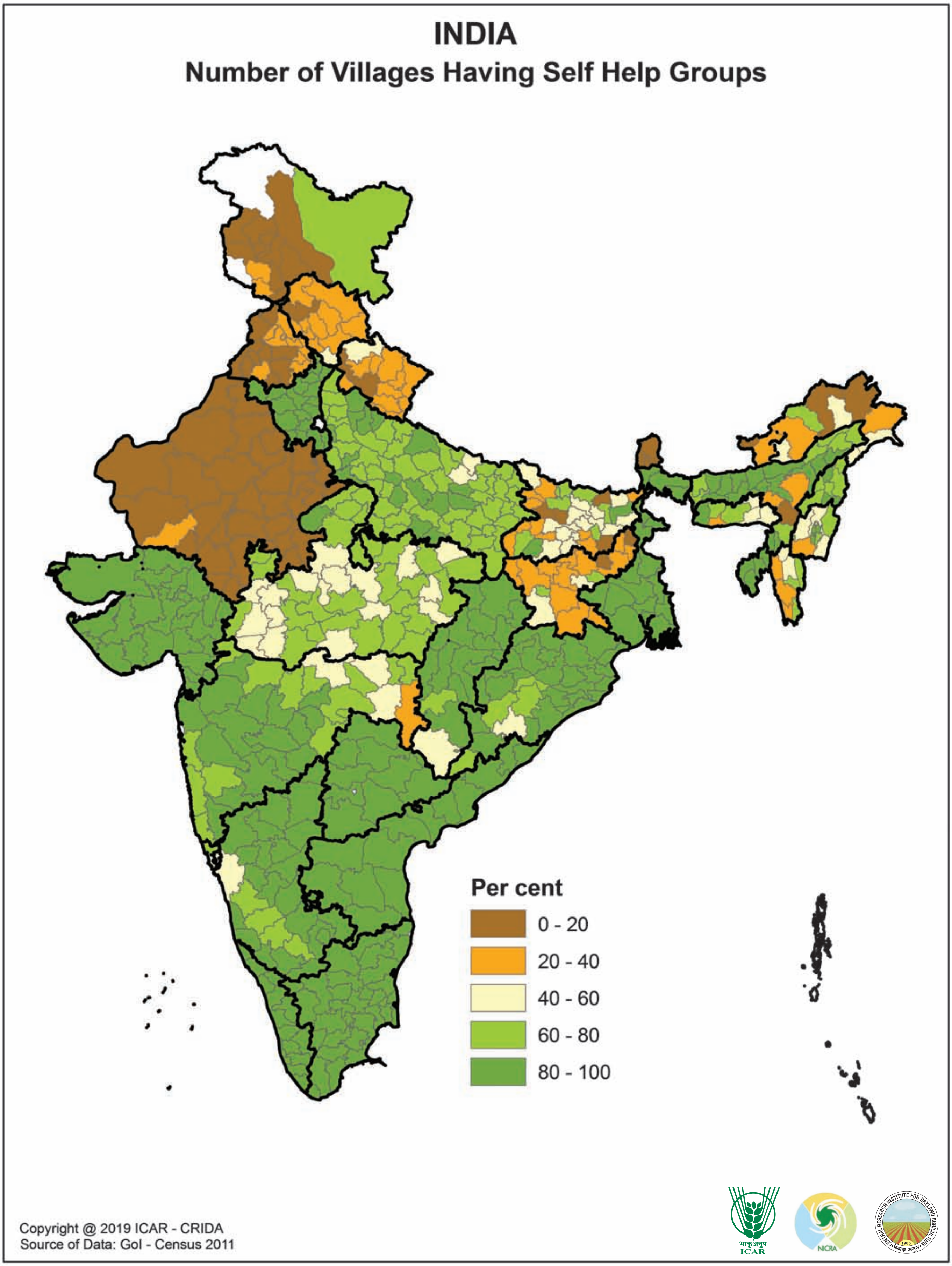

INDIA
Number of Villages Having Self Help Groups
Per cent
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Copyright @ 2019 ICAR - CRIDA
Source of Data: GoI - Census 2011

Fig. V8

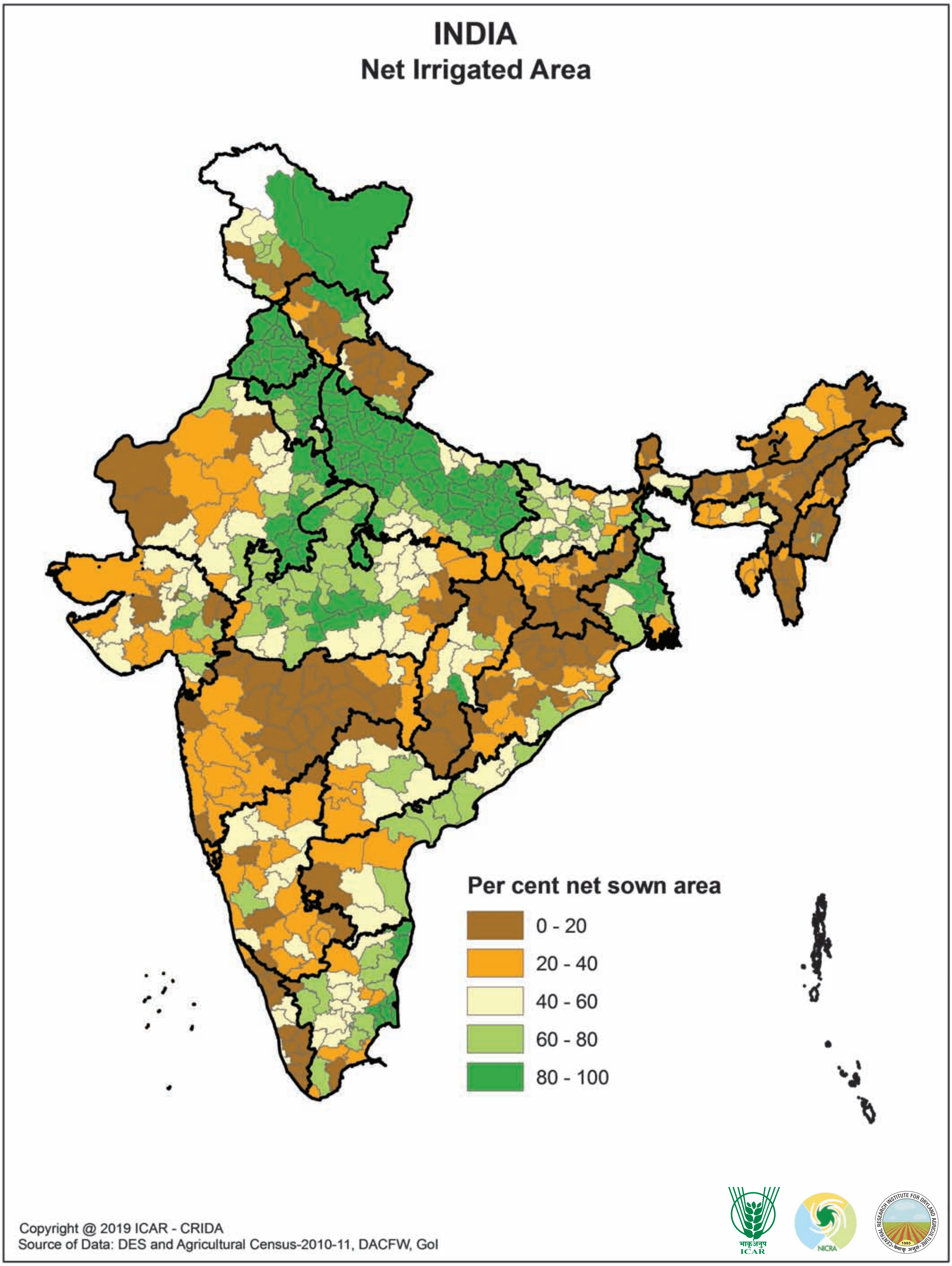

INDIA
Net Irrigated Area
Per cent net sown area
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Copyright @ 2019 ICAR - CRIDA
Source of Data: DES and Agricultural Census-2010-11, DACFW, GoI

Fig. V9

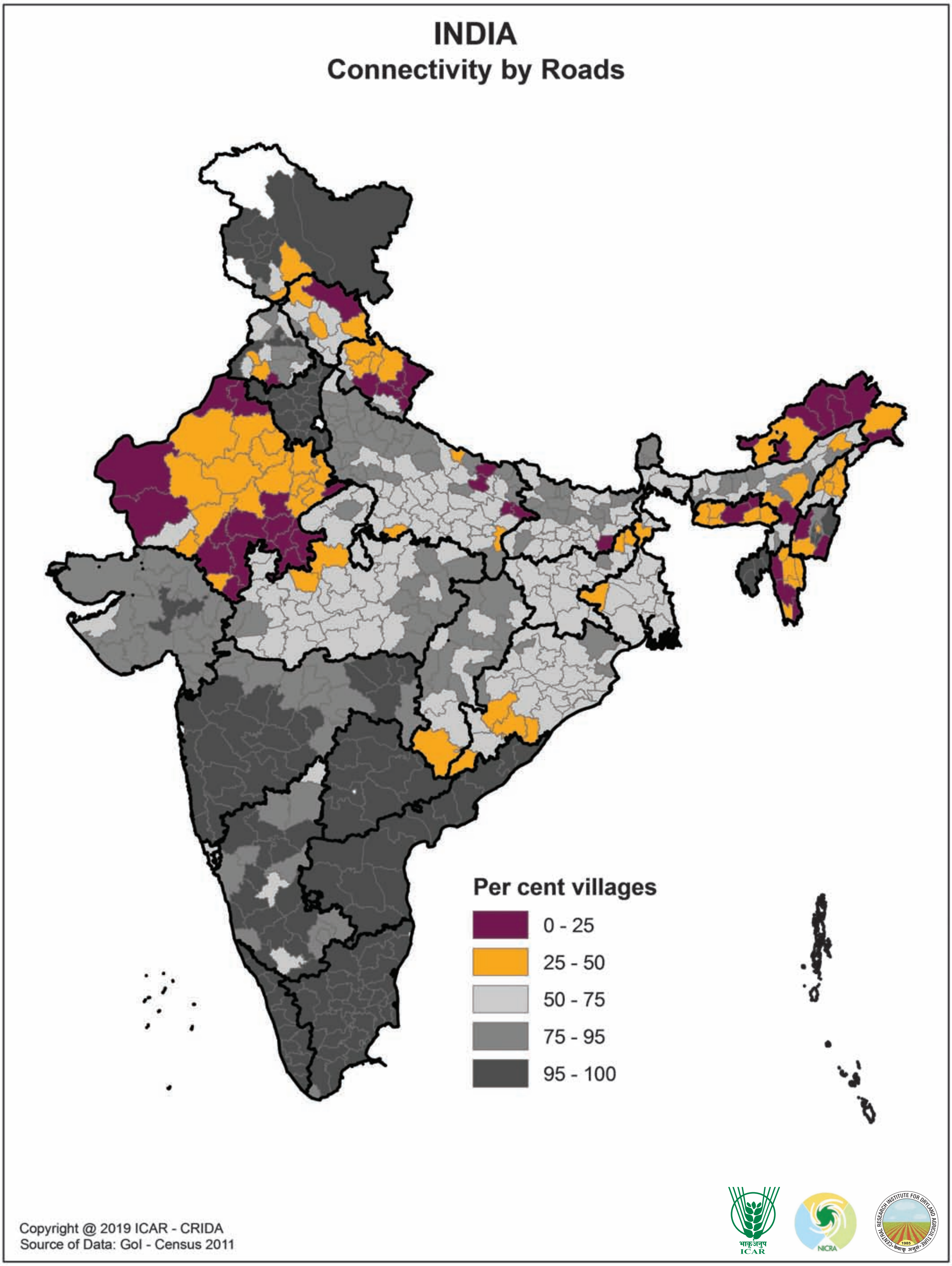
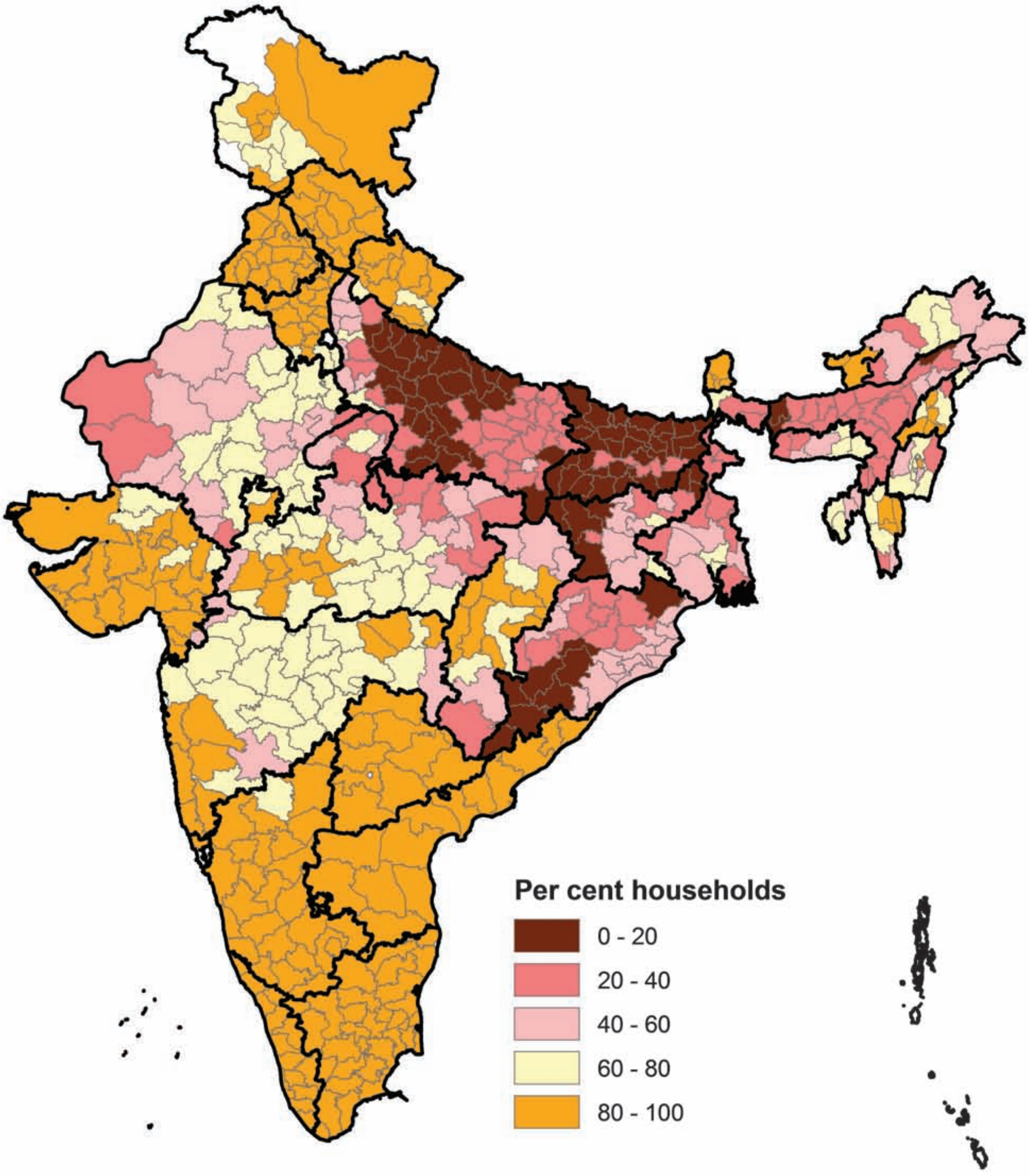

INDIA
Connectivity by Roads
Per cent villages
0 - 25
25 - 50
50 - 75
75 - 95
95 - 100
Copyright @ 2019 ICAR - CRIDA
Source of Data: GoI - Census 2011

Fig. V10

INDIA
Rural Households Having Electricity as Source of Lighting



Source of Data: GoI - Census 2011

Fig. V11

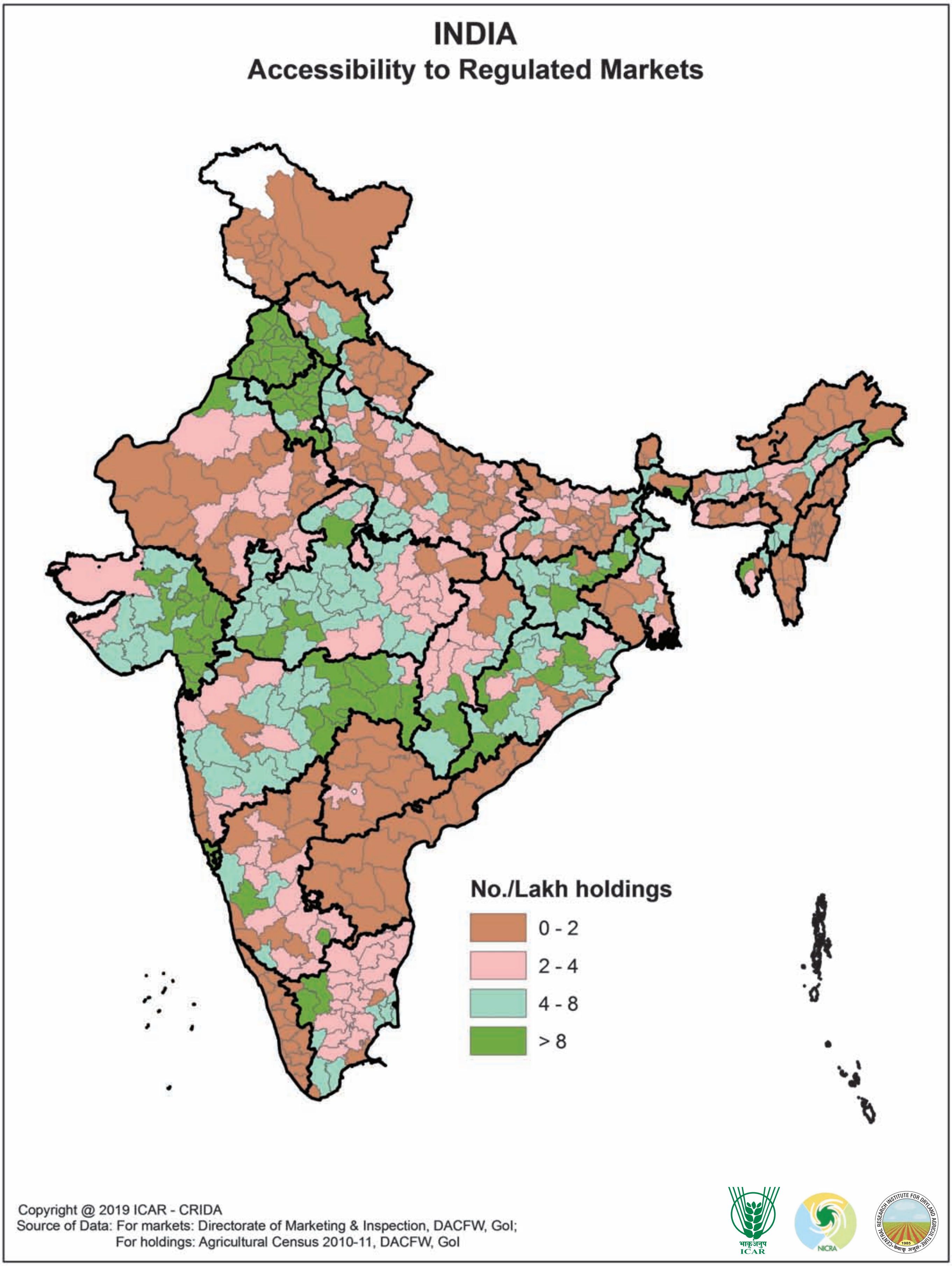

INDIA
Accessibility to Regulated Markets
No./Lakh holdings
0 - 2
2 - 4
4 - 8
> 8
Copyright @ 2019 ICAR - CRIDA
Source of Data: For markets: Directorate of Marketing & Inspection, DACFW, GoI;
For holdings: Agricultural Census 2010-11, DACFW, GoI
ICAR
NICRA

Fig. V12

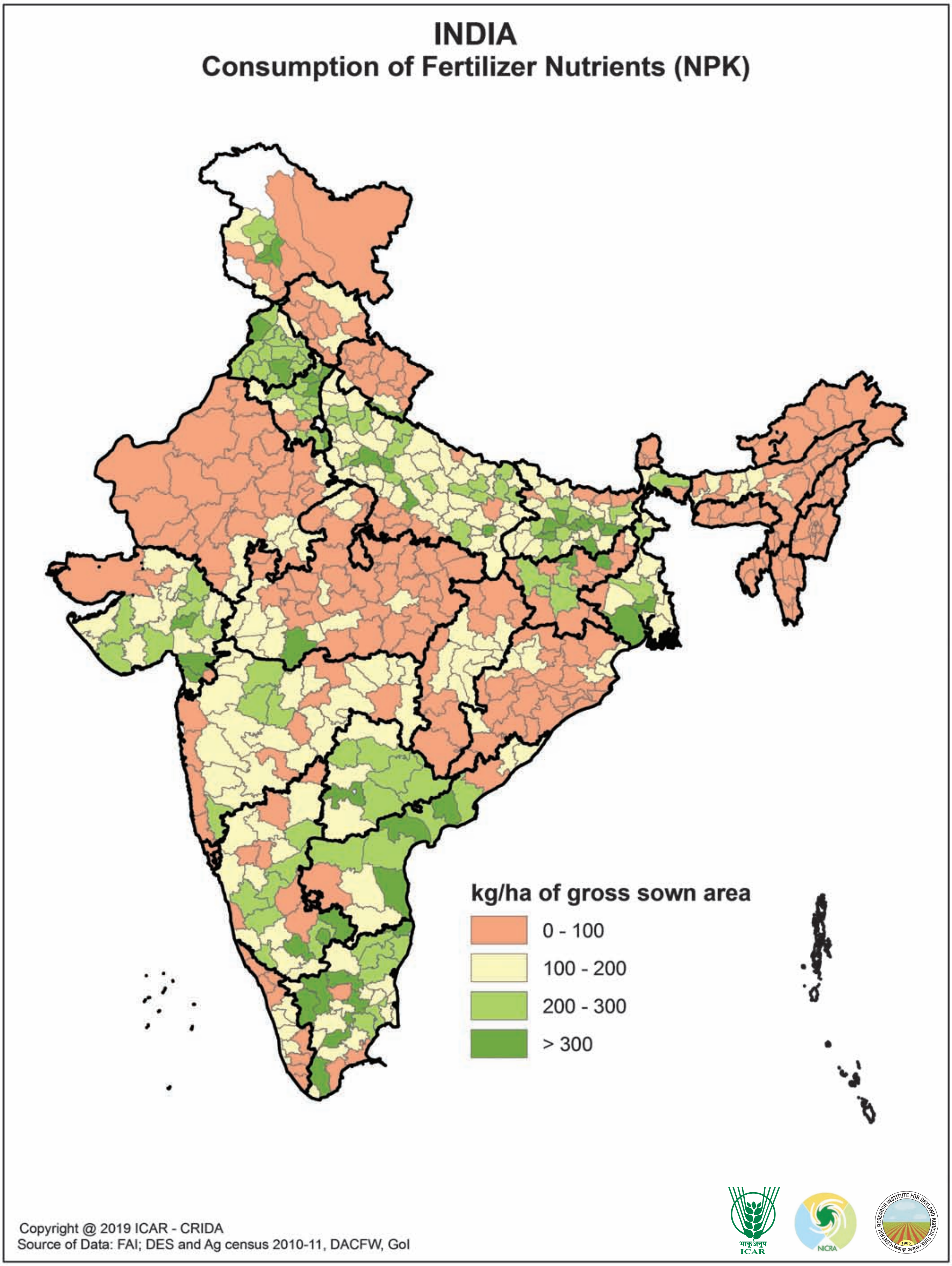
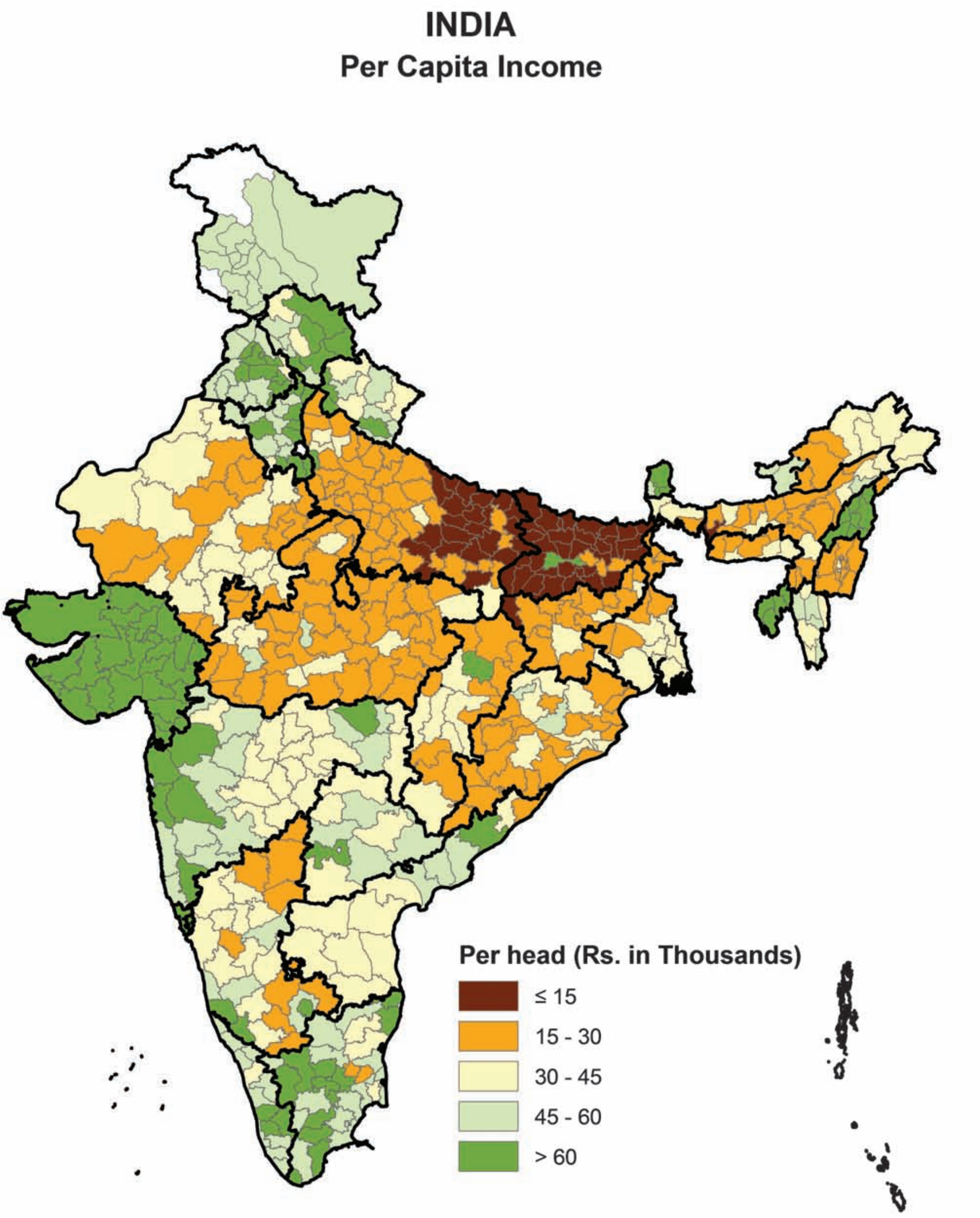

INDIA
Consumption of Fertilizer Nutrients (NPK)
kg/ha of gross sown area
0 - 100
100 - 200
200 - 300
> 300
Copyright @ 2019 ICAR - CRIDA
Source of Data: FAI; DES and Ag census 2010-11, DACFW, GoI

Fig. V13



Source of Data: RBI and Planning Commission

Fig. V14

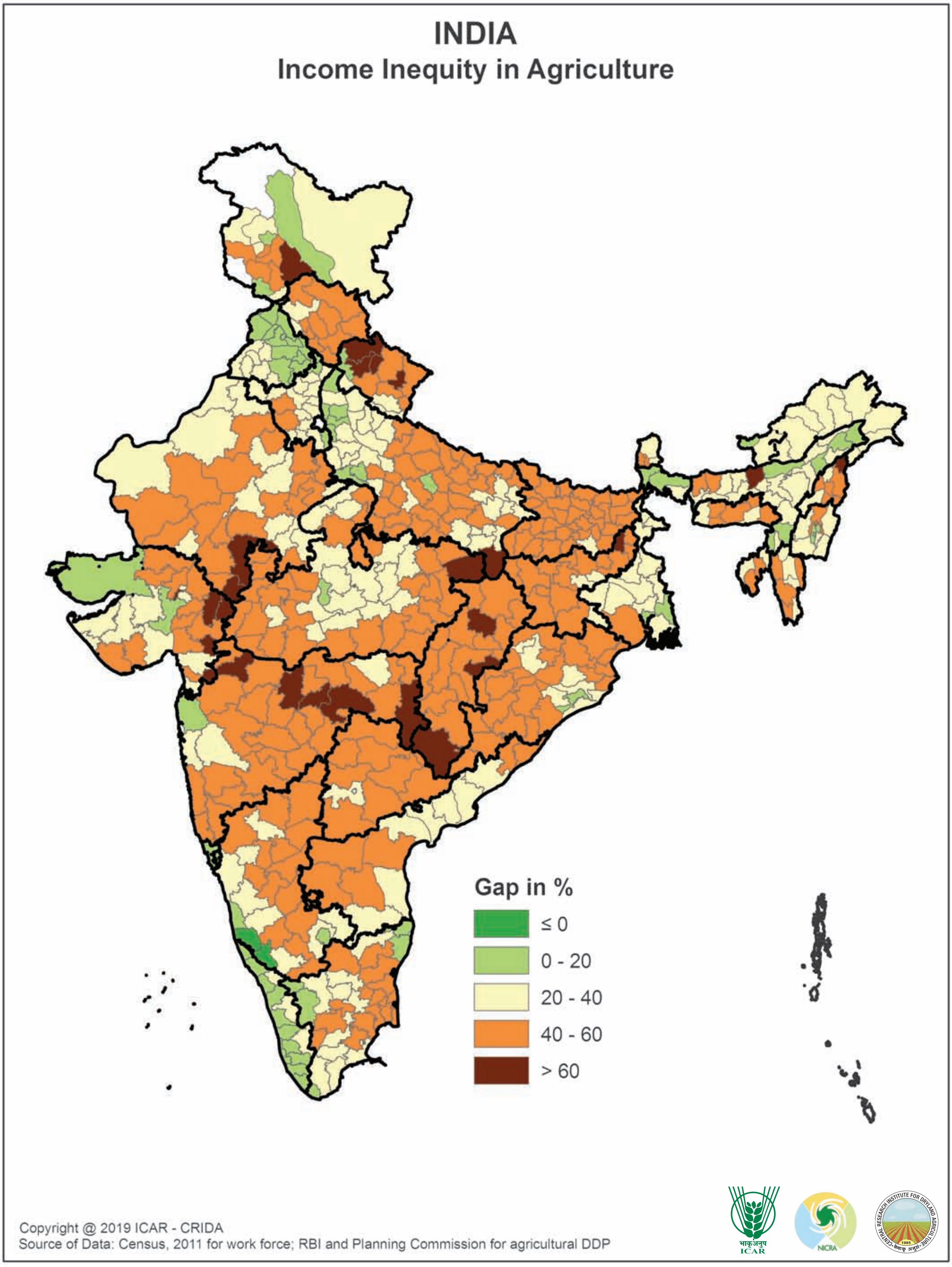

INDIA
Income Inequity in Agriculture
Gap in %
≤ 0
0 - 20
20 - 40
40 - 60
> 60
Copyright @ 2019 ICAR - CRIDA
Source of Data: Census, 2011 for work force; RBI and Planning Commission for agricultural DDP

Fig. V15

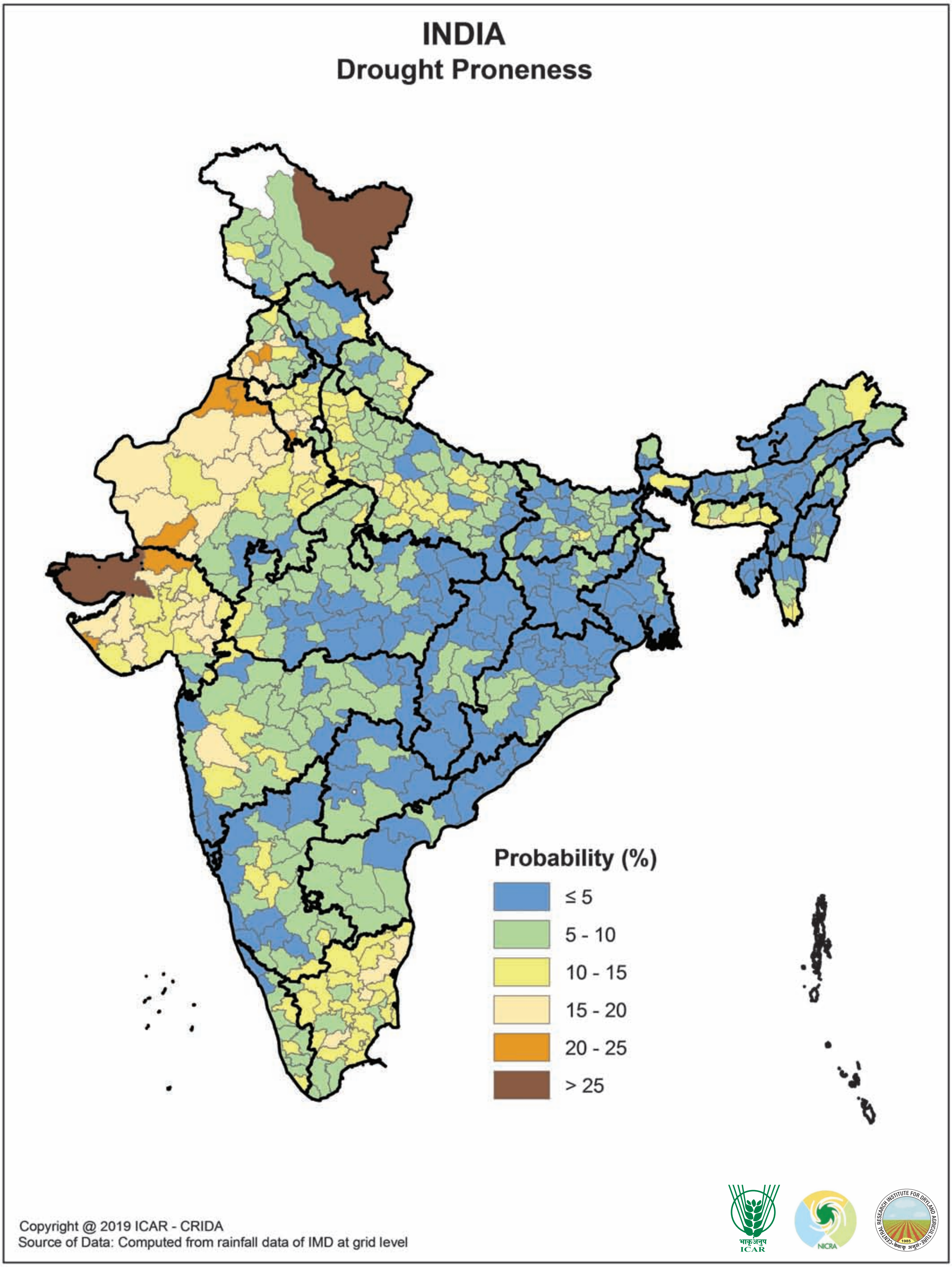

INDIA
Drought Proneness
Probability (%)
≤ 5
5 - 10
10 - 15
15 - 20
20 - 25
> 25
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed from rainfall data of IMD at grid level

Fig. HH1

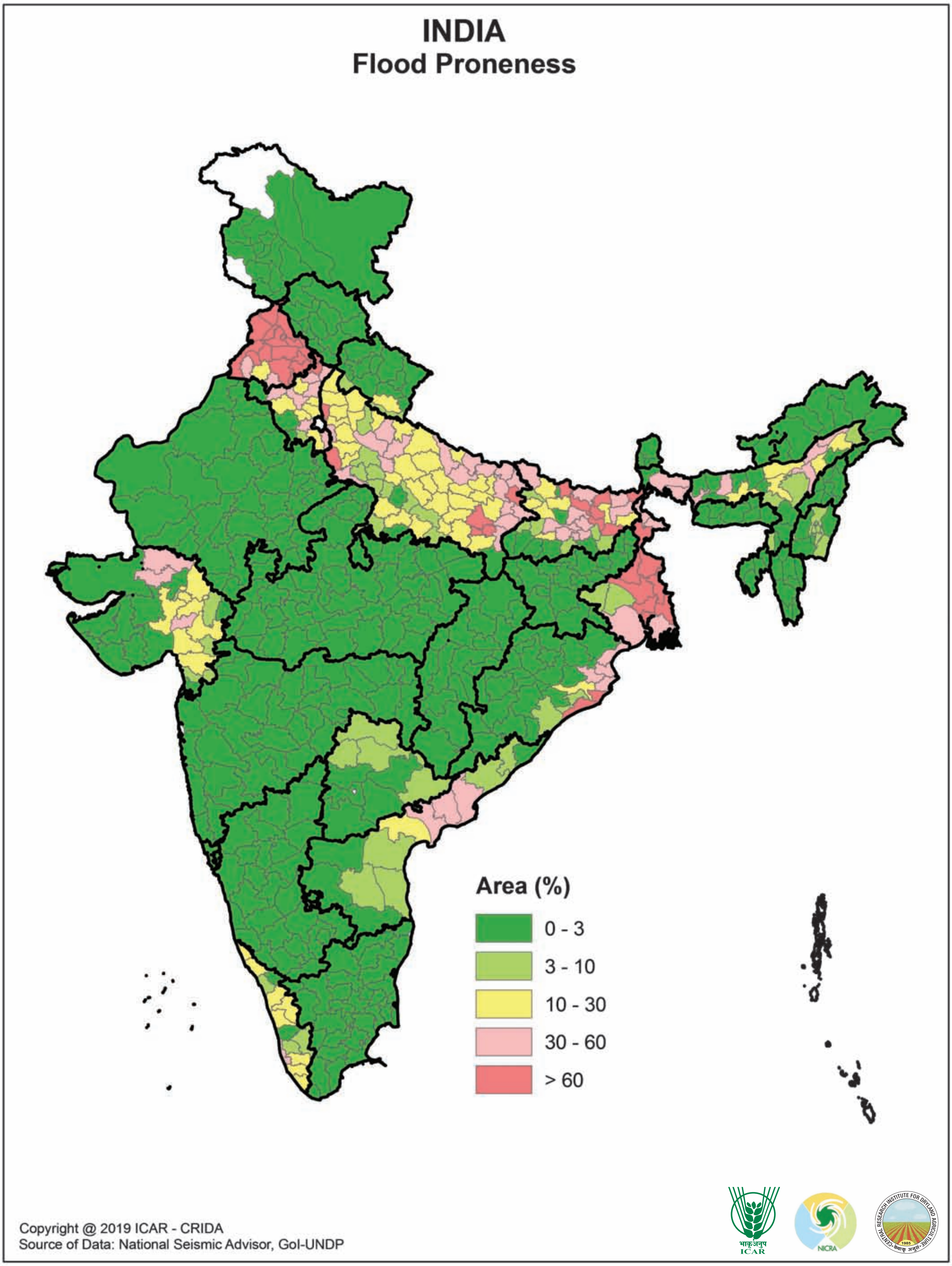

INDIA
Flood Proneness
Area (%)
0 - 3
3 - 10
10 - 30
30 - 60
> 60
Copyright @ 2019 ICAR - CRIDA
Source of Data: National Seismic Advisor, GoI-UNDP

Fig. HH2

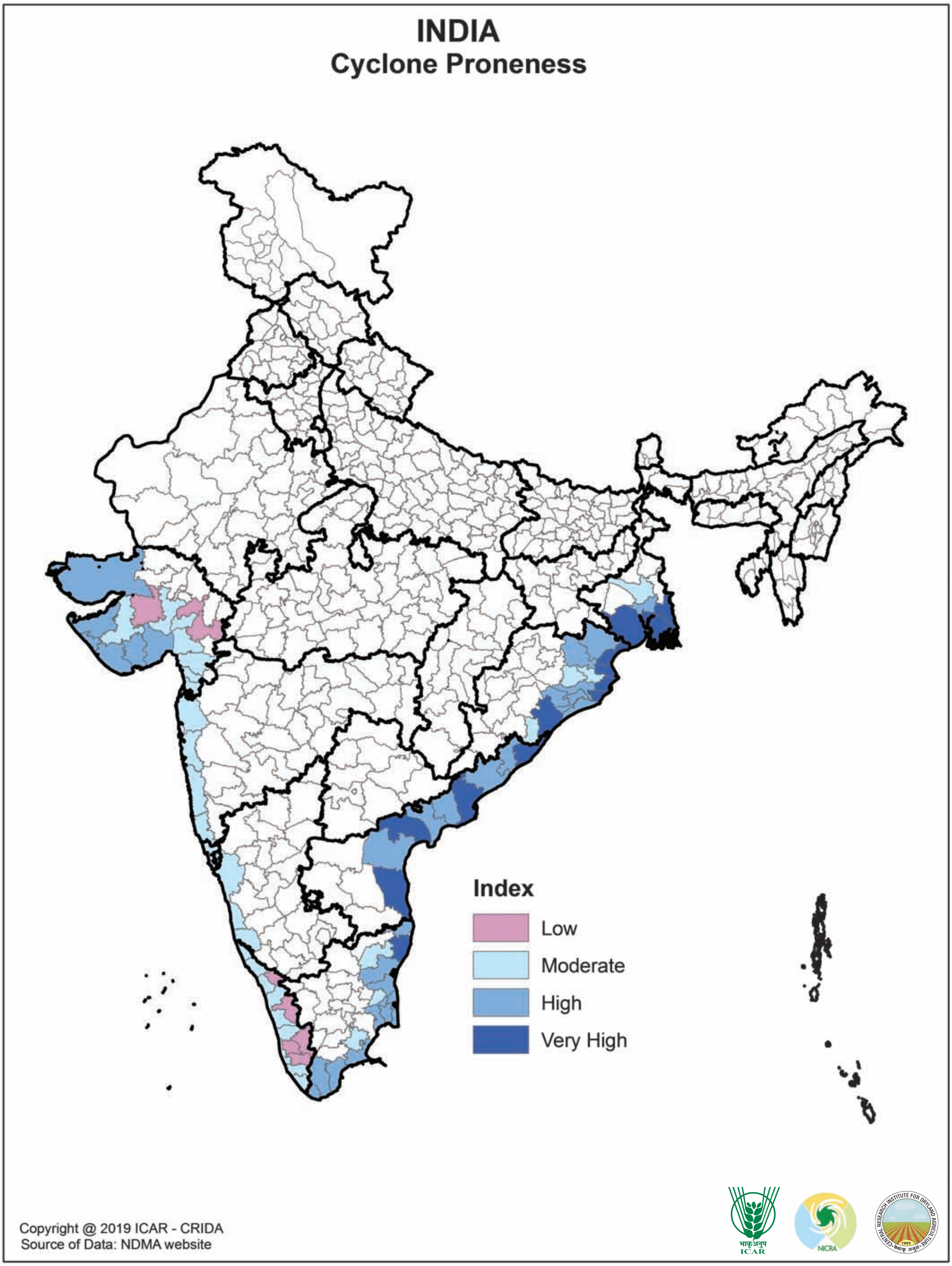

INDIA
Cyclone Proneness
Index
Low
Moderate
High
Very High
Copyright @ 2019 ICAR - CRIDA
Source of Data: NDMA website

Fig. HH3

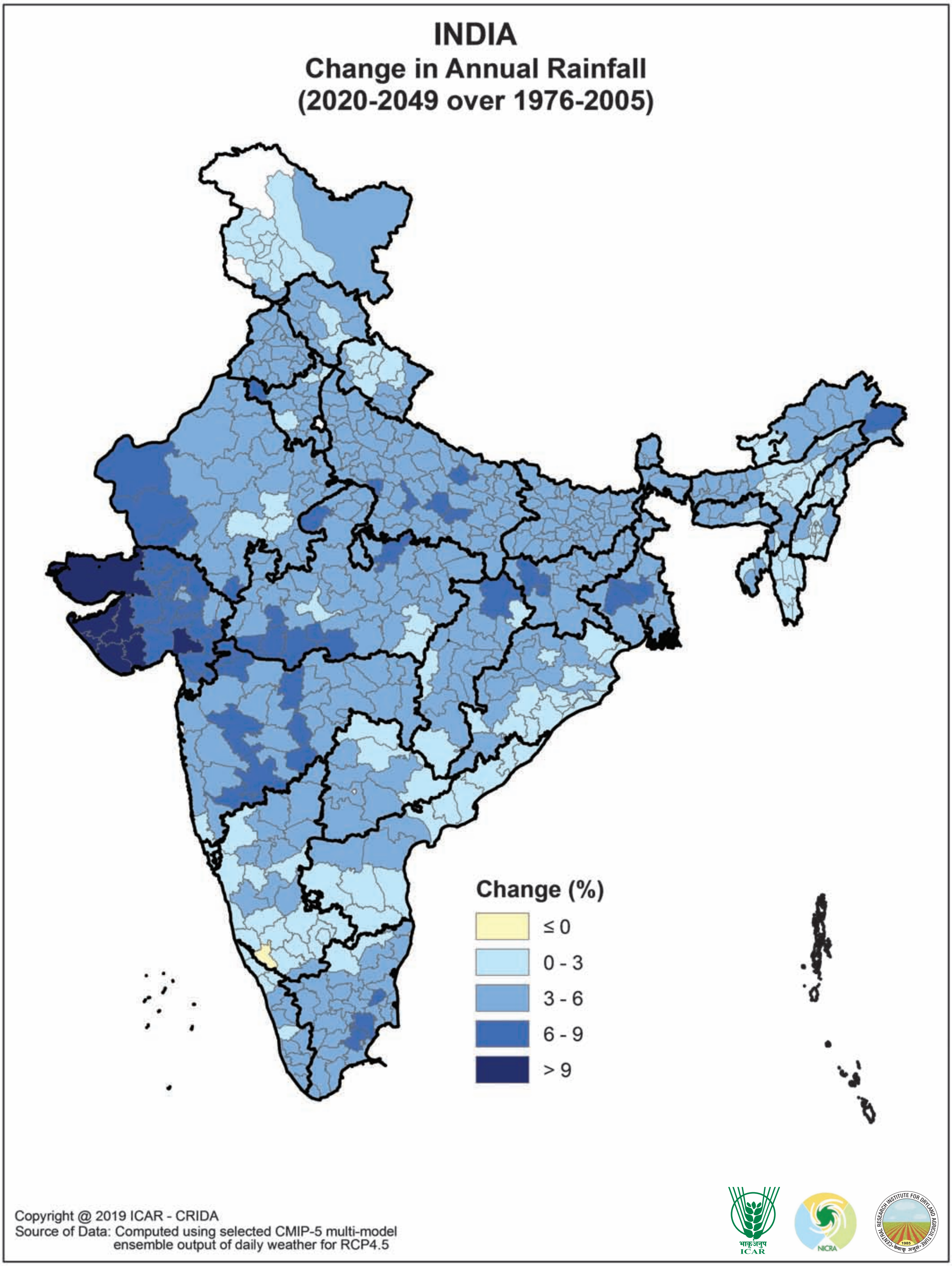

INDIA
Change in Annual Rainfall
(2020-2049 over 1976-2005)
Change (%)
≤ 0
0 - 3
3 - 6
6 - 9
> 9
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed using selected CMIP-5 multi-model ensemble output of daily weather for RCP4.5
ICAR
NICRA

Fig. FH1

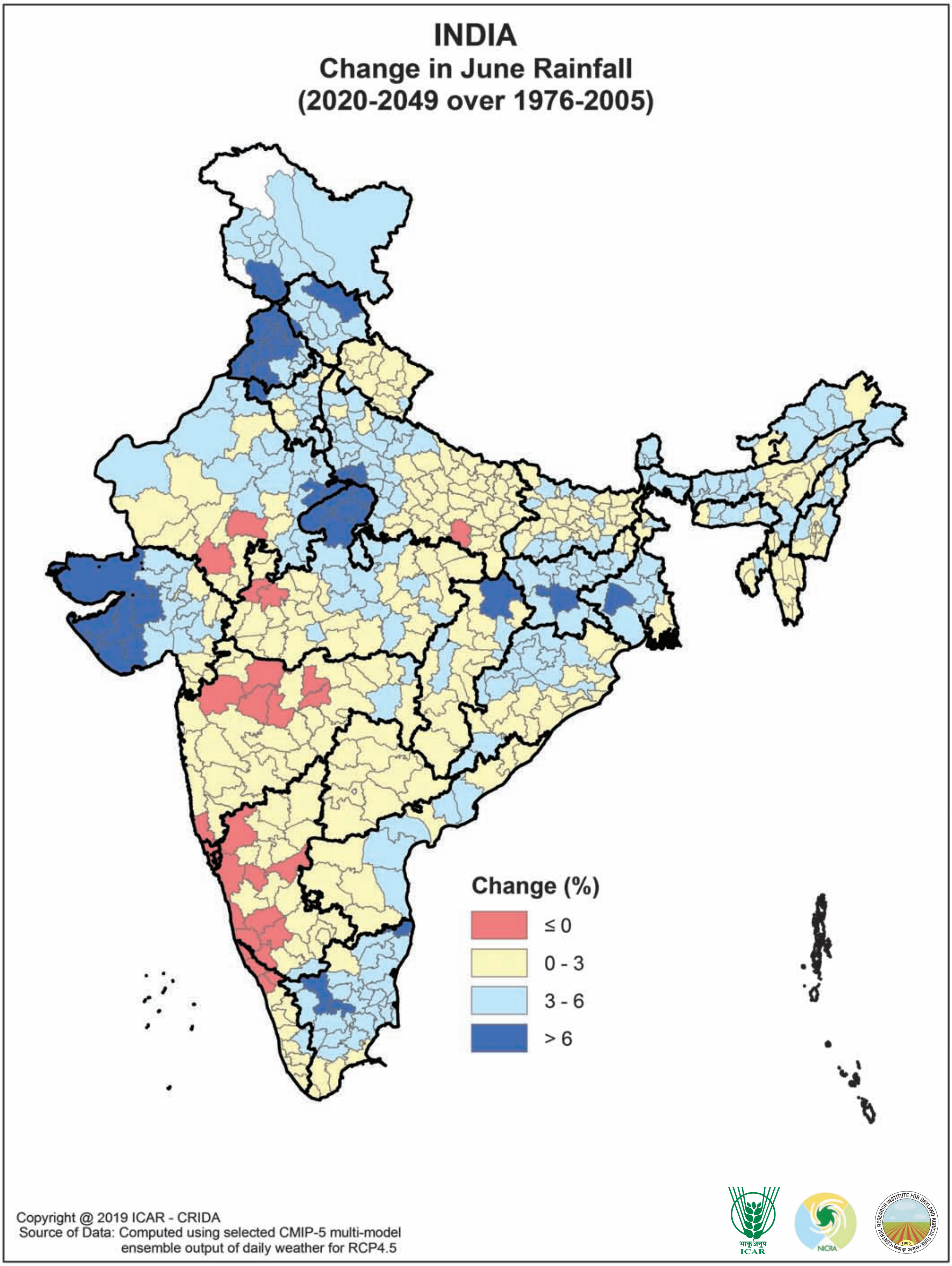
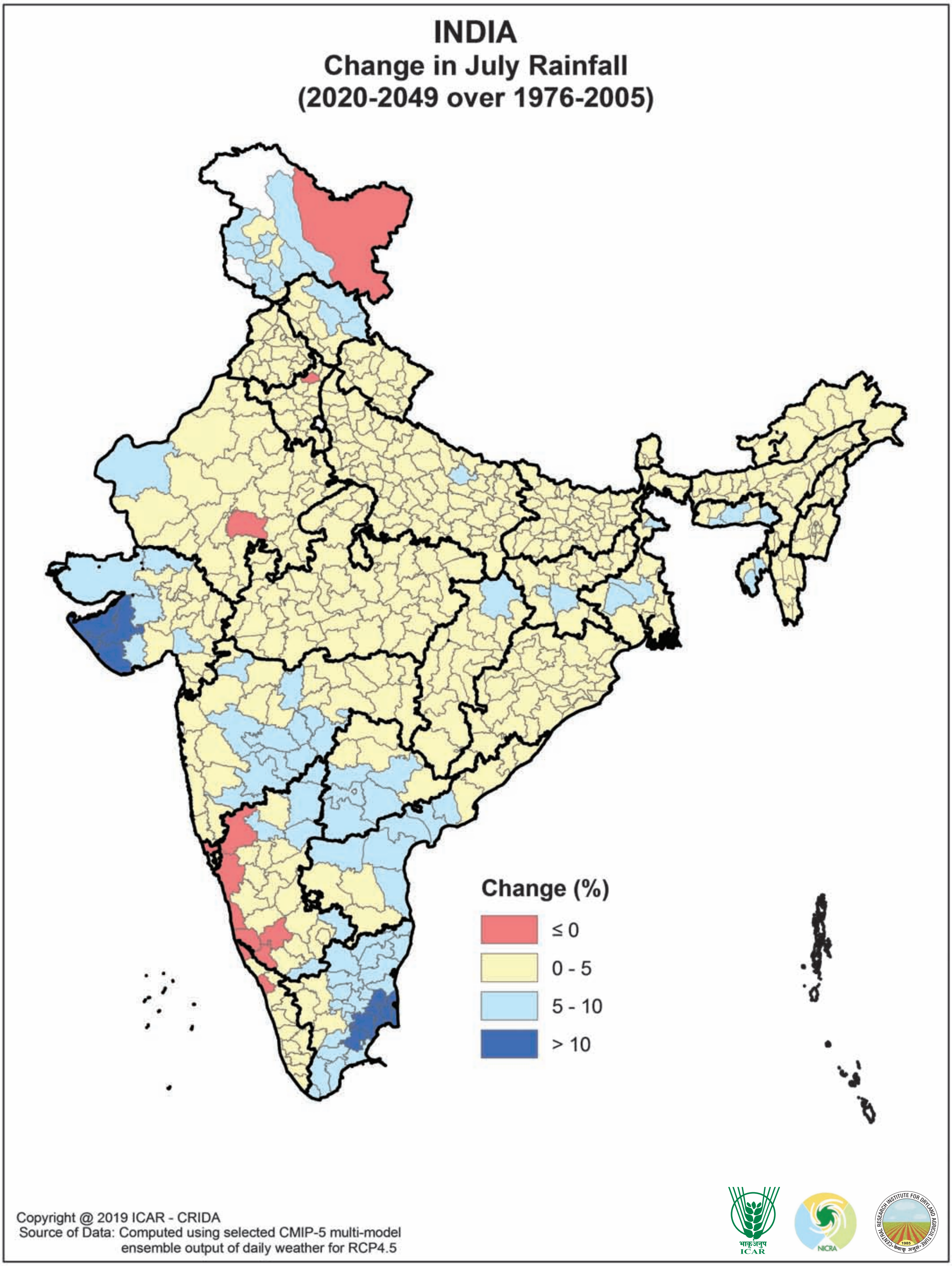

INDIA
Change in June Rainfall
(2020-2049 over 1976-2005)
Change (%)
≤ 0
0 - 3
3 - 6
> 6
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed using selected CMIP-5 multi-model ensemble output of daily weather for RCP4.5
ICAR
NICRA

Fig. FH2



INDIA
Change in July Rainfall
(2020-2049 over 1976-2005)
Change (%)
≤ 0
0 - 5
5 - 10
> 10
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed using selected CMIP-5 multi-model
ensemble output of daily weather for RCP4.5

Fig. FH3

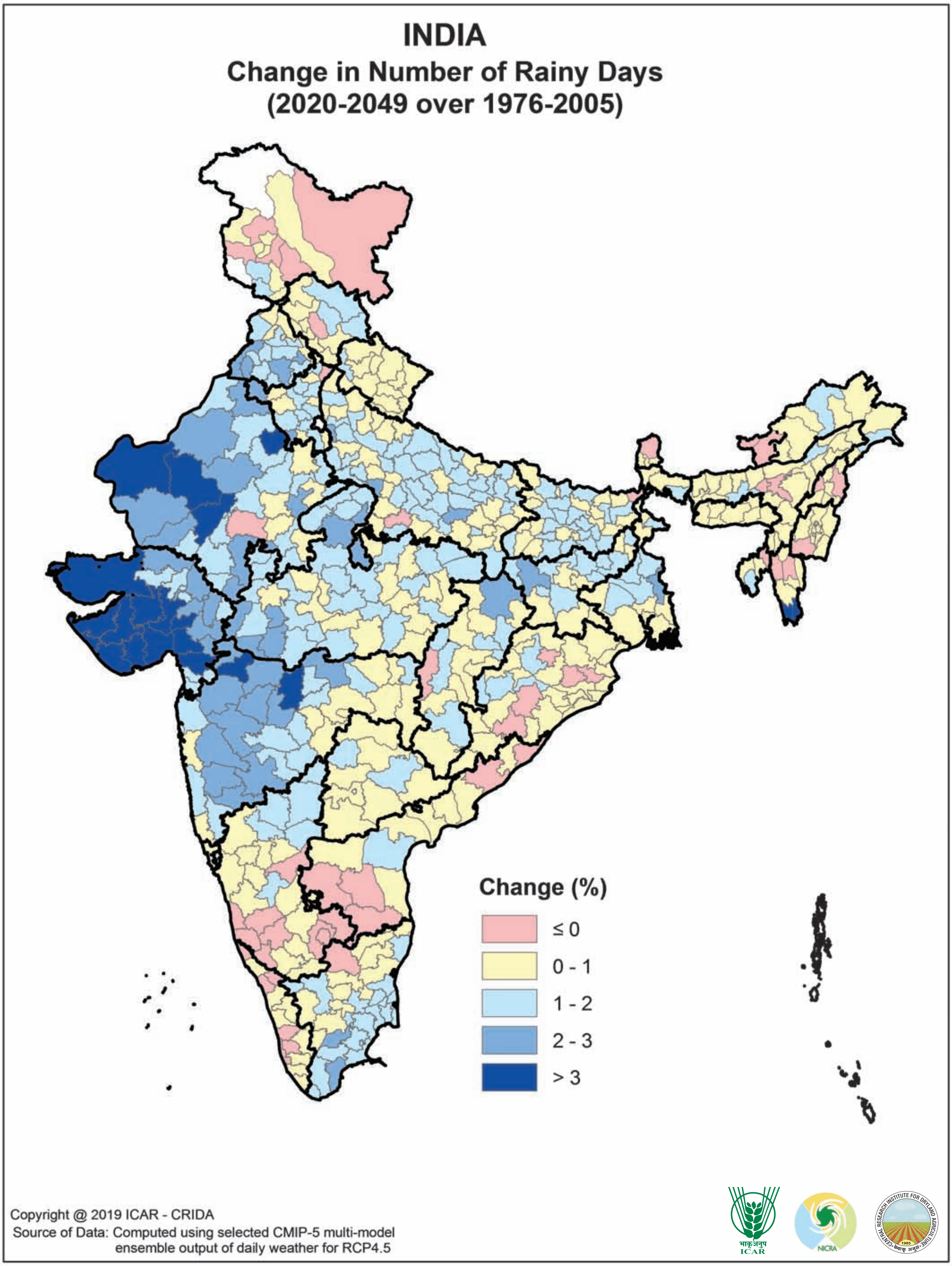

INDIA
Change in Number of Rainy Days
(2020-2049 over 1976-2005)
Change (%)
≤ 0
0 - 1
1 - 2
2 - 3
> 3
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed using selected CMIP-5 multi-model ensemble output of daily weather for RCP4.5
ICAR
NICRA

Fig. FH4

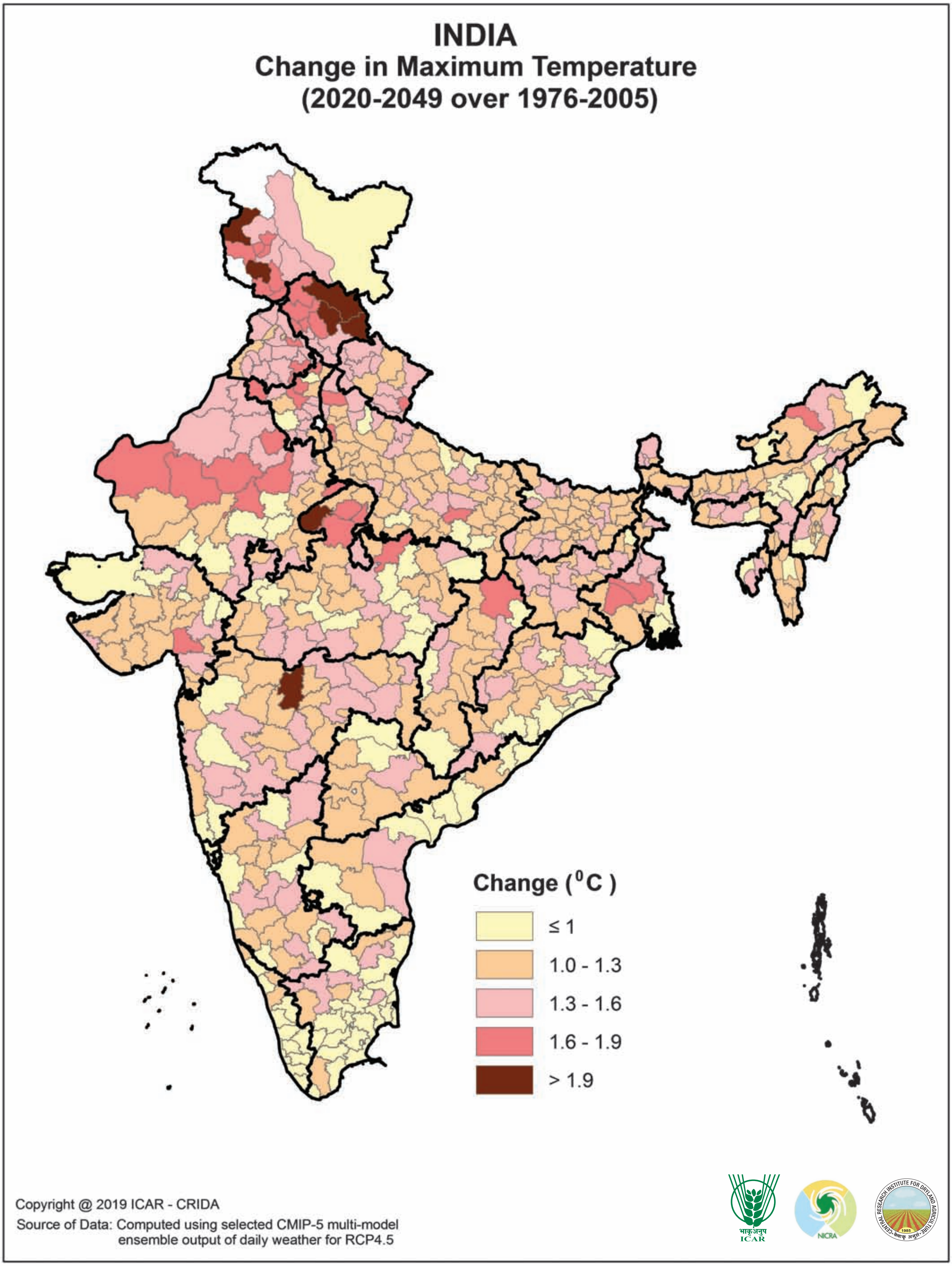

INDIA
Change in Maximum Temperature
(2020-2049 over 1976-2005)
Change (°C)
≤ 1
1.0 - 1.3
1.3 - 1.6
1.6 - 1.9
> 1.9
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed using selected CMIP-5 multi-model ensemble output of daily weather for RCP4.5

Fig. FH5

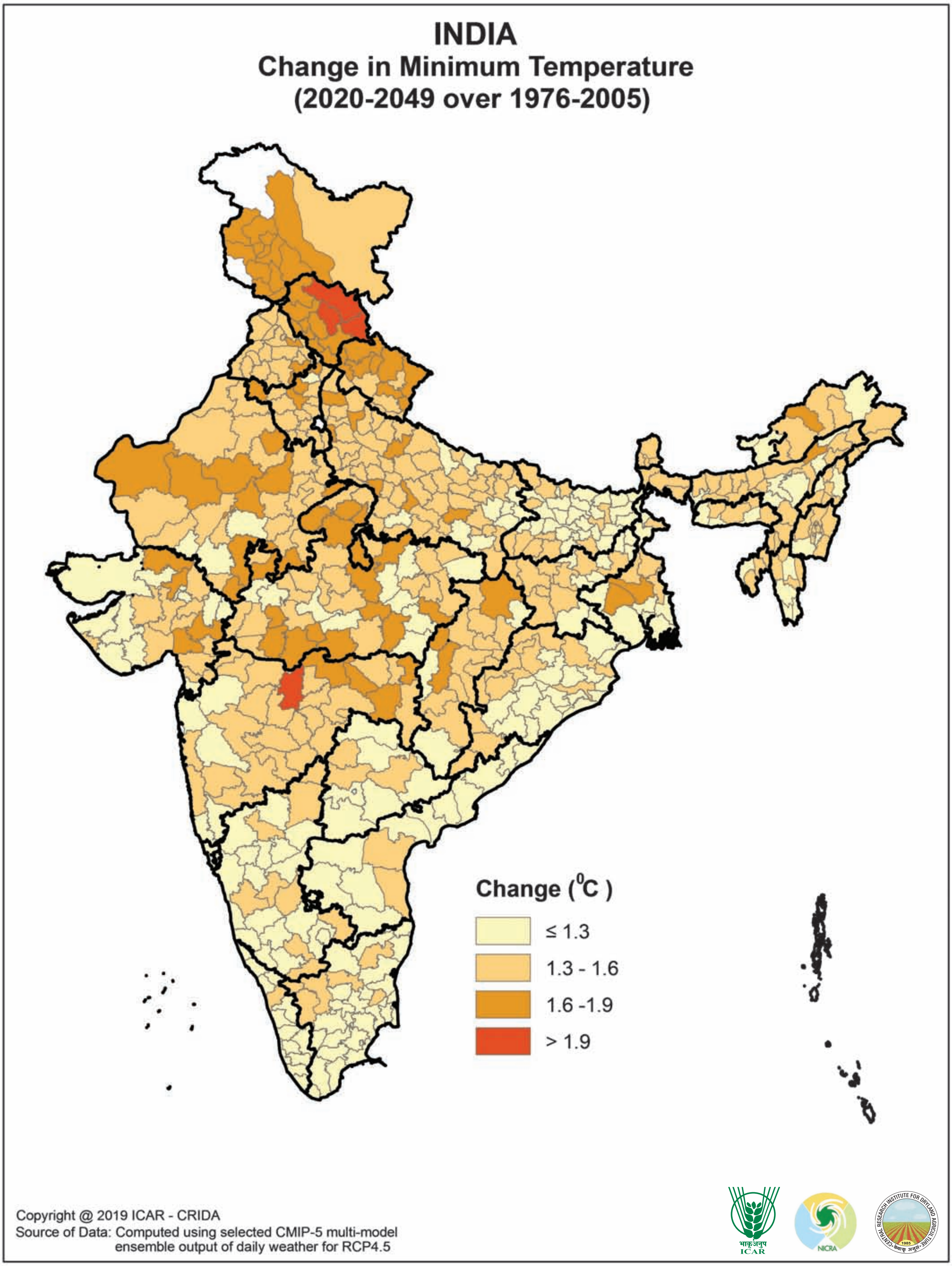

INDIA
Change in Minimum Temperature
(2020-2049 over 1976-2005)
Change (⁰C)
≤ 1.3
1.3 - 1.6
1.6 -1.9
> 1.9
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed using selected CMIP-5 multi-model ensemble output of daily weather for RCP4.5

Fig. FH6

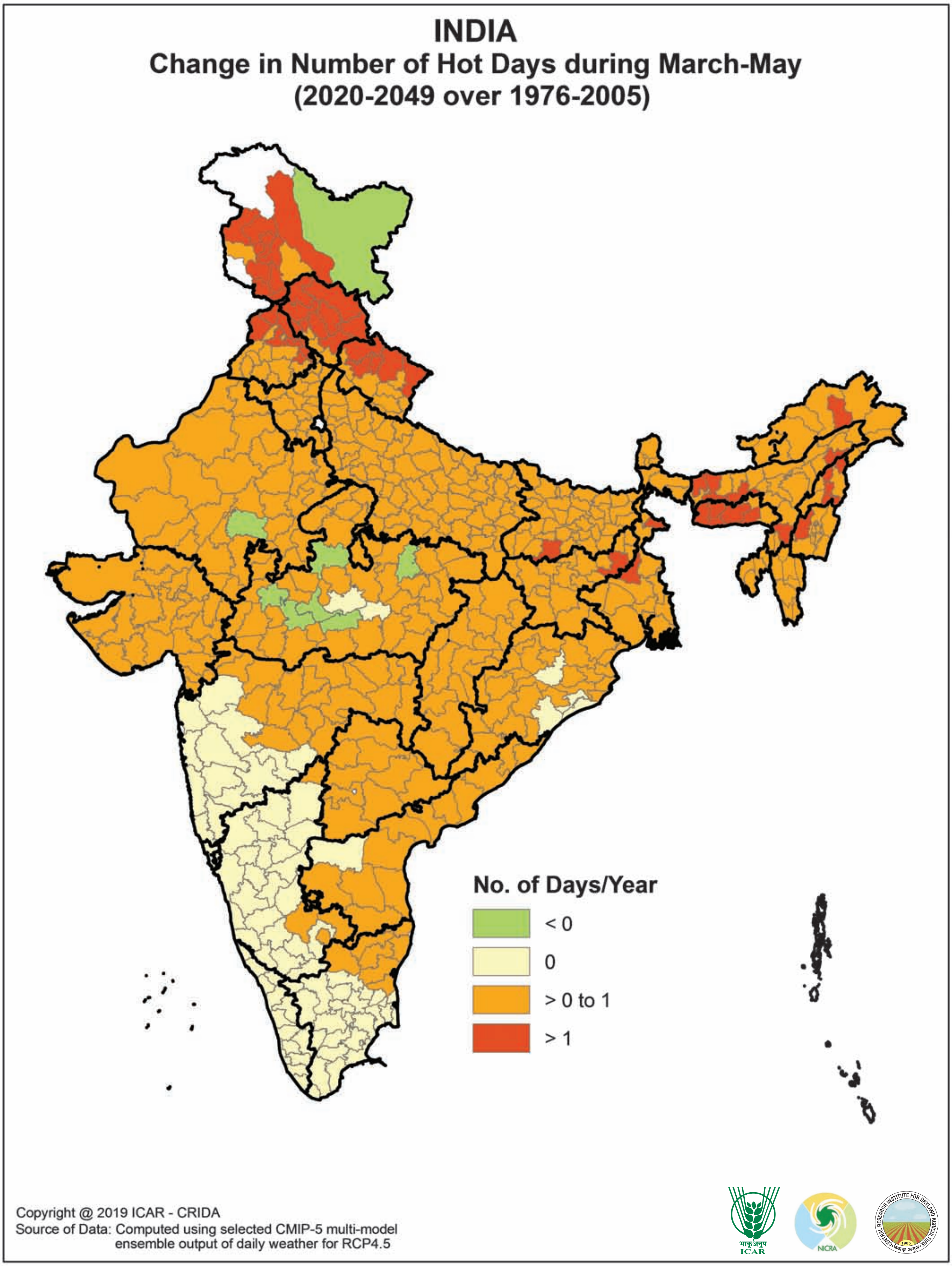

INDIA
Change in Number of Hot Days during March-May
(2020-2049 over 1976-2005)
No. of Days/Year
< 0
0
> 0 to 1
> 1
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed using selected CMIP-5 multi-model ensemble output of daily weather for RCP4.5

Fig. FH7

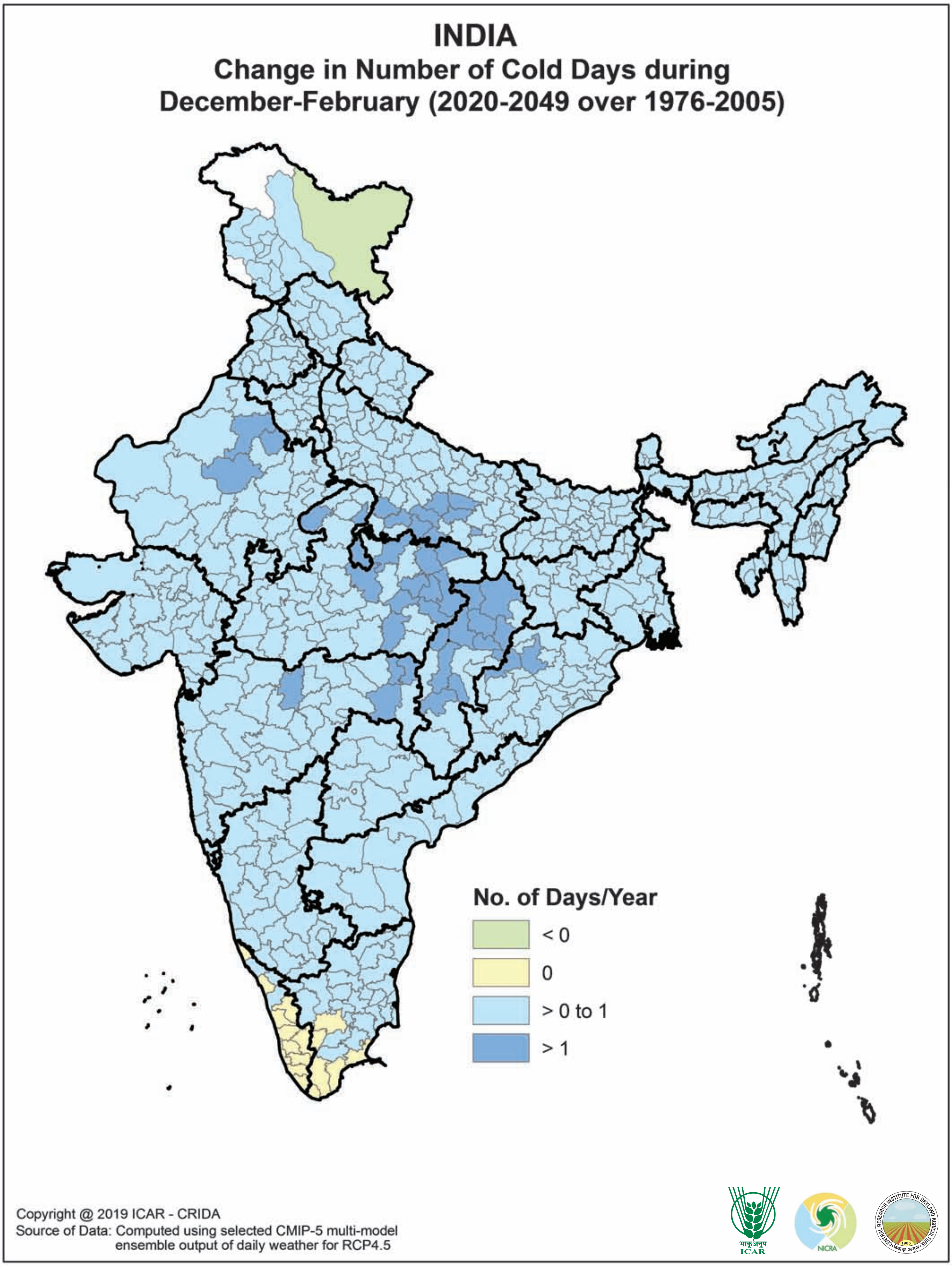

INDIA
Change in Number of Cold Days during
December-February (2020-2049 over 1976-2005)
No. of Days/Year
< 0
0
> 0 to 1
> 1
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed using selected CMIP-5 multi-model ensemble output of daily weather for RCP4.5
ICAR
NICRA

Fig. FH8

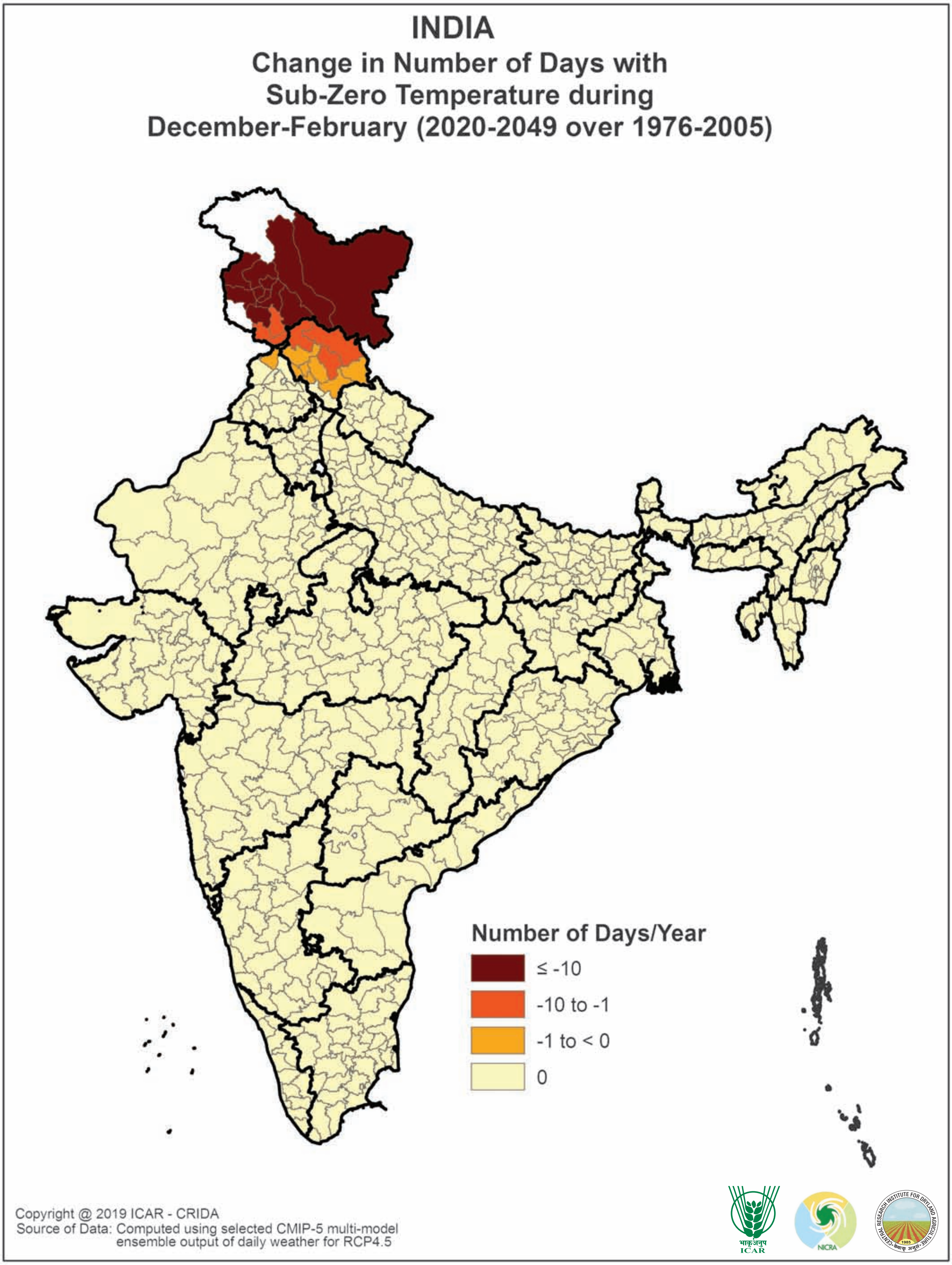

INDIA
Change in Number of Days with
Sub-Zero Temperature during
December-February (2020-2049 over 1976-2005)
Number of Days/Year
≤ -10
-10 to -1
-1 to < 0
0
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed using selected CMIP-5 multi-model ensemble output of daily weather for RCP4.5

Fig. FH9

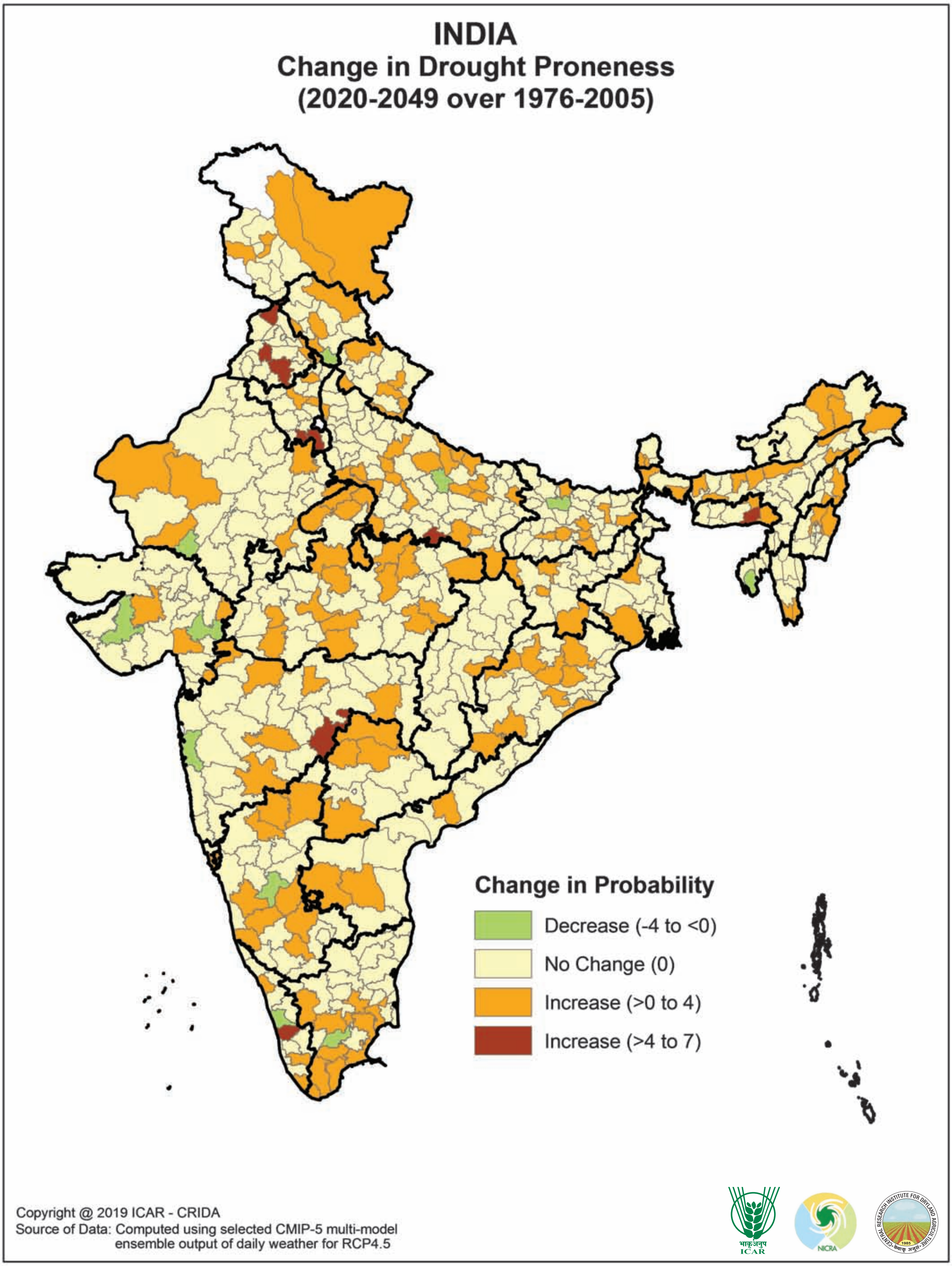

INDIA
Change in Drought Proneness
(2020-2049 over 1976-2005)
Change in Probability
Decrease (-4 to <0)
No Change (0)
Increase (>0 to 4)
Increase (>4 to 7)
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed using selected CMIP-5 multi-model ensemble output of daily weather for RCP4.5

Fig. FH10

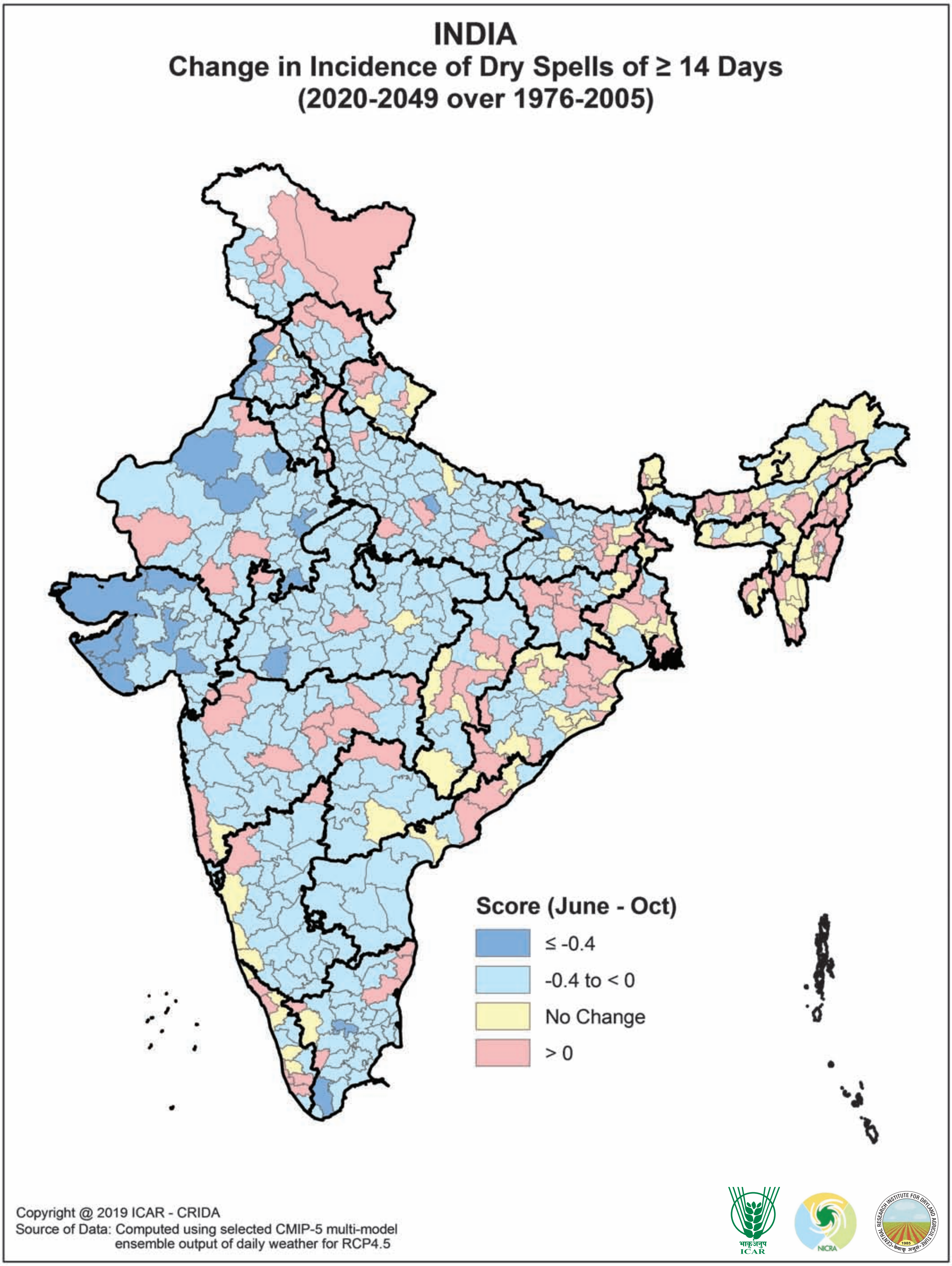

INDIA
Change in Incidence of Dry Spells of ≥ 14 Days
(2020-2049 over 1976-2005)
Score (June - Oct)
≤ -0.4
-0.4 to < 0
No Change
> 0
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed using selected CMIP-5 multi-model ensemble output of daily weather for RCP4.5
ICAR
NICRA

Fig. FH11

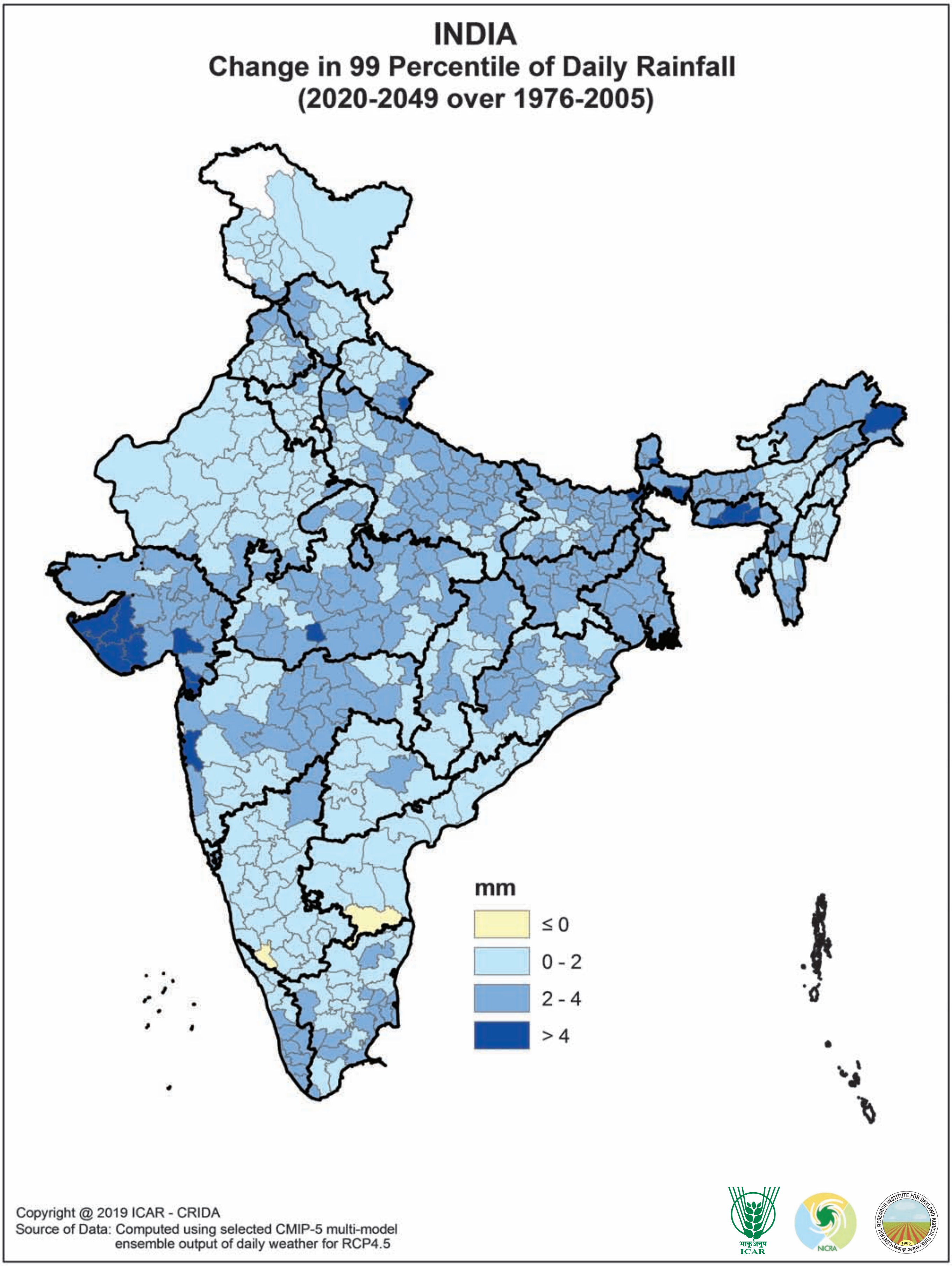

INDIA
Change in 99 Percentile of Daily Rainfall
(2020-2049 over 1976-2005)
mm
≤ 0
0 - 2
2 - 4
> 4
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed using selected CMIP-5 multi-model ensemble output of daily weather for RCP4.5

Fig. FH12

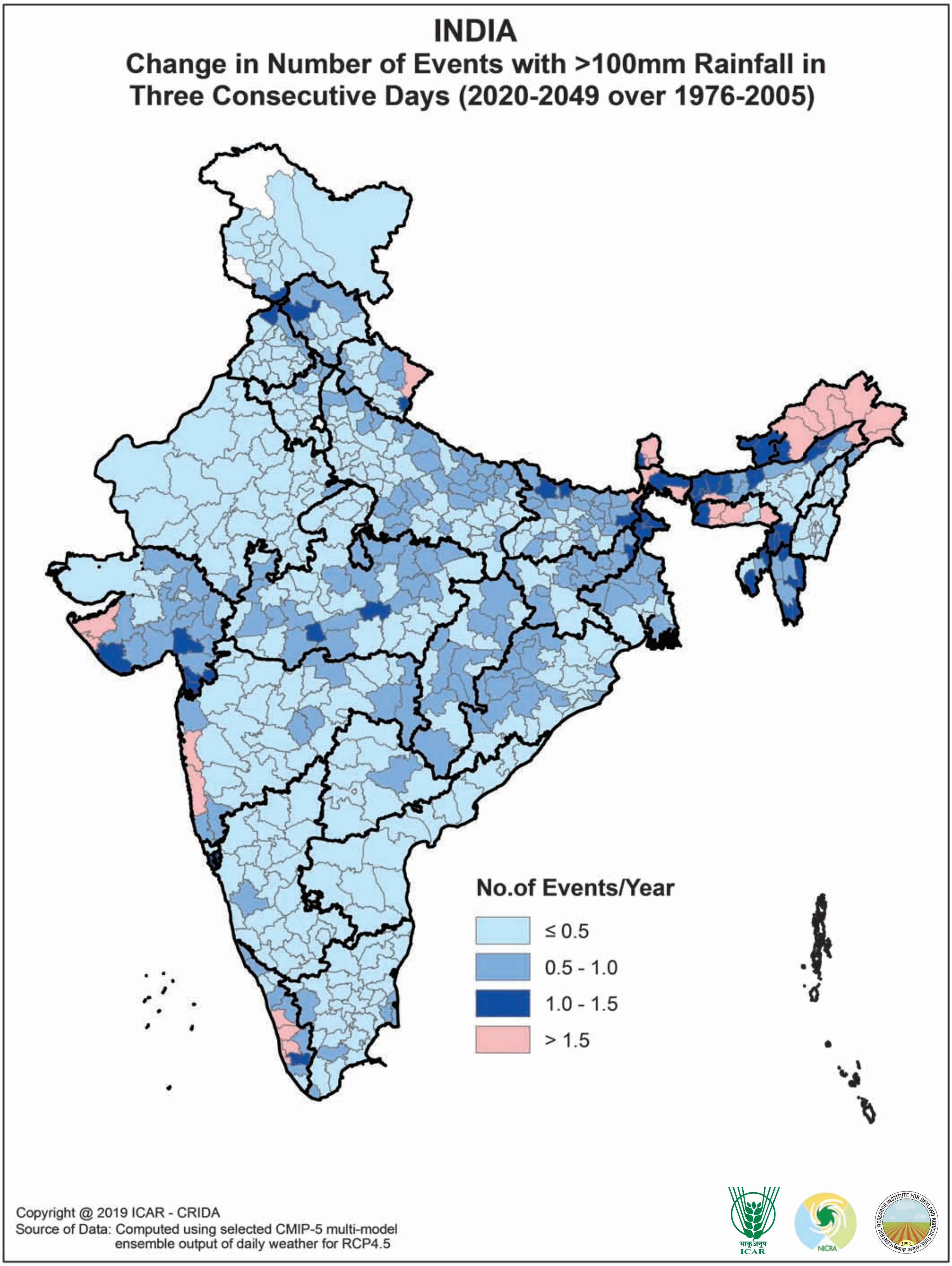

INDIA
Change in Number of Events with >100mm Rainfall in Three Consecutive Days (2020-2049 over 1976-2005)
No.of Events/Year
≤ 0.5
0.5 - 1.0
1.0 - 1.5
> 1.5
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed using selected CMIP-5 multi-model ensemble output of daily weather for RCP4.5
ICAR
NICRA

Fig. FH13

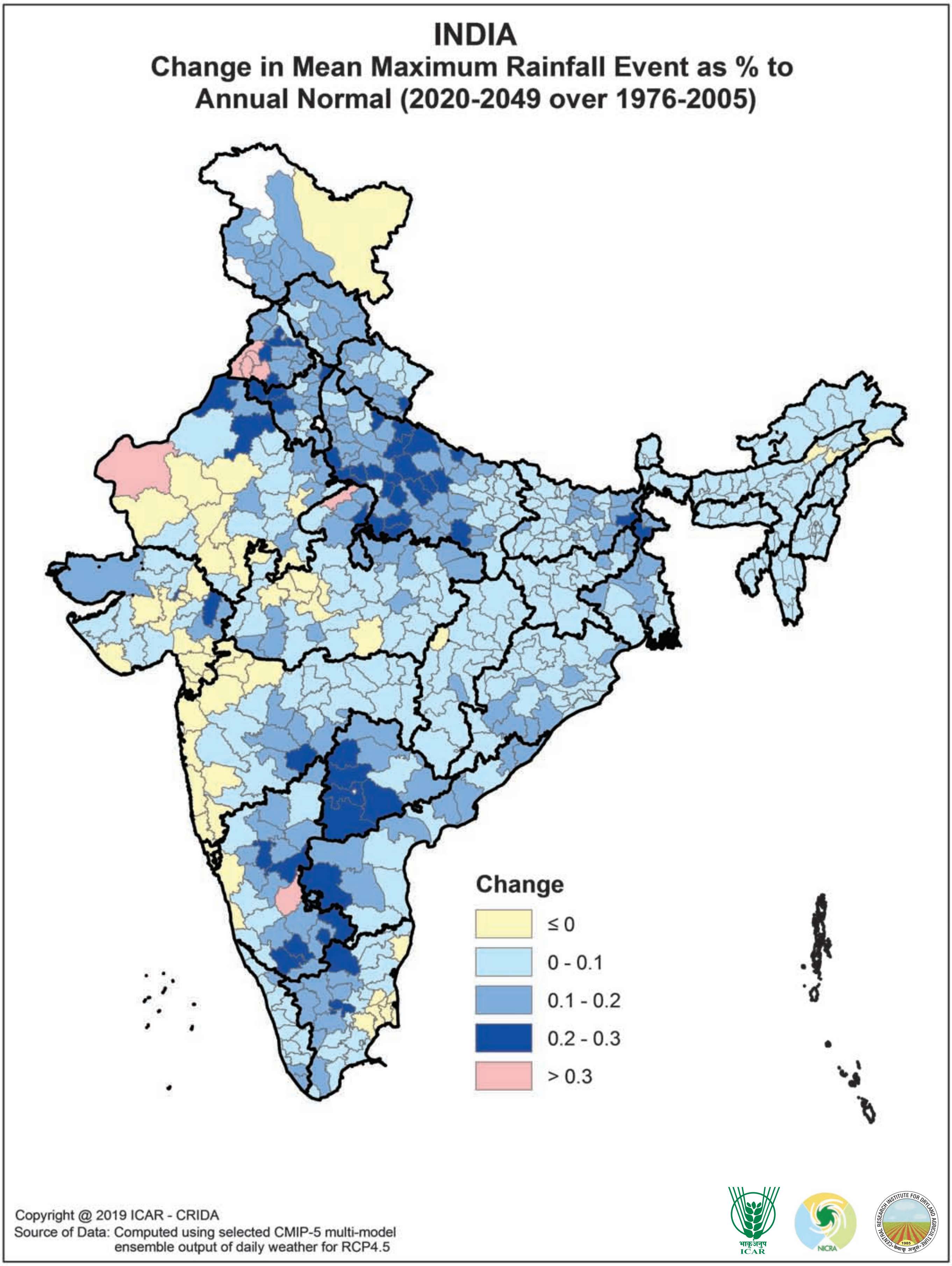

INDIA
Change in Mean Maximum Rainfall Event as % to Annual Normal (2020-2049 over 1976-2005)
Change
≤ 0
0 - 0.1
0.1 - 0.2
0.2 - 0.3
> 0.3
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed using selected CMIP-5 multi-model ensemble output of daily weather for RCP4.5
ICAR
NICRA

Fig. FH14

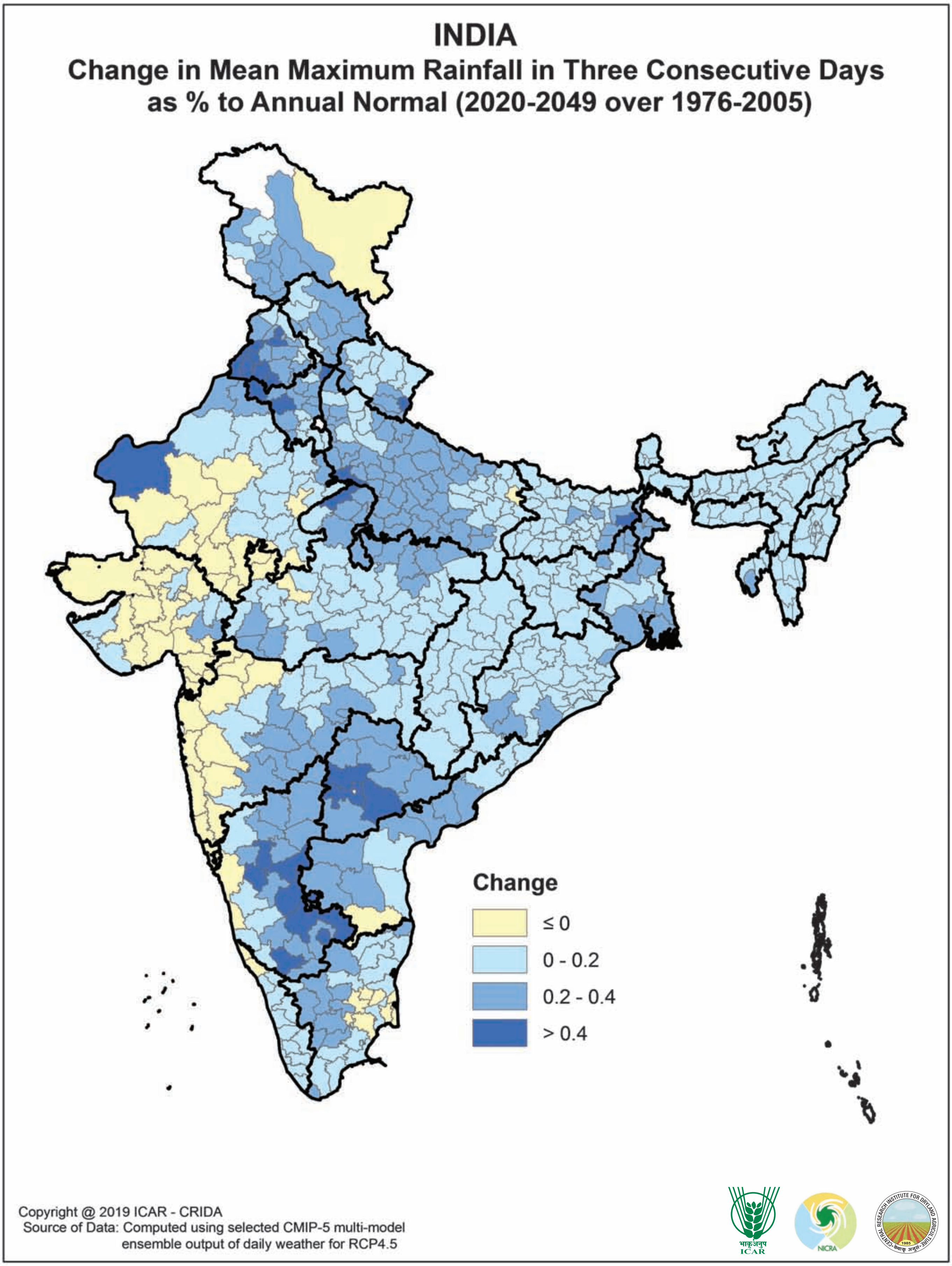

INDIA
Change in Mean Maximum Rainfall in Three Consecutive Days
as % to Annual Normal (2020-2049 over 1976-2005)
Change
≤ 0
0 - 0.2
0.2 - 0.4
> 0.4
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed using selected CMIP-5 multi-model
ensemble output of daily weather for RCP4.5
ICAR
NICRA

Fig. FH15

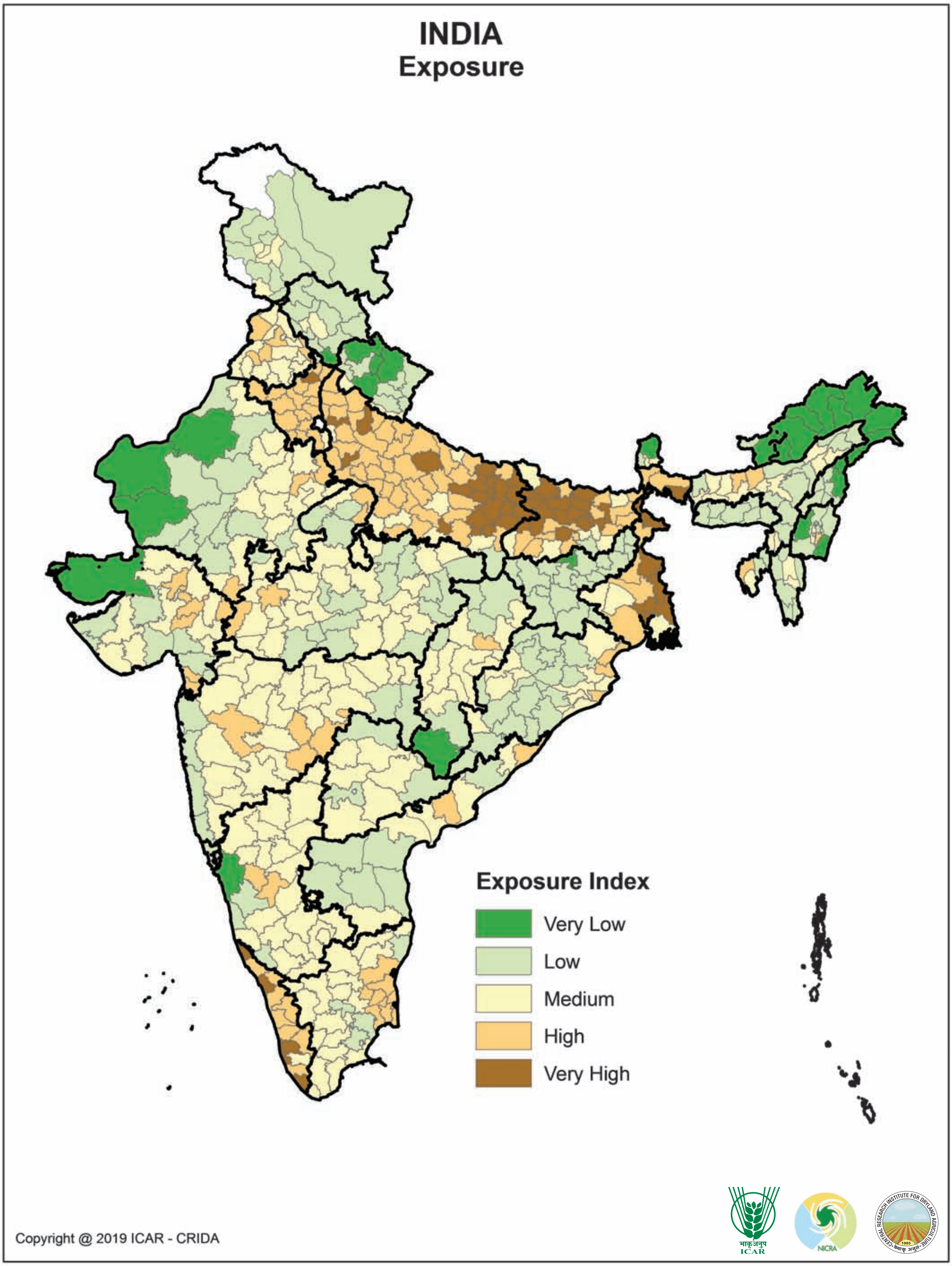
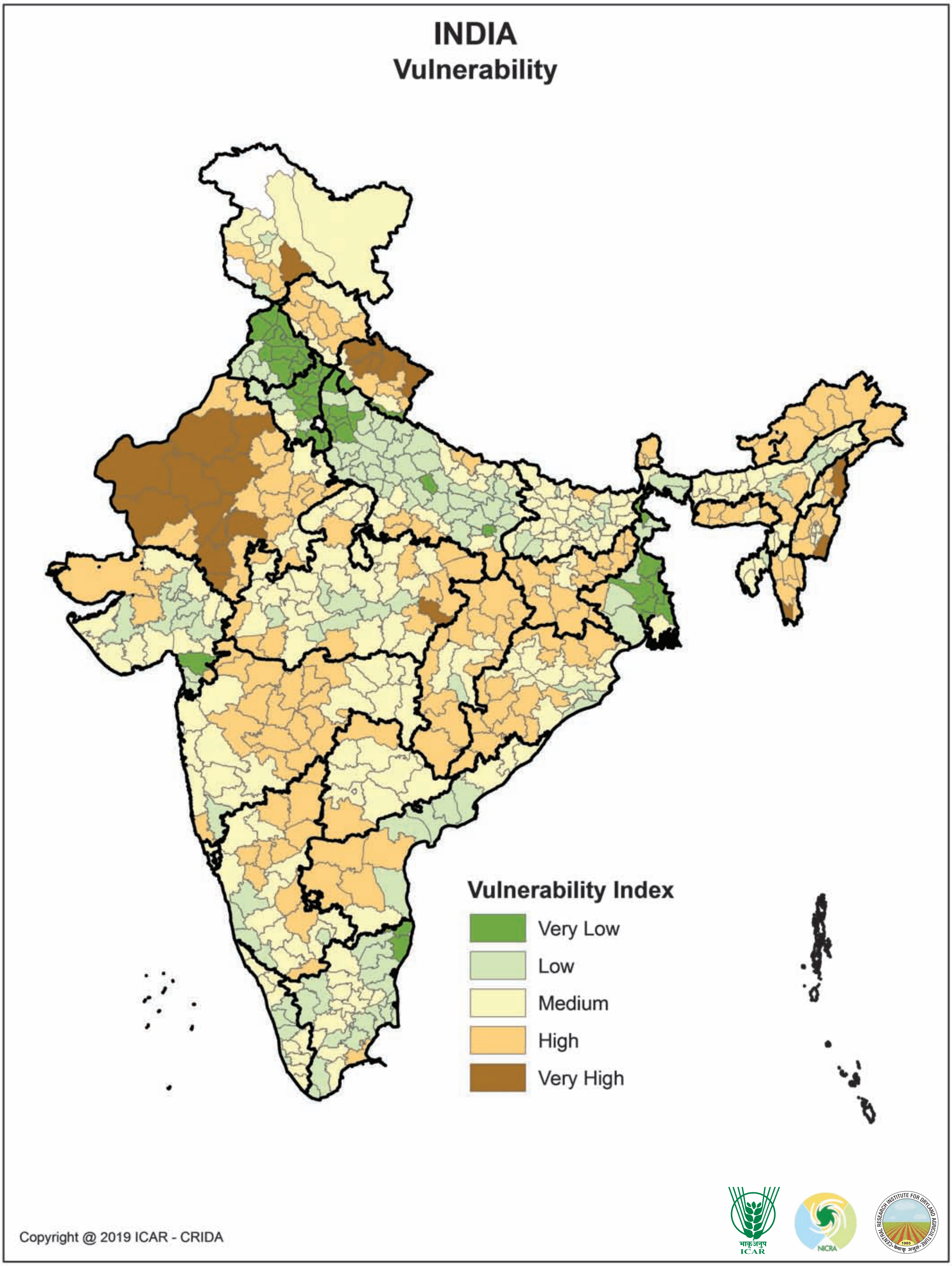

INDIA
Exposure
Exposure Index
Very Low
Low
Medium
High
Very High
Copyright @ 2019 ICAR - CRIDA

Fig. E6



INDIA
Vulnerability
Vulnerability Index
Very Low
Low
Medium
High
Very High
Copyright @ 2019 ICAR - CRIDA

Fig. V16

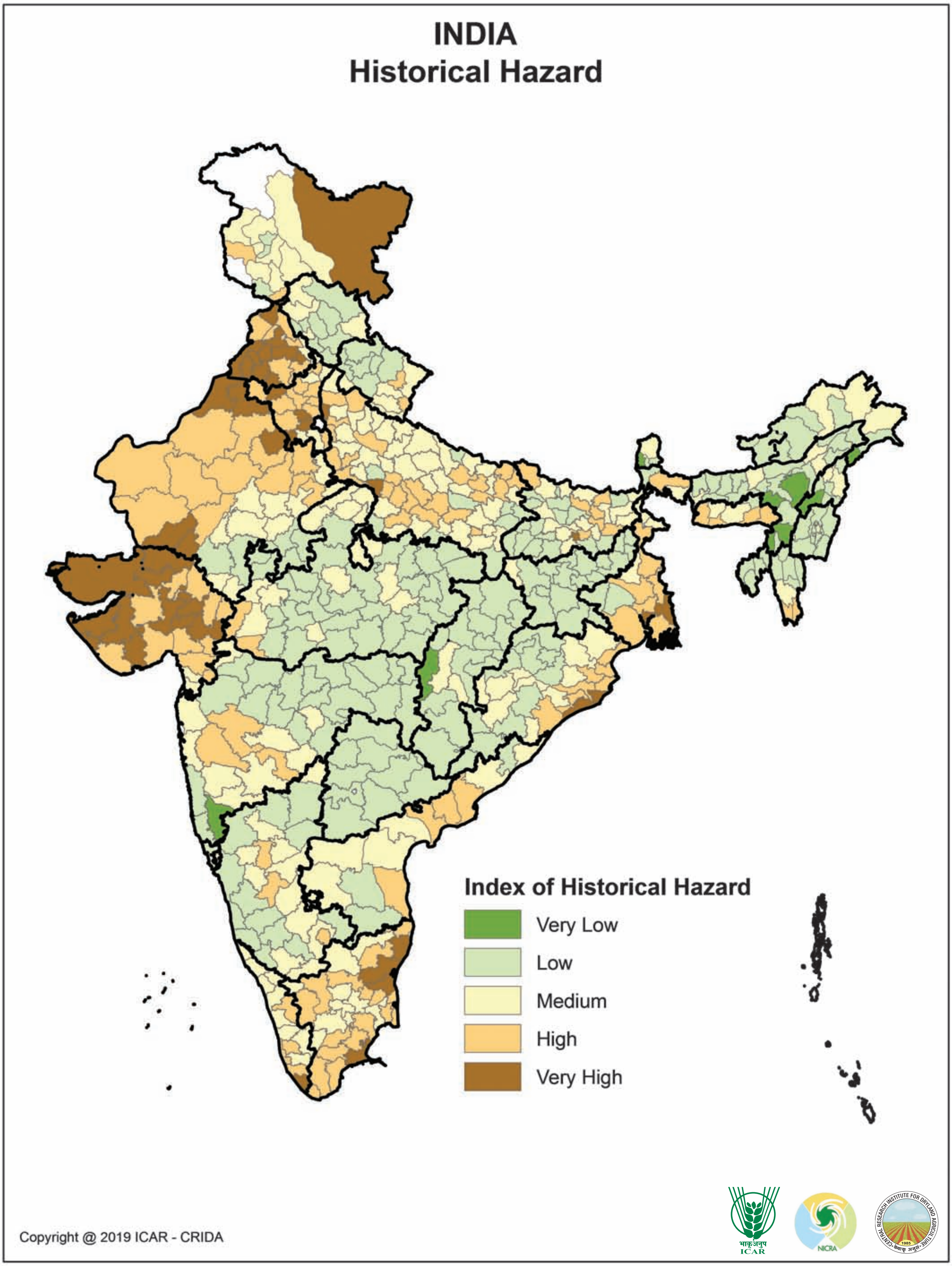
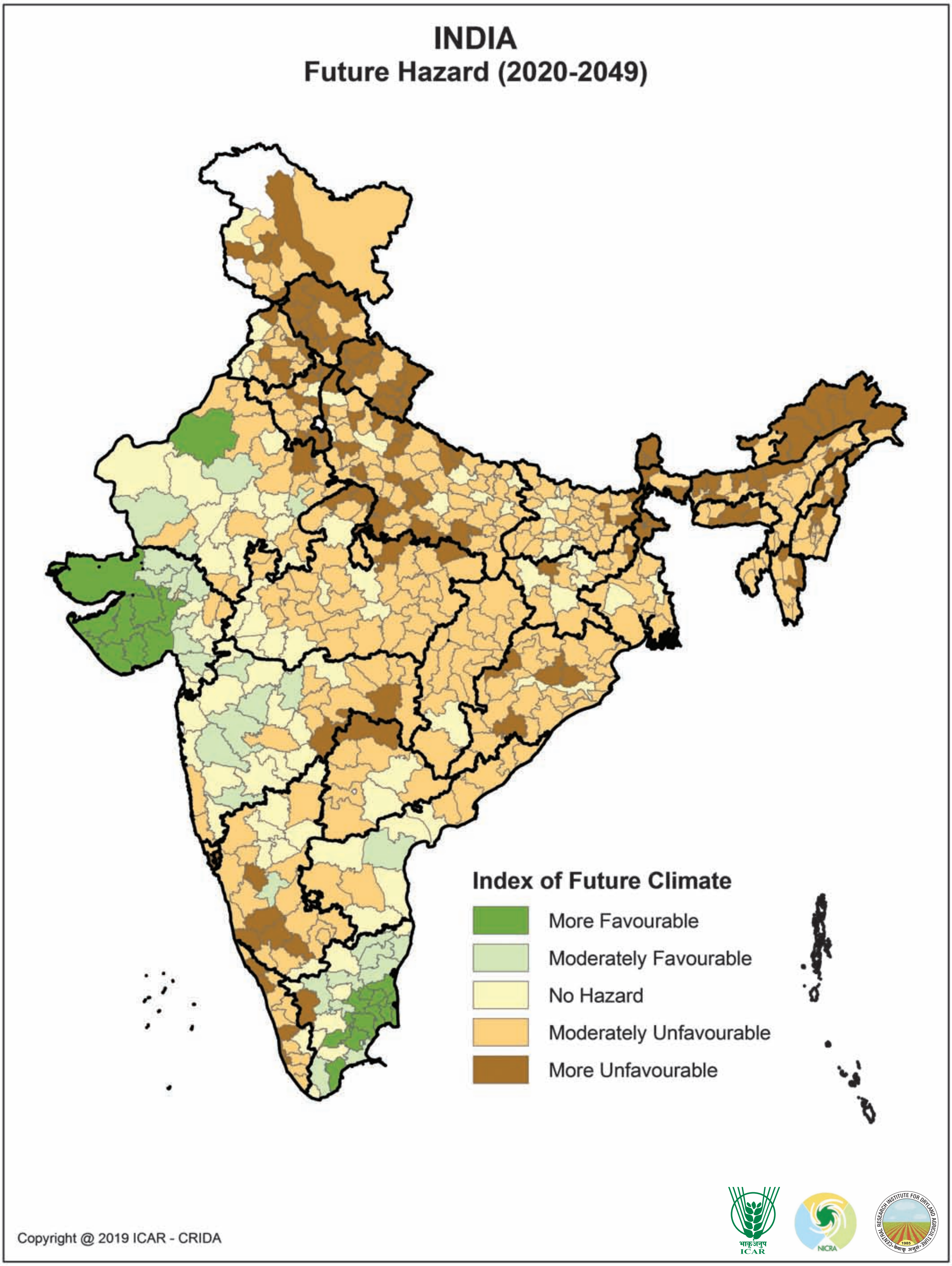

INDIA
Historical Hazard
Index of Historical Hazard
Very Low
Low
Medium
High
Very High
Copyright @ 2019 ICAR - CRIDA

Fig. HH4



INDIA
Future Hazard (2020-2049)
Index of Future Climate
More Favourable
Moderately Favourable
No Hazard
Moderately Unfavourable
More Unfavourable
Copyright @ 2019 ICAR - CRIDA

Fig. FH16

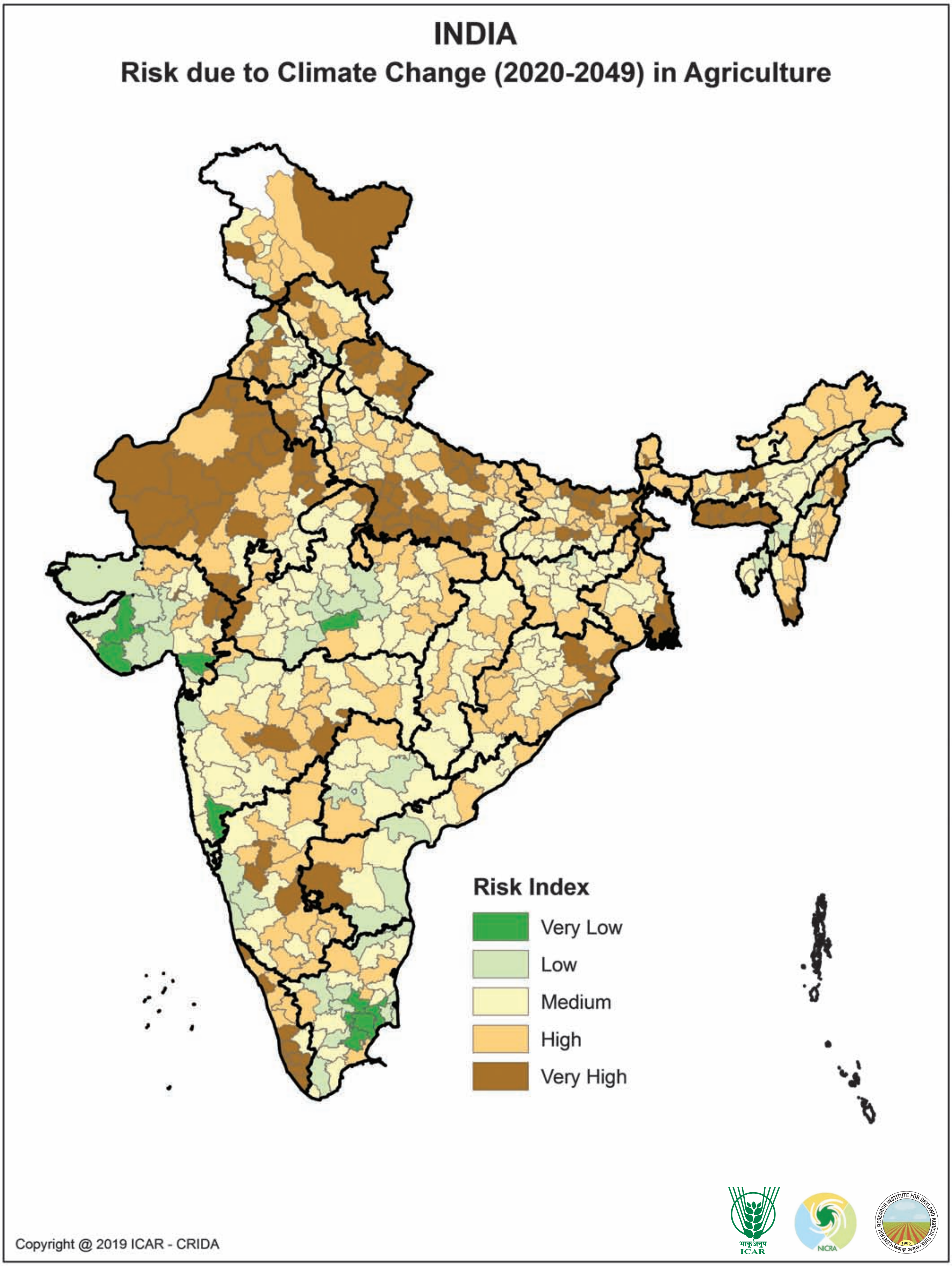

INDIA
Risk due to Climate Change (2020-2049) in Agriculture
Risk Index
Very Low
Low
Medium
High
Very High
Copyright @ 2019 ICAR - CRIDA
ICAR
NICRA

Fig. R1

Table 8. State-wise distribution of districts based on exposure to climate change

State	Exposure category					
	Very Low	Low	Medium	High	Very High	Total
Andhra Pradesh	0	6	5	2	0	13
Arunachal Pradesh	12	1	0	0	0	13
Assam	0	9	12	2	0	23
Bihar	0	1	7	13	16	37
Chhattisgarh	1	5	9	1	0	16
Dadra & Nagar Haveli	0	0	1	0	0	1
Daman & Diu	0	0	2	0	0	2
Goa	0	2	0	0	0	2
Gujarat	1	7	10	7	0	25
Haryana	0	1	1	16	1	19
Himachal Pradesh	1	9	2	0	0	12
Jammu & Kashmir	0	10	4	0	0	14
Jharkhand	1	17	0	0	0	18
Karnataka	1	3	21	2	0	27
Kerala	0	0	1	8	5	14
Madhya Pradesh	0	18	23	4	0	45
Maharashtra	0	6	23	4	0	33
Manipur	2	4	2	1	0	9
Meghalaya	0	7	0	0	0	7
Mizoram	0	6	2	0	0	8
Nagaland	2	5	1	0	0	8
Odisha	0	17	10	3	0	30
Pondicherry	0	0	1	1	0	2
Punjab	0	0	12	5	0	17
Rajasthan	3	11	15	3	0	32
Sikkim	1	1	2	0	0	4
Tamil Nadu	0	4	18	7	0	29
Telangana	0	3	6	0	0	9
Tripura	0	2	1	1	0	4
Uttar Pradesh	0	1	8	41	20	70
Uttarakhand	4	7	2	0	0	13
West Bengal	0	0	3	6	8	17
Total	**29**	**163**	**204**	**127**	**50**	**573**

Table 9. State-wise distribution of districts based on vulnerability to climate change

State	Vulnerability category					
	Very low	Low	Medium	High	Very High	Total
Andhra Pradesh	0	5	4	4	0	13
Arunachal Pradesh	0	0	0	13	0	13
Assam	0	4	17	2	0	23
Bihar	0	6	30	1	0	37
Chhattisgarh	0	1	3	12	0	16
Dadra & Nagar Haveli	0	0	1	0	0	1
Daman & Diu	0	0	2	0	0	2
Goa	0	0	2	0	0	2
Gujarat	1	9	11	4	0	25
Haryana	13	4	2	0	0	19
Himachal Pradesh	0	0	5	7	0	12
Jammu & Kashmir	0	2	7	4	1	14
Jharkhand	0	0	3	15	0	18
Karnataka	0	5	11	11	0	27
Kerala	0	4	10	0	0	14
Madhya Pradesh	0	7	25	12	1	45
Maharashtra	0	1	15	17	0	33
Manipur	0	0	4	4	1	9
Meghalaya	0	0	1	6	0	7
Mizoram	0	0	1	6	1	8
Nagaland	0	1	1	4	2	8
Odisha	0	3	13	14	0	30
Pondicherry	2	0	0	0	0	2
Punjab	12	5	0	0	0	17
Rajasthan	0	0	4	17	11	32
Sikkim	0	0	1	3	0	4
Tamil Nadu	2	14	12	1	0	29
Telangana	0	0	7	2	0	9
Tripura	0	1	3	0	0	4
Uttar Pradesh	9	40	14	7	0	70
Uttarakhand	2	0	2	4	5	13
West Bengal	7	7	2	1	0	17
Total	**48**	**119**	**213**	**171**	**22**	**573**

Table 10. State-wise distribution of districts based on historical hazard

State	Historical Hazard Category					
	Very low	Low	Medium	High	Very High	Total
Andhra Pradesh	0	3	6	4	0	13
Arunachal Pradesh	1	8	4	0	0	13
Assam	3	16	4	0	0	23
Bihar	0	16	13	7	1	37
Chhattisgarh	1	13	2	0	0	16
Dadra & Nagar Haveli	0	0	1	0	0	1
Daman & Diu	0	0	1	0	1	2
Goa	0	1	1	0	0	2
Gujarat	0	0	2	11	12	25
Haryana	0	0	5	10	4	19
Himachal Pradesh	0	8	4	0	0	12
Jammu & Kashmir	0	3	8	2	1	14
Jharkhand	0	17	1	0	0	18
Karnataka	0	13	11	3	0	27
Kerala	0	0	9	4	1	14
Madhya Pradesh	0	30	13	2	0	45
Maharashtra	1	20	9	3	0	33
Manipur	0	8	1	0	0	9
Meghalaya	0	1	2	4	0	7
Mizoram	0	5	1	2	0	8
Nagaland	1	5	2	0	0	8
Odisha	0	11	10	7	2	30
Pondicherry	0	0	0	1	1	2
Punjab	0	0	1	6	10	17
Rajasthan	0	5	10	12	5	32
Sikkim	1	2	1	0	0	4
Tamil Nadu	0	0	9	16	4	29
Telangana	0	9	0	0	0	9
Tripura	0	4	0	0	0	4
Uttar Pradesh	0	9	35	24	2	70
Uttarakhand	0	6	5	2	0	13
West Bengal	0	3	4	8	2	17
Total	**8**	**216**	**175**	**128**	**46**	**573**

Table 11. State-wise distribution of districts based on future hazard

State	Future Hazard Category					
	More Favourable	Moderately Favourable	No Hazard	Moderately Unfavourable	More Unfavourable	Total
Andhra Pradesh	0	1	5	7	0	13
Arunachal Pradesh	0	0	0	2	11	13
Assam	0	0	0	14	9	23
Bihar	0	0	6	28	3	37
Chhattisgarh	0	0	1	15	0	16
Dadra & Nagar Haveli	0	1	0	0	0	1
Daman & Diu	0	1	1	0	0	2
Goa	0	0	0	1	1	2
Gujarat	9	8	6	2	0	25
Haryana	0	0	1	10	8	19
Himachal Pradesh	0	0	0	3	9	12
Jammu & Kashmir	0	0	2	6	6	14
Jharkhand	0	0	5	11	2	18
Karnataka	0	1	7	14	5	27
Kerala	0	0	1	9	4	14
Madhya Pradesh	0	0	10	31	4	45
Maharashtra	0	6	13	12	2	33
Manipur	0	0	0	8	1	9
Meghalaya	0	0	0	4	3	7
Mizoram	0	0	0	5	3	8
Nagaland	0	0	0	4	4	8
Odisha	0	0	2	24	4	30
Pondicherry	1	1	0	0	0	2
Punjab	0	0	3	9	5	17
Rajasthan	1	4	11	15	1	32
Sikkim	0	0	0	0	4	4
Tamil Nadu	11	9	8	0	1	29
Telangana	0	0	2	6	1	9
Tripura	0	0	0	4	0	4
Uttar Pradesh	0	0	8	43	19	70
Uttarakhand	0	0	0	2	11	13
West Bengal	0	0	2	10	5	17
Total	**22**	**32**	**94**	**299**	**126**	**573**

Table 12. State-wise distribution of districts based on intensity of climate change risk

State	Risk category					
	Very Low	Low	Medium	High	Very High	Total
Andhra Pradesh	0	3	6	3	1	13
Arunachal Pradesh	0	1	5	6	1	13
Assam	0	2	14	5	2	23
Bihar	0	0	14	13	10	37
Chhattisgarh	0	0	10	6	0	16
Dadra & Nagar Haveli	0	1	0	0	0	1
Daman & Diu	0	0	2	0	0	2
Goa	0	1	1	0	0	2
Gujarat	3	7	7	6	2	25
Haryana	0	0	8	8	3	19
Himachal Pradesh	0	1	3	6	2	12
Jammu & Kashmir	0	1	3	7	3	14
Jharkhand	0	1	11	6	0	18
Karnataka	0	3	9	12	3	27
Kerala	0	0	1	5	8	14
Madhya Pradesh	1	7	21	14	2	45
Maharashtra	1	2	17	11	2	33
Manipur	0	0	3	6	0	9
Meghalaya	0	0	0	1	6	7
Mizoram	0	0	1	5	2	8
Nagaland	0	2	0	5	1	8
Odisha	0	0	11	13	6	30
Pondicherry	1	1	0	0	0	2
Punjab	0	2	6	4	5	17
Rajasthan	0	0	5	10	17	32
Sikkim	0	0	0	3	1	4
Tamil Nadu	4	9	11	5	0	29
Telangana	0	2	5	2	0	9
Tripura	0	2	2	0	0	4
Uttar Pradesh	0	1	21	26	22	70
Uttarakhand	0	0	4	2	7	13
West Bengal	0	0	3	11	3	17
Total	**10**	**49**	**204**	**201**	**109**	**573**

5 Targeting Interventions and Prioritization for Resource Allocation

Tables 8 to 12 and figures E6, HH4, FH16, V16 and R1 present the distribution of districts across states based on different determinants of risk and also based on degree of risk. In order to identify appropriate interventions that help reduce risk, identification of sources of risk for districts identified to have relatively more risk to climate change will be helpful. Table 13 identifies one most important factor contributing most to each determinant of risk. Thus, four important sources of risk are identified for each of the districts with 'high' and 'very high' risk.

5.1. Sources of risk for targeting interventions

Among various drivers of exposure, high proportion of NSA in relation to the geographical area is identified as the most prominent one as it is contributing most to exposure in 134 of 310 districts. A land use pattern that reflects high NSA indicates high population pressure, less area under other land uses such as forests and also high fertility and productivity of soils as in case of states such as Punjab. Many of these districts are in Uttar Pradesh, Rajasthan, Madhya Pradesh, Haryana, Punjab, Karnataka, etc. When NSA is high, more area is being exposed to climate change and even a moderate hazard can afflict considerable damage. Social backwardness as reflected in the high per cent of SC/ST population is identified as the most significant cause of exposure in 71 districts many of which are located in north-eastern states. These groups of population are not well placed in terms of literacy, income levels, access to economic infrastructure, etc. which make them more susceptible to hazard when exposed. Dominance of small and marginal farmers in Indian agriculture is well known. The problems such as lack of economies of scale, weak bargaining power, difficulties in accessing information and capital associated with small farm size are a cause of vulnerability and a high proportion of small and marginal farmers emerged as a strong exposure-related risk driver in 52 of 310 districts identified as having 'very high' or 'high' risk. Exposure is also concerned with existence of high value capital assets in places of occurrence of a hazard. In agriculture, cross-bred cattle is one such example. Cross-bred cattle are highly productive but also sensitive to climate variability and require high investments in fodder, veterinary care, etc. Presence of high proportion of cross-bred cattle is driving risk in 29 districts of which 10 are in Kerala and a few in Tamil Nadu, Karnataka, Jammu & Kashmir, etc. High population density is a cause of high risk in 14 districts of Bihar and a few in Uttar Pradesh, West Bengal, Kerala.

Changes in temperature and rainfall patterns are the two most significant aspects of climate change in relation to agriculture. A rising temperature is evident from historical trends which further increases the importance of access to irrigation. Low access to irrigation, expressed in terms of per cent NSA with access to irrigation, emerged as the most prominent vulnerability-related driver of risk in 116 districts. Expansion, equitable access to and efficiency of irrigation have to receive more attention as part of any adaptation strategy. Harvesting rainwater, *in-situ* conservation and groundwater recharge should be the three principal supply side components of water management in rainfed areas. In both irrigated and rainfed areas, demand management for irrigation water holds key to more sustainable water use. This requires changes in cropping pattern as per the actual plans of irrigation projects on one hand and promotion of crops that require less water in rainfed regions on the other. Technologies (e.g. micro-irrigation), policies and other instruments have to be purposefully tailored together to suit different regions in this regard. Low annual rainfall was found to be an important source of risk in 91 districts.

Table 13. Most Important Factors Contributing to Risk

State	District	Risk Category	Exposure	Vulnerability	Historic Hazard	Future Hazard
Andhra Pradesh	Anantapur	Very High	-	Low NIA	High drought proneness	Rise in Min T
Andhra Pradesh	East Godavari	High	Small farm size	-	High cyclone proneness	Rise in Min T
Andhra Pradesh	Kurnool	High	-	Low NIA	High drought proneness	Rise in Min T
Andhra Pradesh	Srikakulam	High	Small farm size	Low AWHC	High cyclone proneness	Rise in Min T
Arunachal Pradesh	Upper Siang	Very High	-	Low AWHC	High drought proneness	Rise in Min T
Arunachal Pradesh	Dibang valley	High	-	Low NIA	High drought proneness	Rise in Min T
Arunachal Pradesh	East Siang	High	-	Low NIA	-	Rise in Min T
Arunachal Pradesh	Lohit	High	-	Low NIA	High drought proneness	Rise in extreme rainfall events
Arunachal Pradesh	Lower Subansiri	High	-	Low groundwater availability	-	Rise in Min T
Arunachal Pradesh	Tawang	High	-	Low NIA	-	Rise in Min T
Arunachal Pradesh	West Siang	High	-	Low groundwater availability	High drought proneness	Rise in Min T
Assam	Darrang	Very High	High SC/ST population	Low NIA	High drought proneness	Rise in Min T
Assam	Nalbari	Very High	High NSA	Low NIA	-	Rise in Min T
Assam	Barpeta	High	High NSA	Low AWHC	-	Rise in Min T
Assam	Dhemaji	High	-	Low NIA	-	Rise in Min T
Assam	Dhubri	High	High population density	Low NIA	High flood proneness	Rise in Min T
Assam	Kokrajhar	High	-	Low NIA	-	Rise in Min T
Assam	Morigaon	High	High population density	Low NIA	-	Rise in Min T
Bihar	Darbhanga	Very High	High population density	Low AWHC	High flood proneness	Rise in Min T
Bihar	Katihar	Very High	High population density	Low AWHC	High flood proneness	Increase in drought proneness
Bihar	Kishanganj	Very High	High population density	Low NIA	High flood proneness	Rise in Min T
Bihar	Lakhisarai	Very High	Small farm size	Low AWHC	High flood proneness	Rise in Min T
Bihar	Madhubani	Very High	High population density	Low AWHC	High flood proneness	Rise in Min T
Bihar	Nalanda	Very High	High NSA	Low AWHC	High flood proneness	Rise in Min T
Bihar	Saharsa	Very High	High population density	Low AWHC	High flood proneness	Rise in Min T

State	District	Risk Category	Exposure	Vulnerability	Historic Hazard	Future Hazard
Bihar	Sheikhpura	Very High	High NSA	Low AWHC	High drought proneness	Rise in Min T
Bihar	Sitamarhi	Very High	High population density	Low AWHC	High flood proneness	Rise in Min T
Bihar	Supaul	Very High	High population density	Low AWHC	High flood proneness	Rise in Min T
Bihar	Begusarai	High	High population density	-	High flood proneness	Rise in Min T
Bihar	Bhagalpur	High	High population density	Low AWHC	High flood proneness	Rise in Min T
Bihar	Bhojpur	High	High NSA	Low AWHC	-	Rise in Min T
Bihar	Buxar	High	High NSA	Low AWHC	-	Rise in Min T
Bihar	Champaran (East)	High	High NSA	Low AWHC	High flood proneness	Rise in Min T
Bihar	Champaran (West)	High	Small farm size	Low AWHC	High flood proneness	Rise in Min T
Bihar	Gopalganj	High	High NSA	Low AWHC	-	Rise in Min T
Bihar	Khagaria	High	High population density	-	High flood proneness	Rise in Min T
Bihar	Madhepura	High	High NSA	-	High flood proneness	Rise in Min T
Bihar	Patna	High	High population density	Low AWHC	High flood proneness	Rise in Min T
Bihar	Purnea	High	High population density	Low AWHC	High flood proneness	Rise in Min T
Bihar	Samastipur	High	High population density	Low AWHC	-	Rise in Min T
Bihar	Siwan	High	High population density	Low AWHC	-	Rise in Min T
Chhattisgarh	Durg	High	High NSA	Low AWHC	High drought proneness	Rise in Min T
Chhattisgarh	Jashpur	High	High SC/ST population	Low NIA	-	Rise in Min T
Chhattisgarh	Kanker	High	High SC/ST population	Low NIA	-	Rise in Min T
Chhattisgarh	Korba	High	-	Low NIA	-	Rise in Min T
Chhattisgarh	Mahasamund	High	High NSA	High dependence on agriculture for employment	-	Rise in Min T
Chhattisgarh	Raigadh	High	High SC/ST population	Low NIA	-	Rise in Min T
Gujarat	Dahod	Very High	High SC/ST population	Low NIA	High drought proneness	Rise in Min T
Gujarat	Panchmahal	Very High	High NSA	Low NIA	High drought proneness	Rise in Min T
Gujarat	Anand	High	High NSA	-	High drought proneness	-

State	District	Risk Category	Exposure	Vulnerability	Historic Hazard	Future Hazard
Gujarat	Banaskantha	High	High NSA	Low rainfall	High drought proneness	-
Gujarat	Dang	High	-	Low NIA	High drought proneness	Rise in Min T
Gujarat	Kheda	High	High NSA	-	High drought proneness	Rise in Min T
Gujarat	Narmada	High	High SC/ST population	High dependence on agriculture for employment	High drought proneness	Rise in Min T
Gujarat	Patan	High	High NSA	Low rainfall	High drought proneness	-
Haryana	Bhiwani	Very High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Haryana	Fatehabad	Very High	High NSA	-	High drought proneness	Rise in Min T
Haryana	Mahendragarh	Very High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Haryana	Gurgaon	High	High NSA	-	High drought proneness	Increase in drought proneness
Haryana	Hissar	High	High NSA	-	High drought proneness	Rise in Min T
Haryana	Jhajjar	High	High NSA	-	High drought proneness	Rise in Min T
Haryana	Jind	High	High NSA	-	High drought proneness	Rise in Min T
Haryana	Kaithal	High	High NSA	-	High drought proneness	Rise in Min T
Haryana	Rewari	High	High NSA	-	High drought proneness	Increase in drought proneness
Haryana	Rohtak	High	High NSA	-	High drought proneness	Rise in Min T
Haryana	Sirsa	High	High NSA	-	High drought proneness	Rise in Min T
Himachal Pradesh	Chamba	Very High	-	Low NIA	High drought proneness	Rise in Min T
Himachal Pradesh	Mandi	Very High	Small farm size	Low NIA	-	Increase in drought proneness
Himachal Pradesh	Bilaspur	High	-	Low NIA	High drought proneness	Rise in Min T
Himachal Pradesh	Hamirpur	High	Small farm size	Low NIA	-	Rise in Max T
Himachal Pradesh	Kangra	High	-	Low AWHC	High drought proneness	Rise in Min T
Himachal Pradesh	Kinnaur	High	-	Low AWHC	High drought proneness	Rise in Max T
Himachal Pradesh	Kullu	High	-	Low NIA	-	Rise in Max T
Himachal Pradesh	Shimla	High	-	Low NIA	-	Rise in Min T

State	District	Risk Category	Exposure	Vulnerability	Historic Hazard	Future Hazard
Jammu & Kashmir	Kathua	Very High	-	Low AWHC	High drought proneness	Rise in Min T
Jammu & Kashmir	Leh(Ladakh)	Very High	-	Low groundwater availability	High drought proneness	Rise in Min T
Jammu & Kashmir	Poonch	Very High	-	Low NIA	High drought proneness	Increase in drought proneness
Jammu & Kashmir	Anantnag	High	More cross-bred cattle	High dependence on agriculture for employment	High drought proneness	Rise in Min T
Jammu & Kashmir	Baramulla	High	-	Low AWHC	High drought proneness	Rise in Min T
Jammu & Kashmir	Budgam	High	More cross-bred cattle	Low rainfall	High drought proneness	Rise in Min T
Jammu & Kashmir	Doda	High	-	Low NIA	High drought proneness	Rise in Min T
Jammu & Kashmir	Kargil	High	-	Low groundwater availability	High drought proneness	Rise in Min T
Jammu & Kashmir	Rajouri	High	-	Low NIA	High drought proneness	Rise in Max T
Jammu & Kashmir	Udhampur	High	-	Low NIA	High drought proneness	Rise in Min T
Jharkhand	Garhwa	High	-	Low NIA	High drought proneness	Rise in Min T
Jharkhand	Godda	High	-	Low NIA	-	Rise in Min T
Jharkhand	Gumla	High	-	Low NIA	-	Rise in Min T
Jharkhand	Pakur	High	-	Low NIA	-	Rise in Min T
Jharkhand	Sahibganj	High	-	Low NIA	-	Rise in Min T
Jharkhand	West Singbhum	High	-	Low NIA	-	Rise in Min T
Karnataka	Chitradurga	Very High	High SC/ST population	Low rainfall	High drought proneness	Rise in Min T
Karnataka	Gadag	Very High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Karnataka	Haveri	Very High	High NSA	Low NIA	High drought proneness	Rise in Min T
Karnataka	Bagalkot	High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Karnataka	Bangalore (Rural)	High	More cross-bred cattle	Low NIA	High drought proneness	Rise in Min T
Karnataka	Bellary	High	High NSA	Low rainfall	High drought proneness	Increase in extreme rainfall
Karnataka	Bidar	High	High NSA	Low NIA	High drought proneness	Rise in Min T
Karnataka	Chamarajanagar	High	More cross-bred cattle	Low rainfall	High drought proneness	Rise in Min T

State	District	Risk Category	Exposure	Vulnerability	Historic Hazard	Future Hazard
Karnataka	Dharwad	High	High NSA	Low NIA	High drought proneness	Rise in Min T
Karnataka	Gulbarga	High	High NSA	Low NIA	-	Increase in drought proneness
Karnataka	Hassan	High	Small farm size	Low NIA	-	Rise in Min T
Karnataka	Kolar	High	More cross-bred cattle	Low NIA	-	Rise in Min T
Karnataka	Koppal	High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Karnataka	Mysore	High	Small farm size	Low rainfall	High drought proneness	Rise in Min T
Karnataka	Tumkur	High	More cross-bred cattle	Low rainfall	High drought proneness	Rise in Min T
Kerala	Alappuzha	Very High	High population density	-	High flood proneness	Rise in extreme rainfall events
Kerala	Ernakulam	Very High	More cross-bred cattle	-	High cyclone proneness	Increase in drought proneness
Kerala	Kasaragod	Very High	High NSA	Low AWHC	High cyclone proneness	Rise in Min T
Kerala	Kollam	Very High	More cross-bred cattle	Low NIA	High cyclone proneness	Rise in Min T
Kerala	Kottayam	Very High	High NSA	Low NIA	High drought proneness	Rise in extreme rainfall events
Kerala	Kozhikode	Very High	More cross-bred cattle	Low NIA	High cyclone proneness	Increase in drought proneness
Kerala	Pathanamthitta	Very High	More cross-bred cattle	Low NIA	High flood proneness	Rise in Min T
Kerala	Thiruvanathapuram	Very High	More cross-bred cattle	Low NIA	High drought proneness	Increase in drought proneness
Kerala	Kannur	High	More cross-bred cattle	Low NIA	High cyclone proneness	Rise in Min T
Kerala	Malappuram	High	More cross-bred cattle	Low NIA	High cyclone proneness	Rise in Min T
Kerala	Palakkad	High	More cross-bred cattle	-	High drought proneness	Rise in Min T
Kerala	Thrissur	High	More cross-bred cattle	-	High cyclone proneness	Rise in extreme rainfall events
Kerala	Wayanad	High	More cross-bred cattle	Low NIA	High drought proneness	Rise in Min T
Madhya Pradesh	Bhind	Very High	High NSA	Low rainfall	High drought proneness	Increase in drought proneness
Madhya Pradesh	Jhabua	Very High	High SC/ST population	Low NIA	High drought proneness	Rise in Min T
Madhya Pradesh	Barwani	High	High SC/ST population	Low rainfall	High drought proneness	Rise in Min T
Madhya Pradesh	Betul	High	-	Low livestock density	-	Increase in drought proneness

State	District	Risk Category	Exposure	Vulnerability	Historic Hazard	Future Hazard
Madhya Pradesh	Chhatarpur	High	-	Low groundwater availability	-	Rise in Max T
Madhya Pradesh	Datia	High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Madhya Pradesh	Dindori	High	-	Low NIA	-	Rise in Min T
Madhya Pradesh	Mandla	High	High SC/ST population	Low NIA	-	Rise in Min T
Madhya Pradesh	Mandsaur	High	High NSA	Low rainfall	-	Rise in Min T
Madhya Pradesh	Morena	High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Madhya Pradesh	Panna	High	-	Low groundwater availability	-	Rise in Min T
Madhya Pradesh	Ratlam	High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Madhya Pradesh	Rewa	High	High NSA	Low NIA	-	Rise in Min T
Madhya Pradesh	Shahdol	High	-	Low NIA	-	Rise in Min T
Madhya Pradesh	Sidhi	High	-	Low NIA	-	Rise in Min T
Madhya Pradesh	Tikamgarh	High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Maharashtra	Beed	Very High	High NSA	Low NIA	High drought proneness	Rise in Min T
Maharashtra	Nanded	Very High	High NSA	Low NIA	-	Increase in drought proneness
Maharashtra	Ahmednagar	High	High NSA	Low rainfall	High drought proneness	-
Maharashtra	Akola	High	High NSA	Low NIA	-	Rise in Min T
Maharashtra	Chandrapur	High	-	Low NIA	-	Rise in Min T
Maharashtra	Hingoli	High	High NSA	Low NIA	High drought proneness	Rise in Min T
Maharashtra	Jalna	High	High NSA	Low NIA	-	Rise in Min T
Maharashtra	Latur	High	High NSA	Low NIA	High drought proneness	Rise in Min T
Maharashtra	Nandurbar	High	High SC/ST population	Low NIA	High drought proneness	Rise in Min T
Maharashtra	Osmanabad	High	High NSA	Low NIA	High drought proneness	Rise in Min T
Maharashtra	Parbhani	High	High NSA	Low NIA	-	Rise in Min T
Maharashtra	Wardha	High	High NSA	Low NIA	-	Rise in Min T
Maharashtra	Washim	High	High NSA	Low NIA	-	Rise in Min T
Manipur	Chandel	High	-	Low NIA	-	Rise in Min T
Manipur	Churachandpur	High	-	Low NIA	-	Rise in Min T
Manipur	Imphal East	High	-	Low NIA	High flood proneness	Rise in Min T
Manipur	Senapati	High	-	Low NIA	-	Rise in Min T

State	District	Risk Category	Exposure	Vulnerability	Historic Hazard	Future Hazard
Manipur	Thoubal	High	High NSA	Low market access	-	Rise in Min T
Manipur	Ukhrul	High	-	Low NIA	-	Rise in Min T
Meghalaya	East Garo Hills	Very High	-	Low groundwater availability	High drought proneness	Rise in Min T
Meghalaya	East Khasi Hills	Very High	-	Low NIA	High drought proneness	Increase in drought proneness
Meghalaya	Jaintia Hills	Very High	-	Low livestock density	High drought proneness	Rise in Min T
Meghalaya	South Garo Hills	Very High	-	Low groundwater availability	High drought proneness	Increase in 99 percentile rainfall
Meghalaya	West Garo Hills	Very High	-	Low NIA	High drought proneness	Rise in Min T
Meghalaya	West Khasi Hills	Very High	-	Low groundwater availability	High drought proneness	Increase in 99 percentile rainfall
Meghalaya	Ri-Bhoi	High	-	Low groundwater availability	-	Rise in Min T
Mizoram	Lawngtlai	Very High	-	Low NIA	High drought proneness	Rise in Min T
Mizoram	Saiha	Very High	-	Low NIA	High drought proneness	Rise in Min T
Mizoram	Aizawl	High	High SC/ST population	Low NIA	-	Rise in Min T
Mizoram	Champhai	High	-	Low AWHC	-	Rise in Min T
Mizoram	Kolasib	High	-	Low NIA	-	Rise in Min T
Mizoram	Lunglei	High	-	Low NIA	High drought proneness	Rise in Min T
Mizoram	Serchhip	High	High SC/ST population	Low NIA	-	Rise in Min T
Nagaland	Tuensang	Very High	-	Low NIA	High drought proneness	Rise in Min T
Nagaland	Mokokchung	High	-	Low NIA	High drought proneness	Rise in Min T
Nagaland	Mon	High	-	Low NIA	-	Rise in Min T
Nagaland	Phek	High	-	Low groundwater availability	-	Rise in Min T
Nagaland	Wokha	High	-	Low NIA	-	Rise in Min T
Nagaland	Zunheboto	High	-	Low NIA	-	Rise in Min T
Orissa	Balasore (Baleshwar)	Very High	Small farm size	Low AWHC	High cyclone proneness	Rise in Min T
Orissa	Jagatsingpur	Very High	More cross-bred cattle	-	High flood proneness	Rise in Min T

State	District	Risk Category	Exposure	Vulnerability	Historic Hazard	Future Hazard
Orissa	Jajpur	Very High	Small farm size	Low NIA	High cyclone proneness	Rise in Min T
Orissa	Kendrapara	Very High	Small farm size	Low AWHC	High cyclone proneness	Rise in Min T
Orissa	Keonjhar	Very High	-	Low NIA	High cyclone proneness	Rise in Min T
Orissa	Puri	Very High	Small farm size	-	High flood proneness	Rise in Min T
Orissa	Baragarh	High	More cross-bred cattle	High dependence on agriculture for employment	-	Increase in drought proneness
Orissa	Bhadrak	High	High NSA	Low AWHC	High cyclone proneness	Rise in Min T
Orissa	Bolangir	High	Small farm size	Low NIA	High drought proneness	Rise in Min T
Orissa	Dhenkanal	High	-	Low NIA	High cyclone proneness	Increase in drought proneness
Orissa	Gajapati	High	-	Low groundwater availability	High cyclone proneness	Rise in Min T
Orissa	Ganjam	High	-	Low AWHC	High cyclone proneness	Rise in Min T
Orissa	Kalahandi	High	-	Low NIA	High drought proneness	Rise in Min T
Orissa	Khurda	High	Small farm size	Low NIA	High cyclone proneness	Rise in Min T
Orissa	Mayurbhanj	High	High SC/ST population	Low NIA	High cyclone proneness	Rise in Min T
Orissa	Nabarangpur	High	High SC/ST population	Low NIA	-	Rise in Min T
Orissa	Nayagarh	High	-	Low NIA	High cyclone proneness	Rise in Min T
Orissa	Nuapada	High	-	Low NIA	High drought proneness	Rise in Min T
Orissa	Rayagada	High	-	Low NIA	-	Rise in Min T
Punjab	Bathinda	Very High	High NSA	-	High drought proneness	Rise in Min T
Punjab	Faridkot	Very High	High NSA	-	High drought proneness	Rise in Min T
Punjab	Gurdaspur	Very High	High NSA	-	High drought proneness	Increase in drought proneness
Punjab	Jalandhar	Very High	High NSA	-	High drought proneness	Rise in Min T
Punjab	Moga	Very High	High NSA	-	High drought proneness	Increase in drought proneness
Punjab	Firozpur	High	High NSA	-	High drought proneness	Rise in Min T

State	District	Risk Category	Exposure	Vulnerability	Historic Hazard	Future Hazard
Punjab	Mansa	High	High NSA	-	High drought proneness	Rise in Min T
Punjab	Muktsar	High	High NSA	-	High drought proneness	Rise in Min T
Punjab	Sangrur	High	High NSA	-	High flood proneness	Increase in drought proneness
Rajasthan	Alwar	Very High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Banswara	Very High	High SC/ST population	High dependence on agriculture for employment	High drought proneness	Rise in Min T
Rajasthan	Barmer	Very High	-	Low rainfall	High drought proneness	-
Rajasthan	Bhilwara	Very High	-	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Churu	Very High	-	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Dausa	Very High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Dungarpur	Very High	High SC/ST population	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Ganganagar	Very High	-	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Hanumangarh	Very High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Jaisalmer	Very High	-	Low rainfall	High drought proneness	Increase in drought proneness
Rajasthan	Jalore	Very High	-	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Jhunjhunu	Very High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Jodhpur	Very High	-	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Karauli	Very High	High SC/ST population	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Nagaur	Very High	-	Low rainfall	High drought proneness	-
Rajasthan	Pali	Very High	-	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Sikar	Very High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Ajmer	High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Bharatpur	High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Bikaner	High	-	Low rainfall	High drought proneness	-

State	District	Risk Category	Exposure	Vulnerability	Historic Hazard	Future Hazard
Rajasthan	Bundi	High	High SC/ST population	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Dholpur	High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Jaipur	High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Rajsamand	High	-	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Sirohi	High	-	Low rainfall	High drought proneness	-
Rajasthan	Tonk	High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Rajasthan	Udaipur	High	-	Low rainfall	-	Rise in Min T
Sikkim	South	Very High	More cross-bred cattle	Low NIA	-	Rise in Min T
Sikkim	East	High	More cross-bred cattle	Low AWHC	-	Rise in Min T
Sikkim	North	High	-	Low NIA	High drought proneness	Rise in Min T
Sikkim	West	High	-	Low groundwater availability	-	Increase in drought proneness
Tamil Nadu	Coimbatore	High	More cross-bred cattle	-	High drought proneness	Rise in Min T
Tamil Nadu	Dharmapuri	High	More cross-bred cattle	Low rainfall	High drought proneness	Rise in Min T
Tamil Nadu	Perambalur	High	More cross-bred cattle	Low NIA	High drought proneness	-
Tamil Nadu	Ramanathapuram	High	Small farm size	Low AWHC	High drought proneness	-
Tamil Nadu	Villupuram	High	More cross-bred cattle	-	High drought proneness	-
Telangana	Adilabad	High	-	Low NIA	-	Rise in Min T
Telangana	Mahabubnagar	High	Small farm size	Low NIA	-	Rise in Min T
Uttar Pradesh	Allahabad	Very High	High population density	-	High drought proneness	Rise in Min T
Uttar Pradesh	Auraiya	Very High	High NSA	-	High drought proneness	Rise in Min T
Uttar Pradesh	Bagpat	Very High	High NSA	-	High drought proneness	Increase in drought proneness
Uttar Pradesh	Bahraich	Very High	High NSA	Low literacy level	High flood proneness	Rise in Min T
Uttar Pradesh	Balrampur	Very High	High NSA	Low AWHC	High flood proneness	Increase in drought proneness
Uttar Pradesh	Banda	Very High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Uttar Pradesh	Basti	Very High	High NSA	Extensive degraded lands	High drought proneness	Rise in Min T

State	District	Risk Category	Exposure	Vulnerability	Historic Hazard	Future Hazard
Uttar Pradesh	Chitrakut	Very High	High NSA	High dependence on agriculture for employment	-	Increase in drought proneness
Uttar Pradesh	Etawah	Very High	High NSA	-	High drought proneness	Rise in Min T
Uttar Pradesh	Fatehpur	Very High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Uttar Pradesh	Gonda	Very High	High NSA	Low AWHC	High flood proneness	Rise in Min T
Uttar Pradesh	Hamirpur	Very High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Uttar Pradesh	Jalaun	Very High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Uttar Pradesh	Jaunpur	Very High	High NSA	-	High flood proneness	Rise in Min T
Uttar Pradesh	Jhansi	Very High	High NSA	Low rainfall	-	Rise in Min T
Uttar Pradesh	Kannauj	Very High	High NSA	-	High drought proneness	Rise in Min T
Uttar Pradesh	Kanpur (Dehat)	Very High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Uttar Pradesh	Kaushambi	Very High	High NSA	Low rainfall	High drought proneness	Rise in Min T
Uttar Pradesh	Mahoba	Very High	High NSA	Extensive degraded lands	High drought proneness	Rise in Min T
Uttar Pradesh	Sant Ravidas Nagar	Very High	High population density	-	High flood proneness	Rise in Min T
Uttar Pradesh	Shravasti	Very High	Small farm size	Low literacy level	-	Rise in Min T
Uttar Pradesh	Unnao	Very High	High NSA	-	High drought proneness	Rise in Min T
Uttar Pradesh	Agra	High	High NSA	-	High drought proneness	Rise in Min T
Uttar Pradesh	Aligarh	High	High NSA	-	High drought proneness	Rise in Min T
Uttar Pradesh	Ambedkar Nagar	High	High NSA	-	High drought proneness	Rise in Min T
Uttar Pradesh	Budaun	High	High NSA	-	High flood proneness	Rise in Min T
Uttar Pradesh	Deoria	High	High NSA	-	High flood proneness	Rise in Min T
Uttar Pradesh	Farrukhabad	High	High NSA	-	High flood proneness	Rise in Min T
Uttar Pradesh	Gorakhpur	High	High NSA	-	High flood proneness	Rise in Min T
Uttar Pradesh	Hathras	High	High NSA	-	High drought proneness	Rise in Min T

State	District	Risk Category	Exposure	Vulnerability	Historic Hazard	Future Hazard
Uttar Pradesh	Jyotiba Phulenagar	High	High NSA	-	High drought proneness	Rise in Min T
Uttar Pradesh	Kanpur City	High	High NSA	-	High drought proneness	Rise in Min T
Uttar Pradesh	Kushi Nagar	High	High NSA	Extensive degraded lands	High flood proneness	Rise in Min T
Uttar Pradesh	Lalitpur	High	High NSA	Extensive degraded lands	High drought proneness	Rise in Min T
Uttar Pradesh	Maharajganj	High	High NSA	Low AWHC	High flood proneness	Rise in Min T
Uttar Pradesh	Mathura	High	High NSA	-	High flood proneness	Rise in Min T
Uttar Pradesh	Mirzapur	High	Small farm size	Extensive degraded lands	High flood proneness	Rise in Min T
Uttar Pradesh	Pilibhit	High	High NSA	-	High flood proneness	Rise in Min T
Uttar Pradesh	Pratapgarh	High	High population density	-	High drought proneness	Rise in Max T
Uttar Pradesh	Rae-Bareily	High	Small farm size	-	High drought proneness	Rise in Min T
Uttar Pradesh	Rampur	High	High NSA	-	High drought proneness	Rise in Min T
Uttar Pradesh	Saharanpur	High	High NSA	-	High drought proneness	Rise in Min T
Uttar Pradesh	Sant Kabir Nagar	High	High NSA	-	High flood proneness	Rise in Min T
Uttar Pradesh	Shahjahanpur	High	High NSA	-	High flood proneness	Rise in Min T
Uttar Pradesh	Siddharth Nagar	High	High NSA	Poor road connectivity	High flood proneness	Rise in Min T
Uttar Pradesh	Sitapur	High	High NSA	-	High flood proneness	Rise in Min T
Uttar Pradesh	Sonbhadra	High	-	Low NIA	-	Rise in Min T
Uttar Pradesh	Varanasi	High	High population density	-	High flood proneness	Rise in Min T
Uttarakhand	Almora	Very High	-	Low NIA	High drought proneness	Rise in Min T
Uttarakhand	Bageshwar	Very High	-	Low NIA	High drought proneness	Rise in Min T
Uttarakhand	Champawat	Very High	-	Low NIA	High drought proneness	Rise in Min T
Uttarakhand	Pithoragarh	Very High	-	Low NIA	High drought proneness	Rise in Min T
Uttarakhand	Rudraprayag	Very High	-	Low NIA	-	Rise in Min T
Uttarakhand	Tehri Garwal	Very High	-	Low NIA	-	Rise in Min T
Uttarakhand	Uttarkashi	Very High	-	Low NIA	-	Rise in Min T
Uttarakhand	Chamoli	High	-	Low NIA	-	Rise in Min T

State	District	Risk Category	Exposure	Vulnerability	Historic Hazard	Future Hazard
Uttarakhand	Pauri Garhwal	High	-	Low NIA	-	Rise in Min T
West Bengal	24-Paraganas (North)	Very High	High population density	-	High cyclone proneness	Rise in Min T
West Bengal	24-Paraganas (South)	Very High	Small farm size	Low AWHC	High cyclone proneness	Rise in Min T
West Bengal	Malda	Very High	High NSA	-	High flood proneness	Rise in Min T
West Bengal	Birbhum	High	High NSA	-	High flood proneness	Rise in Min T
West Bengal	Cooch Behar	High	High NSA	-	High flood proneness	Rise in extreme rainfall events
West Bengal	Darjeeling	High	Small farm size	Low NIA	-	Rise in extreme rainfall events
West Bengal	Dinajpur (Dakshin)	High	High NSA	-	High flood proneness	Rise in Min T
West Bengal	Dinajpur (Uttar)	High	High NSA	-	High flood proneness	Rise in Min T
West Bengal	Howrah	High	High population density	-	High flood proneness	Rise in Min T
West Bengal	Jalpaiguri	High	Small farm size	-	High drought proneness	Rise in Min T
West Bengal	Midnapore	High	Small farm size	-	High cyclone proneness	Rise in Min T
West Bengal	Murshidabad	High	High NSA	-	High flood proneness	Rise in Min T
West Bengal	Nadia	High	High NSA	-	High flood proneness	Rise in Min T
West Bengal	Purulia	High	Small farm size	Low NIA	-	Rise in Min T

Note: - indicates that the respective component is not a significant contributor to risk

The interventions to manage low rainfall to an extent overlap with those related to irrigation. However, the relative importance of *ex situ* and *in situ* rainwater harvesting vary with the quantity and distribution of rainfall and with spatial linkages with other districts. Other related factors contributing to high risk are the available water holding capacity of soils and groundwater availability which are contributing to high risk in 56 and 13 districts, respectively. The former is a slowly responding feature of the soils and therefore needs long term strategies and investments in soil and water conservation, building organic carbon levels, innovative groundwater recharge methods, farm level water harvesting through farm ponds, etc. Presence of large extent of degraded lands, because of their poor ability to support crop growth, enhances vulnerability and thus risk of climate change. This factor is identified as a major source of risk in 13 districts. This also requires long term efforts in soil conservation, runoff management, land reclamation, pasture management, green capping etc. and have to be matched by focused crop improvement programmes for developing appropriate varieties. Poor profitability and high dependence on agriculture as reflected in high income inequity in agriculture, poor literacy and inadequate road and electricity infrastructure are other vulnerability-related drivers of risk in a few districts. Appropriate interventions are required for strengthening such factors.

Among the historical hazard related factors, high incidence of drought was contributing the most to risk in 156 districts, cyclone in 93 districts and flood in 61 districts. They require suitable interventions and long term strategies with adequate investments in forecasting and forewarning capacities and related infrastructure. Even the farmers' perceptions indicate the desirability of and preference to such interventions by the Government (Rama Rao et al., 2018). Breeding for drought and submergence tolerant crop varieties, investments *in situ* and *ex situ* rainwater management for enabling critical irrigation, creating infrastructure for storage of produce immediately after harvest to protect from flood or cyclonic rains, creation of wind breaks, preserving coastal ecosystems (mangroves, wet lands, etc.), strengthening river banks, etc. are some of the interventions needed in managing such hazards.

Climate change projections indicate rise in temperature with more certainty and it is the minimum (night) temperature that is rising more than the maximum temperature. Heat stress/or rising temperature is emerging as an important factor in determining crop yields (Jayaraman and Murari, 2014) and has not received as much attention as the rainfall deficits did in the Indian context. This analysis shows that rise in minimum temperature is the most significant factor in determining risk in 271 districts. The impact of rising minimum temperature or warmer nights in *rabi* crops like wheat is evident from many studies. Some of the desirable interventions in this regard are advancing sowing dates, adoption of short duration varieties, etc. Similarly, rise in maximum temperature was identified as a key driver of risk in six districts. Increase in drought incidence is a cause of high climate change risk in 24 districts. More and better focussed efforts are required for managing drought in these districts. Though gradually changing climate (temperature and rainfall) has received some implicit and explicit attention in research efforts, the effects of incidence of extreme events on crop productivity and on how to minimize extreme event-induced crop losses have not received much attention. Incidence of extreme rainfall events was found to be contributing to risk in ten districts. Forewarning and quick action are the two challenges that have to be addressed in this regard.

Climate and climate change is a spatial phenomenon and hence climate change risk also varies spatially. The analysis showed the variability in risk and also the relative importance of different determinants of risk across districts. Thus, it is important to develop strategies that recognize the location specificity of the extent and causes of risk. Further, it may be more pragmatic to approach risk reduction through addressing vulnerability as reducing exposure is more difficult and require more long term and cross-sector polices and climate projections have always an element of uncertainty and heavy reliance on them as a means of risk reduction may potentially lead to maladaptation.

5.2. Prioritization of districts for resource allocation

The risk analysis presented so far is based on the indicators expressed in terms of proportions within in the district and can be considered as 'intensity based' analysis. For example, relatively more area in relation to geographical area may be under cultivation (NSA), but it may be smaller in extent compared to another district where the NSA is lower in terms of per cent geographical area but may be considerably larger in terms of actual extent. From the perspective of the district concerned, such an 'intensity' based risk measure is appropriate. Resource allocation exclusively on this basis may lead to exclusion of some districts where the 'exposure' is very high in actual units, which when exposed even to a moderate hazard, may result in considerable magnitude of impact from the country's or states perspective. Considering such extensity of what is being exposed to hazard along with the intensity based risk metric may be of interest to policy makers while allocating resources with a view to include 'more area' or 'more people' in any targeted programme. In order to inform such decisions, the intensity based risk is multiplied with the average of the proportion of the district in country's net sown area and in country's agricultural workforce to arrive at an intensity-cum-extensity based risk measure and the districts are categorized as in case of intensity based risk (Fig. R2 and Table 14). In this case, a district with 'high' or 'medium' risk (intensity based measure), if bigger in terms of NSA or agricultural workforce, can become district with 'very high' or 'high' risk (intensity-cum extensity based measure). A few districts in Rajasthan, Maharashtra, Karnataka, Uttar Pradesh, Bihar are examples of such shifts between the two risk measures. The reverse is also possible as in case of a few districts in Kerala, Punjab, Jammu & Kashmir, Uttarakhand, etc.

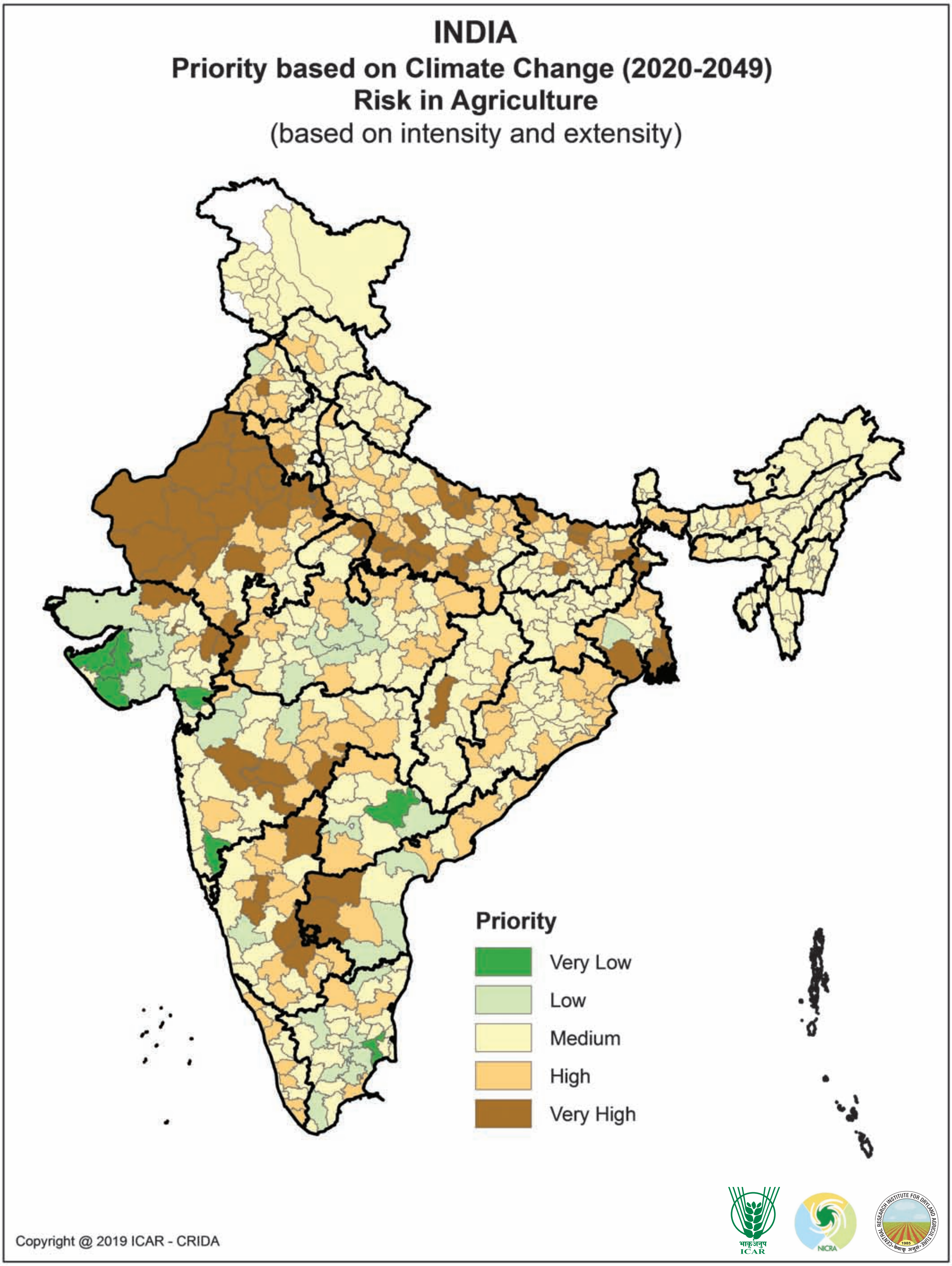

INDIA
Priority based on Climate Change (2020-2049)
Risk in Agriculture
(based on intensity and extensity)
Priority
Very Low
Low
Medium
High
Very High
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Fig. R2

Table 14. State-wise distribution of districts based on intensity-cum-extensity of climate change risk

State	Risk category for prioritization					
	Very Low	Low	Medium	High	Very High	Total
Andhra Pradesh	0	3	3	5	2	13
Arunachal Pradesh	0	0	13	0	0	13
Assam	0	0	21	2	0	23
Bihar	0	0	18	14	5	37
Chhattisgarh	0	0	13	2	1	16
Dadra & Nagar Haveli	0	0	1	0	0	1
Daman & Diu	0	0	2	0	0	2
Goa	0	0	2	0	0	2
Gujarat	4	6	10	2	3	25
Haryana	0	0	13	5	1	19
Himachal Pradesh	0	0	10	2	0	12
Jammu & Kashmir	0	0	14	0	0	14
Jharkhand	0	0	16	2	0	18
Karnataka	0	1	11	10	5	27
Kerala	0	0	7	7	0	14
Madhya Pradesh	0	6	20	17	2	45
Maharashtra	1	3	14	11	4	33
Manipur	0	0	9	0	0	9
Meghalaya	0	0	6	1	0	7
Mizoram	0	0	8	0	0	8
Nagaland	0	0	8	0	0	8
Odisha	0	0	17	13	0	30
Pondicherry	0	0	2	0	0	2
Punjab	0	1	7	8	1	17
Rajasthan	0	0	6	9	17	32
Sikkim	0	0	4	0	0	4
Tamil Nadu	1	7	18	3	0	29
Telangana	1	2	4	2	0	9
Tripura	0	0	4	0	0	4
Uttar Pradesh	0	0	29	31	10	70
Uttarakhand	0	0	12	1	0	13
West Bengal	0	1	5	7	4	17
Total	**7**	**30**	**327**	**154**	**55**	**573**

Based on this measure of risk that considers both intensity and extensity, 55 districts were categorized as those with 'very high' risk and are largely in the states of Rajasthan (17), Uttar Pradesh (10), Karnataka (5), Bihar (5), Maharashtra (4), and West Bengal (4). Of the 154 districts categorized into 'high' risk, 31 are in Uttar Pradesh, 17 in Madhya Pradesh, 14 in Bihar, 13 in Odisha, 11 in Karnataka, 9 in Rajasthan and others in the states of Punjab, West Bengal, Kerala, Andhra Pradesh, Assam, Jharkhand, etc. Thus, the output of the analysis can be used as demanded by the context and purpose. For example, if the plan or programme has to be prepared for a few districts to deal with climate change hazard, use of intensity based risk measure is more relevant and if the purpose is to cover a larger area and larger number of people, with considerable resource allocation, the intensity-cum-extensity based measure may be more meaningful. This perspective is taken because the IPCC defines a risk as a key risk when the magnitude of risk is high among other things.

6 Scope and Limitations

Conceptually, vulnerability arises when an entity or a system of interest is exposed to a situation which it is not used to deal with or an abnormal situation. Considering this, any deviation in climatic variables such as rainfall, temperature should be assumed to increase vulnerability as such deviations necessitate adaptation of the economic activity to the emerging scenario. However, given the nature of agriculture in majority of regions in India, it is more difficult to adapt to decreasing rainfall and rising temperature than to increasing rainfall and decreasing temperature. Sensitivity of crops to heat (temperature) stress is evident and irrigation is one of the key desired management responses. Therefore, we assumed that rising temperature and decreasing rainfall will have adverse impacts on agriculture. However, increase in extreme rainfall and temperature related events are assumed be undesirable and hazardous.

The normalization methods applied while using indicator method assumes linear relationship between the indicator and the phenomenon it is selected to be associated with which many not be the case in reality. We attempted to moderate such issues by fixing upper or lower bounds (e.g. annual rainfall, rural population density, net per capita income, livestock density, fertiliser use, future hazard indicators), transformation of the indicators (e.g. number of markets, dry spells). Obtaining data on all indicators for given reference year is ideal but extremely difficult to get for all the districts in the country. We have taken care to obtain the data for the most recent year depending on availability. Missing values are handled by using the data for immediately preceding year, using the respective state average, etc. The data on indicators for districts in Andhra Pradesh and Telangana refer to the pre-2014 boundaries.

Climate projections are made available for different RCPs and for different time slices. We used in this study the projections for the period 2020-49 based on the RCP 4.5 in line with other climate change related communications such as Intended Nationally Determined Contribution (INDC) which have outlined certain targets for 2030. The RCP 4.5 is also considered as more likely scenario. This choice emerged in a consultation meeting with different stakeholder organizations though we presented the results based on two RCPs for a distant time slice of 2040-2069.

In terms of coverage of the districts, the study considered only those districts as appearing in 2001 census leaving out the urban districts. Though many new districts have been created since then, they could not be included due to non-availability of data on some of the indicators used in the analysis. Further, the two island Union Territories of Andaman & Nicobar Islands and Lakshadweep could not be included as we could not get climate projections for them.

Finally, we would like to discourage any comparison of these findings with those of Rama Rao et al., (2013) though we mentioned that this exercise started as its revision. Such a comparison is not meaningful as the two differ in terms of conceptualization, definitions, data, especially of climate projections. Even the way the districts were categorized is different owing to different normalization methods and the consequent criteria used for categorization of districts.

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Annexure I

Details of GCMs used and the number of runs for downscaling climate projection based on RCP 4.5 for 2020-49

Modeling Center or Group, Country	Model Name	No. of runs
Commonwealth Scientific and Industrial Research Organization and Bureau of Meteorology (CSIRO-BOM), Australia	ACCESS1,0	1
Beijing Climate Center, China Meteorological Administration (BCC), China	BCC-CSM1.1	1
	BCC- CSM1.1(M)	1
College of Global Change and Earth System Science, Beijing Normal University (GCESS), China	BNU-ESM	1
Canadian Centre for Climate Modelling and Analysis (CCCma), Canada	CANESM2	5
National Center for Atmospheric Research, USA	CCSM4	5
Community Earth System Model contributors, USA	CESM1-BGC	1
	CESM1-CAM5	3
Centro Euro-Mediterraneo per I Cambiamenti Climatici (CMCC), Italy	CMCC-CM	1
Centre National de Recherches Météorologiques / Centre Européen de Recherche et Formation Avancée en Calcul Scientifique (CNRM-CERFACS), France	CNRM-CM5	1
Commonwealth Scientific and Industrial Research Organization and Queensland Climate Change Centre of Excellence (CSIRO-QCCCE), Australia	CSIRO-MK3.6.0	10
EC-EARTH consortium	EC-EARTH	3
LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences and CESS, Tsinghua University (LASG-CESS), China	FGOALS-G2	1
The First Institute of Oceanography, SOA, China	FIO-ESM	3
NOAA Geophysical Fluid Dynamics Laboratory (NOAA GFDL), USA	GFDL-CM3	1
	GFDL-ESM2G	1
	GFDL-ESM2M	1
NASA Goddard Institute for Space Studies (NASA GISS), USA	GISS-E2-H-CC	1
	GISS-E2-R	5
	GISS-E2-R-CC	1
National Institute of Meteorological Research/Korea Meteorological Administration (NIMR/KMA), South Korea	HADGEM2-AO	1
Met Office Hadley Centre (additional HadGEM2-ES realizations contributed by Instituto Nacional de Pesquisas Espaciais) (MOHC/ INPE), UK	HADGEM2-ES	2
Institute for Numerical Mathematics (INM), Russia	INMCM4	1
Institut Pierre-Simon Laplace (IPSL), France	IPSL-CM5A-LR	4
	IPSL-CM5A-MR	1
	IPSL-CM5B-LR	1
Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies (MIROC), Japan	MIROC-ESM	1
	MIROC5	1
	MIROC-ESM-CHEM	1
Norwegian Climate Centre (NCC), Norway	NORESM1-M	1
Total models		**30**
Total runs		**61**

Relative ranking of districts based on exposure, hazard, vulnerability and risk

State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Andhra Pradesh	Anantapur	434	63	243	248	103
Andhra Pradesh	Kurnool	385	130	243	447	248
Andhra Pradesh	Srikakulam	170	328	224	420	255
Andhra Pradesh	East Godavari	315	424	132	366	310
Andhra Pradesh	Cuddapah	537	119	355	281	315
Andhra Pradesh	Visakhapatnam	448	249	223	417	317
Andhra Pradesh	Krishna	238	471	59	483	332
Andhra Pradesh	Vizianagaram	302	284	358	350	391
Andhra Pradesh	West Godavari	175	501	169	382	405
Andhra Pradesh	Prakasam	477	178	225	521	463
Andhra Pradesh	Chittoor	377	225	359	503	516
Andhra Pradesh	Nellore	475	425	129	506	519
Andhra Pradesh	Guntur	262	433	199	512	523
Arunachal Pradesh	Upper Siang	571	32	200	12	43
Arunachal Pradesh	West Siang	564	84	280	21	118
Arunachal Pradesh	Dibang valley	573	66	200	71	154
Arunachal Pradesh	Tawang	518	82	435	73	180
Arunachal Pradesh	Lohit	567	74	280	49	183
Arunachal Pradesh	East Siang	566	161	359	15	222
Arunachal Pradesh	Lower Subansiri	556	115	435	41	232
Arunachal Pradesh	East Kameng	562	34	549	95	343
Arunachal Pradesh	Upper Subansiri	569	89	494	42	363
Arunachal Pradesh	West Kameng	560	96	494	148	390
Arunachal Pradesh	Tirap	561	71	568	114	452
Arunachal Pradesh	Papum Pare	563	183	494	113	479
Arunachal Pradesh	Changlang	570	151	494	258	536
Assam	Nalbari	85	238	359	61	82
Assam	Darrang	104	287	280	79	101
Assam	Kokrajhar	428	207	435	17	151
Assam	Dhubri	247	398	230	141	207
Assam	Dhemaji	439	240	417	50	225
Assam	Barpeta	234	313	419	138	266
Assam	Morigaon	251	292	494	62	285
Assam	Jorhat	313	411	263	177	337

State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Assam	N C Hills	452	31	549	380	368
Assam	Karbi-Anglong	508	57	566	252	393
Assam	Tinsukia	491	307	429	150	417
Assam	Goalpara	298	405	549	35	432
Assam	Bongaigaon	244	381	549	74	435
Assam	Sonitpur	446	366	490	72	442
Assam	Lakhimpur	281	440	333	243	447
Assam	Golaghat	405	295	493	223	482
Assam	Kamrup	353	283	434	387	486
Assam	Dibrugarh	390	374	488	202	493
Assam	Sibsagar	337	426	494	119	507
Assam	Hailakandi	372	343	549	168	508
Assam	Nagaon	228	435	545	220	514
Assam	Karimganj	345	378	567	181	531
Assam	Cachar	393	352	568	214	541
Bihar	Darbhanga	14	252	78	296	12
Bihar	Sheikhpura	60	237	38	422	14
Bihar	Kishanganj	169	250	188	38	27
Bihar	Saharsa	91	396	66	155	33
Bihar	Katihar	120	384	342	5	61
Bihar	Nalanda	16	335	196	228	65
Bihar	Lakhisarai	196	258	77	358	67
Bihar	Sitamarhi	59	373	189	166	81
Bihar	Madhubani	49	189	233	425	91
Bihar	Supaul	103	344	127	315	102
Bihar	Bhagalpur	108	377	168	219	112
Bihar	Khagaria	44	438	171	215	124
Bihar	Champaran (West)	179	291	170	301	125
Bihar	Madhepura	46	474	270	40	140
Bihar	Champaran(East)	28	269	348	410	203
Bihar	Gopalganj	27	261	489	275	209
Bihar	Purnea	141	361	261	233	214
Bihar	Siwan	5	346	487	244	227
Bihar	Buxar	15	354	491	179	238
Bihar	Samastipur	20	383	416	280	241
Bihar	Begusarai	17	445	330	276	253
Bihar	Patna	74	364	193	486	294

State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Bihar	Bhojpur	25	282	547	290	296
Bihar	Nawadha	159	251	340	428	313
Bihar	Monghyr	279	309	349	256	336
Bihar	Vaishali	3	350	494	389	346
Bihar	Jahanabad	80	368	418	359	350
Bihar	Araria	214	349	426	211	355
Bihar	Saran	26	290	277	519	361
Bihar	Jamui	420	272	359	239	382
Bihar	Muzafarpur	9	322	350	508	388
Bihar	Banka	273	230	492	357	434
Bihar	Sivhar	4	462	359	454	438
Bihar	Bhabhua (kaimur)	264	367	359	390	466
Bihar	Aurangabad	105	447	359	379	470
Bihar	Rohtas	96	414	494	309	484
Bihar	Gaya	225	334	435	442	500
Chhattisgarh	Durg	209	248	243	333	200
Chhattisgarh	Mahasamund	252	147	494	158	221
Chhattisgarh	Korba	492	48	494	205	252
Chhattisgarh	Raigadh	354	127	435	240	258
Chhattisgarh	Jashpur	361	40	494	355	274
Chhattisgarh	Kanker	379	98	494	257	304
Chhattisgarh	Koriya	539	46	494	229	312
Chhattisgarh	Janjgir	114	314	494	226	352
Chhattisgarh	Sarguja	403	33	549	388	354
Chhattisgarh	Raipur	362	288	359	232	358
Chhattisgarh	Bilaspur	308	175	494	307	359
Chhattisgarh	Dhamtari	340	408	280	162	367
Chhattisgarh	Kawardha	424	79	494	376	373
Chhattisgarh	Dantewara	553	26	494	370	392
Chhattisgarh	Rajnandgaon	364	110	568	218	394
Chhattisgarh	Bastar	495	88	549	438	497
Dadra & Nagar Haveli	Dadra & Nagar Haveli	287	333	226	533	520
Daman & Diu	Diu	366	271	37	547	321
Daman & Diu	Daman	276	387	237	476	481
Goa	South Goa	487	389	274	67	329
Goa	North Goa	384	391	424	377	524
Gujarat	Panchmahal	227	273	67	320	64

State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Gujarat	Dahod	152	222	151	283	74
Gujarat	Patan	365	150	20	540	130
Gujarat	Banaskantha	288	308	10	550	193
Gujarat	Dang	525	143	110	459	196
Gujarat	Narmada	290	302	50	510	215
Gujarat	Kheda	171	488	18	500	234
Gujarat	Anand	131	524	7	536	269
Gujarat	Vadodara	257	497	43	489	374
Gujarat	Gandhinagar	133	505	32	534	410
Gujarat	Bharuch	435	340	49	538	416
Gujarat	Sabarkanta	249	395	92	529	425
Gujarat	Mehsana	143	420	113	530	459
Gujarat	Valsad	174	442	190	496	483
Gujarat	Porbandar	417	306	4	569	492
Gujarat	Surendranagar	441	173	103	563	529
Gujarat	Ahmedabad	335	410	45	557	535
Gujarat	Kutch	568	166	2	571	542
Gujarat	Bhavnagar	478	289	80	558	544
Gujarat	Amreli	320	351	30	568	548
Gujarat	Navsari	76	517	271	514	556
Gujarat	Jamnagar	535	216	11	570	561
Gujarat	Surat	486	558	95	541	568
Gujarat	Junagadh	367	338	48	572	571
Gujarat	Rajkot	370	417	14	573	572
Haryana	Mahendragarh	107	369	16	378	21
Haryana	Bhiwani	173	370	54	183	48
Haryana	Fatehabad	109	510	33	134	68
Haryana	Hissar	177	465	74	163	111
Haryana	Rewari	115	529	185	7	115
Haryana	Jind	86	536	51	110	120
Haryana	Jhajjar	117	493	29	375	126
Haryana	Sirsa	93	473	81	291	143
Haryana	Gurgaon	168	530	219	29	259
Haryana	Rohtak	121	542	41	365	262
Haryana	Kaithal	128	545	76	186	276
Haryana	Panipet	149	552	143	58	339
Haryana	Yamunanagar	151	563	195	19	377

State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Haryana	Kurukshetra	48	559	279	36	412
Haryana	Faridabad	188	562	141	104	457
Haryana	Sonipet	172	553	99	343	474
Haryana	Karnal	118	556	96	433	494
Haryana	Ambala	146	570	174	117	501
Haryana	Panchkula	526	534	178	152	512
Himachal Pradesh	Mandi	381	100	359	9	30
Himachal Pradesh	Chamba	528	24	280	59	58
Himachal Pradesh	Bilaspur	414	242	243	53	131
Himachal Pradesh	Kullu	502	35	359	169	138
Himachal Pradesh	Kangra	426	172	280	83	139
Himachal Pradesh	Kinnaur	509	162	200	227	156
Himachal Pradesh	Shimla	503	47	494	92	190
Himachal Pradesh	Hamirpur	378	152	494	75	236
Himachal Pradesh	Una	465	392	494	10	327
Himachal Pradesh	Lahaul & Spiti	504	239	435	124	365
Himachal Pradesh	Solan	510	348	494	60	468
Himachal Pradesh	Sirmaur	546	304	435	288	522
Jammu & Kashmir	Poonch	467	25	151	108	15
Jammu & Kashmir	Leh (Ladakh)	514	323	6	326	19
Jammu & Kashmir	Kathua	449	191	151	84	66
Jammu & Kashmir	Doda	542	11	280	401	157
Jammu & Kashmir	Udhampur	505	36	280	344	179
Jammu & Kashmir	Baramulla	416	243	243	147	181
Jammu & Kashmir	Kargil	409	316	280	27	184
Jammu & Kashmir	Anantnag	360	285	280	98	213
Jammu & Kashmir	Rajouri	455	109	280	332	230
Jammu & Kashmir	Budgam	191	300	243	436	307
Jammu & Kashmir	Pulwama	182	393	435	90	323
Jammu & Kashmir	Srinagar	533	413	359	20	369
Jammu & Kashmir	Kupwara	453	206	280	439	399
Jammu & Kashmir	Jammu	303	500	549	203	560
Jharkhand	Godda	422	51	359	197	136
Jharkhand	Garhwa	501	69	280	317	206
Jharkhand	Pakur	391	91	494	121	211
Jharkhand	Sahibganj	389	102	359	383	275
Jharkhand	West Singbhum	493	37	549	185	290

State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Jharkhand	Gumla	413	65	435	386	302
Jharkhand	Chatra	536	120	494	106	316
Jharkhand	Dumka	520	45	494	360	357
Jharkhand	Lohardaga	406	200	494	180	379
Jharkhand	Deoghar	511	174	359	371	404
Jharkhand	Ranchi	470	114	435	453	437
Jharkhand	Giridish	519	61	359	501	441
Jharkhand	East Singbhum	473	112	494	409	445
Jharkhand	Bokaro	532	126	359	457	448
Jharkhand	Hazaribag	530	198	435	336	477
Jharkhand	Dhanbad	523	180	435	413	489
Jharkhand	Palamu	484	148	435	477	502
Jharkhand	Koderma	555	218	435	465	550
Karnataka	Haveri	166	171	200	112	32
Karnataka	Gadag	199	75	151	432	55
Karnataka	Chitradurga	358	70	280	175	93
Karnataka	Tumkur	333	135	280	178	137
Karnataka	Dharwad	216	117	280	353	152
Karnataka	Bellary	341	210	243	200	161
Karnataka	Hassan	250	208	435	77	173
Karnataka	Bangalore (Rural)	220	209	280	246	176
Karnataka	Mysore	192	253	280	216	187
Karnataka	Bidar	240	64	280	484	218
Karnataka	Koppal	346	103	243	472	239
Karnataka	Chamarajanagar	339	167	200	473	246
Karnataka	Bagalkot	263	197	243	455	260
Karnataka	Gulbarga	260	87	435	418	270
Karnataka	Kolar	210	211	359	405	308
Karnataka	Chikmagalur	373	329	435	57	324
Karnataka	Bijapur	241	55	494	467	326
Karnataka	Bangalore (Urban)	343	443	151	277	328
Karnataka	Davanagere	176	266	151	520	334
Karnataka	Mandya	300	371	435	123	385
Karnataka	Belgaum	314	310	494	156	407
Karnataka	Raichur	230	177	359	502	429
Karnataka	Dakshina Kannada	348	486	413	54	453
Karnataka	Kodagu	440	422	359	192	498

State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Karnataka	Udupi	438	409	486	274	526
Karnataka	Uttara Kannada	554	341	413	354	537
Karnataka	Shimoga	496	491	359	184	549
Kerala	Thiruvanathapuram	29	318	44	334	16
Kerala	Alappuzha	13	457	93	65	22
Kerala	Kottayam	11	386	112	206	39
Kerala	Ernakulam	112	415	226	8	40
Kerala	Kozhikode	33	331	269	34	45
Kerala	Kollam	72	326	108	335	75
Kerala	Kasaragod	50	347	234	129	79
Kerala	Pathanamthitta	208	337	180	144	106
Kerala	Kannur	55	356	339	81	122
Kerala	Wayanad	81	281	272	194	123
Kerala	Malappuram	83	363	192	295	142
Kerala	Palakkad	122	416	128	411	216
Kerala	Thrissur	139	439	175	356	278
Kerala	Idukki	148	286	276	468	349
Madhya Pradesh	Bhind	163	229	243	45	51
Madhya Pradesh	Jhabua	142	99	113	499	84
Madhya Pradesh	Dindori	459	12	494	159	110
Madhya Pradesh	Datia	156	299	200	273	147
Madhya Pradesh	Morena	280	339	280	37	159
Madhya Pradesh	Barwani	321	155	151	463	166
Madhya Pradesh	Sidhi	443	85	435	131	182
Madhya Pradesh	Mandla	336	90	494	130	192
Madhya Pradesh	Shahdol	419	41	435	286	208
Madhya Pradesh	Chhatarpur	392	228	435	46	226
Madhya Pradesh	Rewa	248	186	494	116	229
Madhya Pradesh	Tikamgarh	331	245	280	209	235
Madhya Pradesh	Panna	451	149	359	189	242
Madhya Pradesh	Ratlam	178	233	243	448	245
Madhya Pradesh	Mandsaur	261	204	359	352	298
Madhya Pradesh	Betul	398	184	435	191	306
Madhya Pradesh	Vidisha	286	330	280	255	320
Madhya Pradesh	Ujjain	155	353	280	362	333
Madhya Pradesh	Damoh	396	259	280	305	338
Madhya Pradesh	Guna	342	226	359	329	348

State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Madhya Pradesh	Sheopur Kalan	527	268	280	201	353
Madhya Pradesh	Gwalior	410	390	280	136	362
Madhya Pradesh	Dhar	190	270	280	466	370
Madhya Pradesh	Neemuch	423	182	435	303	380
Madhya Pradesh	Shajapur	202	294	359	396	384
Madhya Pradesh	Umaria	480	134	494	245	387
Madhya Pradesh	Rajgarh	233	298	359	395	402
Madhya Pradesh	Jabalpur	311	451	280	164	403
Madhya Pradesh	Shivpuri	418	179	359	437	408
Madhya Pradesh	Katni	338	257	435	322	427
Madhya Pradesh	Balaghat	468	276	359	321	449
Madhya Pradesh	Indore	235	454	435	137	454
Madhya Pradesh	Chhindwara	375	221	435	402	455
Madhya Pradesh	Satna	324	231	549	247	461
Madhya Pradesh	Khargone (West Nimar)	325	187	359	494	469
Madhya Pradesh	Dewas	332	315	435	361	490
Madhya Pradesh	Seoni	351	275	494	385	510
Madhya Pradesh	Sagar	329	342	359	487	532
Madhya Pradesh	Sehore	318	400	494	363	540
Madhya Pradesh	Harda	404	485	280	372	546
Madhya Pradesh	Khandwa (East Nimar)	471	325	435	460	551
Madhya Pradesh	Raisen	400	428	494	345	555
Madhya Pradesh	Bhopal	382	429	435	456	558
Madhya Pradesh	Narsinghpur	293	456	435	490	563
Madhya Pradesh	Hoshangabad	431	514	494	266	566
Maharashtra	Nanded	165	181	435	48	100
Maharashtra	Beed	200	97	280	312	109
Maharashtra	Osmanabad	282	113	151	480	145
Maharashtra	Ahmednagar	127	144	113	531	178
Maharashtra	Hingoli	206	156	280	399	198
Maharashtra	Nandurbar	277	136	200	481	210
Maharashtra	Washim	232	101	359	421	220
Maharashtra	Latur	132	176	280	462	231
Maharashtra	Chandrapur	401	236	359	115	257
Maharashtra	Parbhani	162	133	359	458	261
Maharashtra	Wardha	309	194	359	299	271
Maharashtra	Akola	198	118	435	424	272

State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Maharashtra	Jalna	185	131	359	475	300
Maharashtra	Yavatmal	352	220	359	311	335
Maharashtra	Satara	221	263	200	498	344
Maharashtra	Bhandara	265	255	494	213	376
Maharashtra	Gondia	355	246	494	176	396
Maharashtra	Solapur	229	199	280	507	409
Maharashtra	Amravati	304	164	359	485	413
Maharashtra	Sindhudurg	515	116	546	304	419
Maharashtra	Pune	211	372	81	543	421
Maharashtra	Jalgaon	243	188	359	493	426
Maharashtra	Aurangabad	197	170	359	526	475
Maharashtra	Sangli	203	203	280	528	476
Maharashtra	Ratnagiri	430	234	424	404	478
Maharashtra	Raigad	490	311	235	470	487
Maharashtra	Nagpur	363	280	435	384	488
Maharashtra	Nasik	268	256	359	504	505
Maharashtra	Gadchiroli	543	215	494	259	506
Maharashtra	Buldhana	219	123	359	548	509
Maharashtra	Thane	521	296	265	479	518
Maharashtra	Dhule	292	95	494	549	553
Maharashtra	Kolhapur	239	427	568	451	565
Manipur	Chandel	545	8	353	294	134
Manipur	Churachandpur	462	29	435	167	149
Manipur	Ukhrul	482	38	494	154	199
Manipur	Senapati	474	44	548	101	212
Manipur	Imphal East	429	201	347	139	219
Manipur	Thoubal	126	375	351	224	295
Manipur	Imphal West	344	254	430	242	366
Manipur	Tamenglong	559	39	494	251	383
Manipur	Bishnupur	356	345	359	238	423
Meghalaya	South Garo Hills	433	59	54	97	6
Meghalaya	East Khasi Hills	458	235	113	3	10
Meghalaya	West Khasi Hills	488	78	200	80	52
Meghalaya	Jaintia Hills	485	168	113	161	59
Meghalaya	West Garo Hills	445	108	113	270	60
Meghalaya	East Garo Hills	460	54	280	140	86
Meghalaya	Ri-Bhoi	411	122	359	193	197

State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Mizoram	Lawngtlai	425	20	151	260	24
Mizoram	Saiha	456	62	151	254	54
Mizoram	Lunglei	395	42	280	268	117
Mizoram	Serchhip	374	104	359	120	133
Mizoram	Champhai	421	60	494	126	189
Mizoram	Aizawl	291	163	494	170	263
Mizoram	Kolasib	507	202	359	109	265
Mizoram	Mamit	497	56	549	269	356
Nagaland	Tuensang	551	10	280	56	42
Nagaland	Mon	550	7	435	264	150
Nagaland	Wokha	506	141	359	122	217
Nagaland	Zunheboto	522	93	435	142	240
Nagaland	Phek	524	105	494	69	251
Nagaland	Mokokchung	489	190	280	271	291
Nagaland	Dimapur	323	494	494	86	530
Nagaland	Kohima	541	223	568	262	543
Odisha	Jagatsingpur	92	450	8	292	11
Odisha	Puri	294	455	9	217	28
Odisha	Kendrapara	205	214	63	328	35
Odisha	Balasore (Baleshwar)	153	359	68	298	76
Odisha	Jajpur	246	297	167	153	87
Odisha	Keonjhar	383	158	232	157	99
Odisha	Bhadrak	113	404	107	282	121
Odisha	Nabarangpur	259	72	435	222	148
Odisha	Nayagarh	479	193	220	208	155
Odisha	Nuapada	407	73	280	302	158
Odisha	Bolangir	307	106	280	323	160
Odisha	Baragarh	231	267	435	30	162
Odisha	Gajapati	461	80	239	348	164
Odisha	Dhenkanal	463	232	346	33	167
Odisha	Kalahandi	397	132	243	310	175
Odisha	Mayurbhanj	297	169	278	337	201
Odisha	Rayagada	436	81	549	89	247
Odisha	Ganjam	386	303	149	367	249
Odisha	Khurda	316	376	142	408	286
Odisha	Sonepur	271	321	243	364	311
Odisha	Deogarh	494	121	435	250	322

State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Odisha	Koraput	444	137	435	272	330
Odisha	Angul	517	212	435	102	331
Odisha	Malkangiri	402	50	494	412	340
Odisha	Phulbani (Kandhamal)	516	83	435	374	364
Odisha	Sundargarh	415	140	494	265	372
Odisha	Cuttack	283	448	136	427	375
Odisha	Boudh	499	196	280	441	422
Odisha	Jharsuguda	394	260	494	182	431
Odisha	Sambalpur	457	279	494	160	450
Pondicherry	Pondicherry (Dist)	98	567	34	546	557
Pondicherry	Karaikal	328	572	69	561	573
Punjab	Moga	154	548	3	4	1
Punjab	Faridkot	167	512	1	230	8
Punjab	Jalandhar	123	564	5	285	92
Punjab	Gurdaspur	184	568	23	11	95
Punjab	Bathinda	222	489	22	278	108
Punjab	Mansa	256	482	26	316	132
Punjab	Muktsar	245	484	21	445	188
Punjab	Sangrur	223	555	52	55	224
Punjab	Firozpur	189	525	12	482	237
Punjab	Fatehgarh Sahib	187	569	42	241	411
Punjab	Ludhiana	213	571	15	416	424
Punjab	Kapurthala	194	550	71	324	433
Punjab	Shahid Bhagat Singh Nagar	180	560	139	96	439
Punjab	Hoshiarpur	270	546	98	340	473
Punjab	Rupnagar	150	557	241	78	491
Punjab	Amritsar	147	554	53	497	517
Punjab	Patiala	237	565	126	267	525
Rajasthan	Churu	498	3	81	253	2
Rajasthan	Hanumangarh	278	76	24	331	5
Rajasthan	Jalore	483	28	16	423	7
Rajasthan	Sikar	258	30	81	398	13
Rajasthan	Alwar	224	219	81	111	17
Rajasthan	Barmer	547	2	54	527	18
Rajasthan	Jhunjhunu	204	77	39	491	23
Rajasthan	Ganganagar	442	159	24	406	31

State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Rajasthan	Karauli	380	111	113	188	34
Rajasthan	Jaisalmer	572	1	54	509	38
Rajasthan	Jodhpur	529	5	113	474	41
Rajasthan	Banswara	135	23	243	391	46
Rajasthan	Bhilwara	427	21	243	165	49
Rajasthan	Dausa	136	165	151	338	56
Rajasthan	Dungarpur	253	18	280	419	70
Rajasthan	Nagaur	408	6	81	544	77
Rajasthan	Pali	481	19	81	518	85
Rajasthan	Jaipur	306	157	151	394	113
Rajasthan	Bharatpur	116	264	200	300	116
Rajasthan	Ajmer	368	43	200	450	119
Rajasthan	Dholpur	310	185	200	289	127
Rajasthan	Sirohi	500	53	39	539	135
Rajasthan	Udaipur	450	15	359	443	171
Rajasthan	Bikaner	552	4	81	552	202
Rajasthan	Bundi	359	138	243	429	233
Rajasthan	Tonk	312	92	280	478	273
Rajasthan	Rajsamand	512	17	280	513	297
Rajasthan	Sawai Madhopur	218	146	200	524	314
Rajasthan	Baran	376	224	359	349	378
Rajasthan	Chittorgarh	326	58	435	505	406
Rajasthan	Jhalawar	350	153	359	492	451
Rajasthan	Kota	412	324	435	212	458
Sikkim	South	317	94	549	13	98
Sikkim	West	469	145	568	1	168
Sikkim	North	565	125	280	31	195
Sikkim	East	327	265	494	26	244
Tamil Nadu	Ramanathapuram	275	160	35	535	129
Tamil Nadu	Perambalur	71	195	81	553	281
Tamil Nadu	Villupuram	134	434	19	542	284
Tamil Nadu	Coimbatore	322	509	113	125	289
Tamil Nadu	Dharmapuri	301	247	200	471	303
Tamil Nadu	The Nilgiris	289	213	280	461	351
Tamil Nadu	Theni	236	358	200	488	414
Tamil Nadu	Virudhunagar	330	362	151	495	430
Tamil Nadu	Ariyalur	160	227	60	564	436

State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Tamil Nadu	Dindigul	285	241	243	511	444
Tamil Nadu	Kanyakumari	181	441	130	515	462
Tamil Nadu	Cuddalore	69	476	31	559	480
Tamil Nadu	Thoothukudi	284	217	105	556	485
Tamil Nadu	Thiruvannamalai	254	421	125	525	496
Tamil Nadu	Salem	207	388	151	537	499
Tamil Nadu	Kancheepuram	388	535	13	532	503
Tamil Nadu	Namakkal	215	320	280	516	515
Tamil Nadu	Erode	266	432	151	523	521
Tamil Nadu	Nagapattinam	66	479	47	562	528
Tamil Nadu	Thiruvallur	319	537	58	517	533
Tamil Nadu	Thiruvarur	54	460	69	565	534
Tamil Nadu	Vellore	274	431	200	522	539
Tamil Nadu	Thirunelveli	349	463	105	545	552
Tamil Nadu	Madurai	295	478	81	554	559
Tamil Nadu	Karur	437	319	200	551	562
Tamil Nadu	Thiruchirappalli	272	402	200	555	564
Tamil Nadu	Sivagangai	432	423	94	566	567
Tamil Nadu	Pudukkottai	387	469	151	560	569
Tamil Nadu	Thanjavur	110	507	194	567	570
Telangana	Adilabad	447	192	421	103	250
Telangana	Mahabubnagar	334	124	359	414	293
Telangana	Medak	296	205	435	407	401
Telangana	Karimnagar	369	394	357	210	446
Telangana	Nalgonda	347	278	359	431	464
Telangana	Nizamabad	371	385	432	198	472
Telangana	Khammam	464	312	422	368	511
Telangana	Rangareddy	472	360	435	393	538
Telangana	Warangal	357	379	435	469	554
Tripura	South Tripura	299	277	435	392	460
Tripura	West Tripura	161	401	549	225	504
Tripura	North Tripura	399	412	549	187	545
Tripura	Dhalai	454	305	549	341	547
Uttar Pradesh	Hamirpur	226	129	73	146	9
Uttar Pradesh	Banda	129	142	186	118	20
Uttar Pradesh	Balrampur	140	154	191	135	25
Uttar Pradesh	Chitrakut	269	128	423	6	26

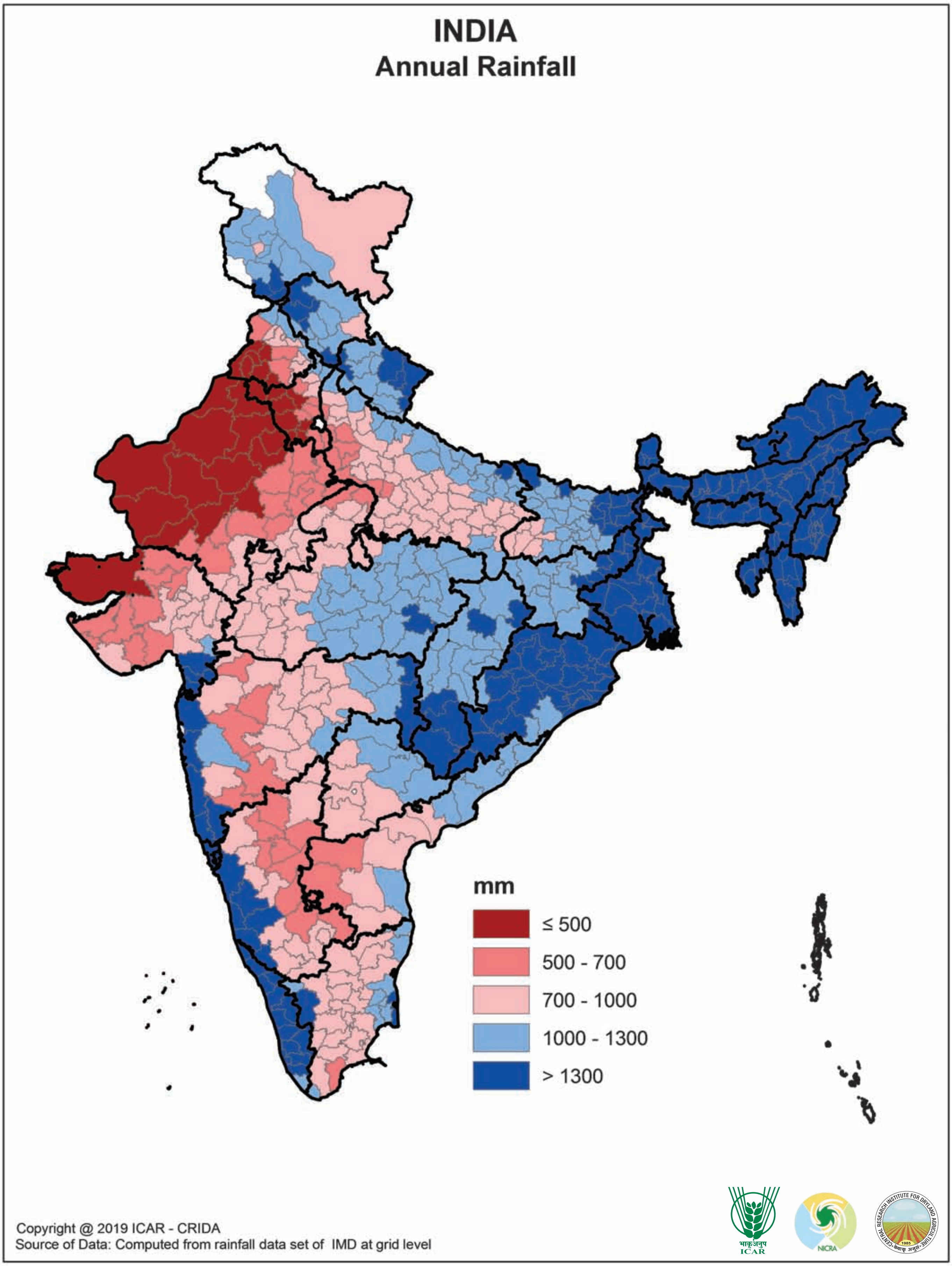
State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Uttar Pradesh	Bahraich	88	244	221	88	36
Uttar Pradesh	Bagpat	51	549	27	24	44
Uttar Pradesh	Mahoba	130	107	243	195	47
Uttar Pradesh	Kaushambi	40	336	181	174	53
Uttar Pradesh	Auraiya	79	419	101	133	57
Uttar Pradesh	Kannauj	75	461	135	39	63
Uttar Pradesh	Sant Ravidas Nagar	6	496	134	64	69
Uttar Pradesh	Basti	31	382	104	330	71
Uttar Pradesh	Jalaun	138	317	231	51	72
Uttar Pradesh	Kanpur (Dehat)	82	399	113	204	80
Uttar Pradesh	Shravasti	186	139	431	52	83
Uttar Pradesh	Fatehpur	97	357	137	234	88
Uttar Pradesh	Unnao	87	466	140	63	89
Uttar Pradesh	Jhansi	193	262	352	22	90
Uttar Pradesh	Gonda	64	365	75	449	94
Uttar Pradesh	Etawah	119	430	46	339	96
Uttar Pradesh	Allahabad	106	446	198	44	105
Uttar Pradesh	Jaunpur	39	464	176	128	107
Uttar Pradesh	Kanpur City	158	480	102	107	128
Uttar Pradesh	Kushi Nagar	8	380	173	452	144
Uttar Pradesh	Maharajganj	62	397	146	347	146
Uttar Pradesh	Siddharth Nagar	37	332	221	415	153
Uttar Pradesh	Mathura	102	495	61	314	165
Uttar Pradesh	Agra	111	503	100	172	169
Uttar Pradesh	Farrukhabad	94	472	183	149	170
Uttar Pradesh	Sonbhadra	476	68	435	127	174
Uttar Pradesh	Shahjahanpur	84	477	229	93	177
Uttar Pradesh	Pratapgarh	125	453	150	231	194
Uttar Pradesh	Deoria	7	452	332	199	204
Uttar Pradesh	Hathras	47	511	109	287	205
Uttar Pradesh	Mirzapur	255	293	335	171	228
Uttar Pradesh	Rampur	58	522	197	100	243
Uttar Pradesh	Aligarh	53	523	228	99	254
Uttar Pradesh	Lalitpur	267	274	280	261	256
Uttar Pradesh	Jyotiba Phulenagar	78	538	184	87	267
Uttar Pradesh	Budaun	68	459	172	434	277
Uttar Pradesh	Gorakhpur	18	508	148	403	279

State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Uttar Pradesh	Saharanpur	77	533	262	43	282
Uttar Pradesh	Varanasi	30	547	182	132	287
Uttar Pradesh	Sitapur	43	499	268	173	292
Uttar Pradesh	Sant Kabir Nagar	32	444	242	400	299
Uttar Pradesh	Pilibhit	157	506	236	70	301
Uttar Pradesh	Ambedkar Nagar	41	504	133	440	305
Uttar Pradesh	Rae-Bareily	195	418	138	444	309
Uttar Pradesh	Azamgarh	23	470	329	319	318
Uttar Pradesh	Bijnor	90	519	144	297	319
Uttar Pradesh	Bareilly	57	513	240	190	325
Uttar Pradesh	Ballia	38	355	433	381	341
Uttar Pradesh	Faizabad	35	502	264	279	345
Uttar Pradesh	Firozabad	70	515	345	68	347
Uttar Pradesh	Ghazipur	34	449	415	318	360
Uttar Pradesh	Moradabad	24	521	273	221	371
Uttar Pradesh	Sultanpur	73	437	356	306	386
Uttar Pradesh	Ghaziabad	21	573	65	263	389
Uttar Pradesh	Muzaffarnagar	52	520	145	446	395
Uttar Pradesh	Chandauli	145	436	334	293	397
Uttar Pradesh	Hardoi	67	458	341	342	398
Uttar Pradesh	Mainpuri	95	475	353	237	415
Uttar Pradesh	Kheri	144	468	338	236	420
Uttar Pradesh	Barabanki	124	490	266	313	440
Uttar Pradesh	Etah	89	498	238	397	443
Uttar Pradesh	Bulandshahar	100	544	179	325	465
Uttar Pradesh	Meerut	63	561	177	207	467
Uttar Pradesh	Lucknow	137	528	187	369	471
Uttar Pradesh	Mau	36	483	420	435	495
Uttar Pradesh	Gautam Buddh Nagar	305	551	72	464	527
Uttarakhand	Bageshwar	531	27	81	18	3
Uttarakhand	Champawat	540	52	113	2	4
Uttarakhand	Pithoragarh	538	22	200	66	29
Uttarakhand	Uttarkashi	557	13	359	16	37
Uttarakhand	Almora	466	67	280	23	50
Uttarakhand	Tehri Garwal	534	16	435	47	73
Uttarakhand	Rudraprayag	548	9	435	94	97
Uttarakhand	Chamoli	558	14	359	151	114

State	District	Exposure	Vulnerability	Historical Hazard	Future Hazard	Risk
Uttarakhand	Pauri Garhwal	549	49	359	143	172
Uttarakhand	Nainital	544	403	267	76	400
Uttarakhand	Udham Singh Nagar	217	539	275	28	418
Uttarakhand	Haridwar	212	532	343	32	428
Uttarakhand	Dehradun	513	406	359	91	456
West Bengal	Malda	61	492	64	105	62
West Bengal	24-Paraganas (South)	242	327	79	235	78
West Bengal	24-Paraganas (North)	42	527	36	284	104
West Bengal	Howrah	45	541	28	346	141
West Bengal	Jalpaiguri	99	467	111	249	163
West Bengal	Midnapore	101	487	131	196	185
West Bengal	Purulia	201	86	427	351	186
West Bengal	Darjeeling	164	301	549	14	191
West Bengal	Cooch Behar	22	518	344	25	223
West Bengal	Dinajpur (Dakshin)	12	516	330	85	264
West Bengal	Murshidabad	10	531	147	308	268
West Bengal	Dinajpur (Uttar)	2	526	337	82	280
West Bengal	Nadia	1	543	97	426	283
West Bengal	Birbhum	56	481	336	145	288
West Bengal	Hooghly	19	566	62	327	342
West Bengal	Burdwan	65	540	124	373	381
West Bengal	Bankura	183	407	428	430	513

Note: Ranks are assigned based on the index value. Rank 1 indicates highest index value. A district with rank 1 in exposure has highest exposure and the district with rank 573 the least. Similar interpretation applies to other indices as well.

Baseline (1976 – 2005)
Climate Indicators


INDIA
Annual Rainfall
mm
≤ 500
500 - 700
700 - 1000
1000 - 1300
> 1300
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Source of Data: Computed from rainfall data set of IMD at grid level

Fig. BL1

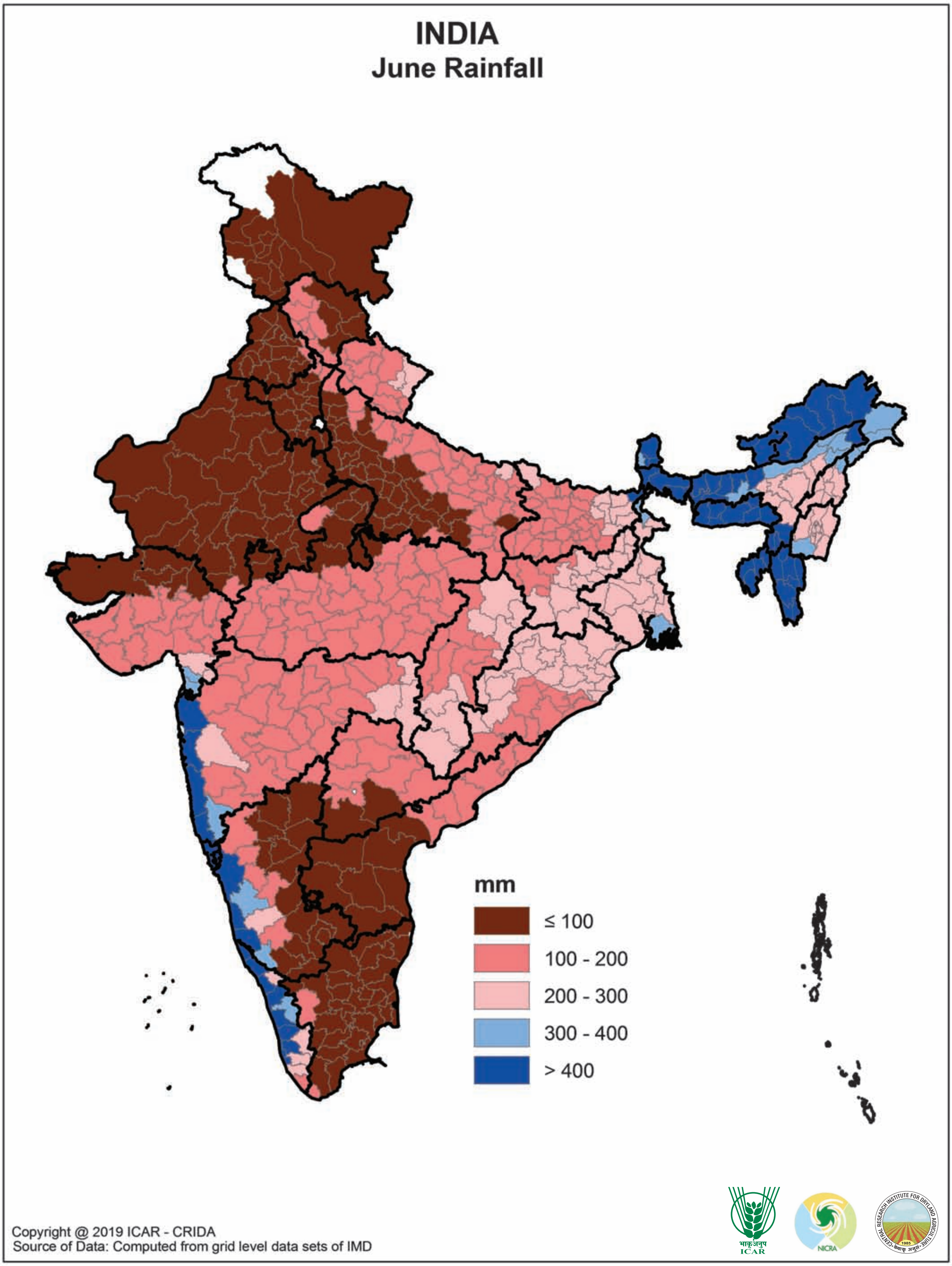

INDIA
June Rainfall
mm
≤ 100
100 - 200
200 - 300
300 - 400
> 400
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed from grid level data sets of IMD
ICAR
NICRA

Fig. BL2

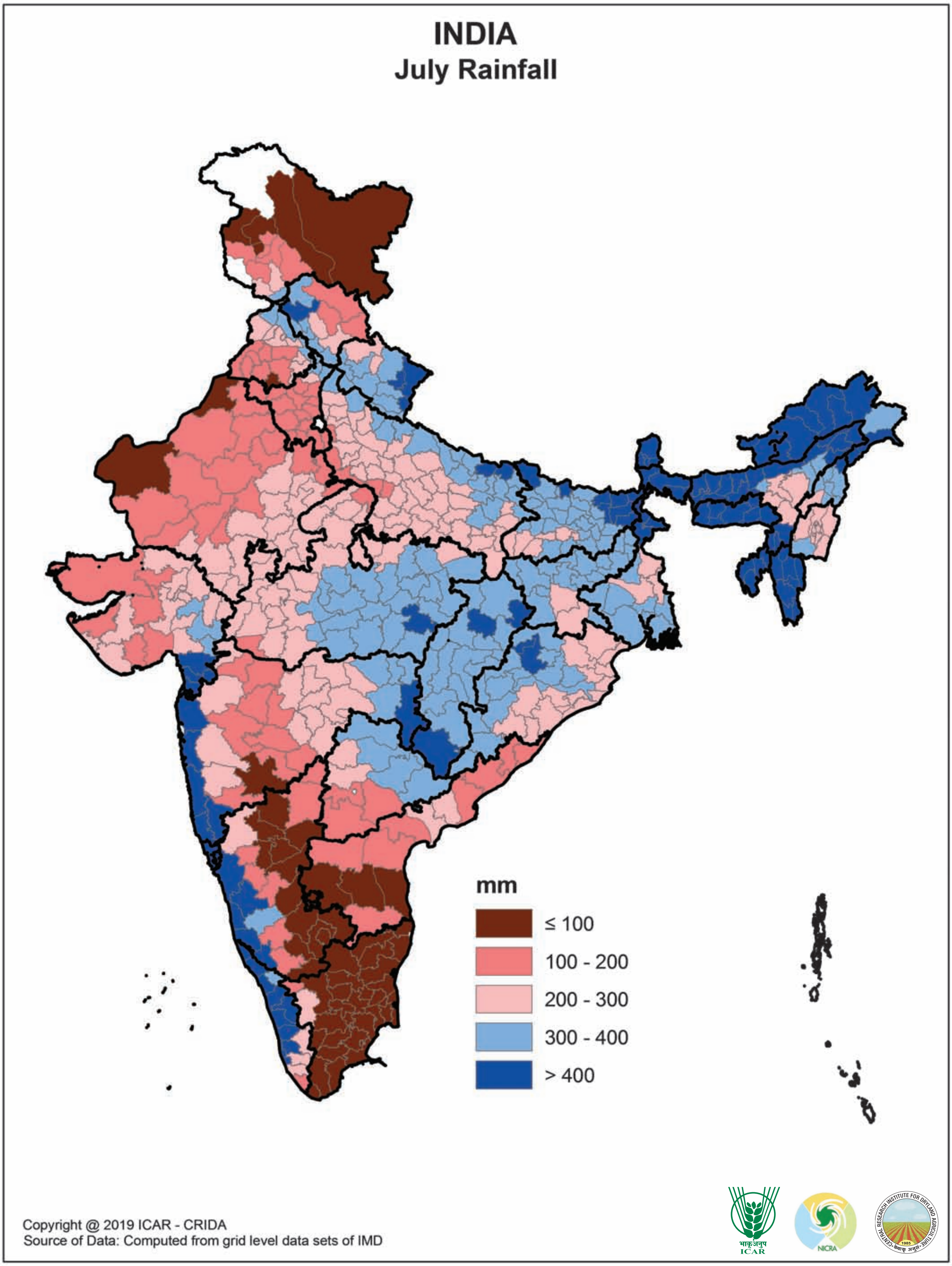
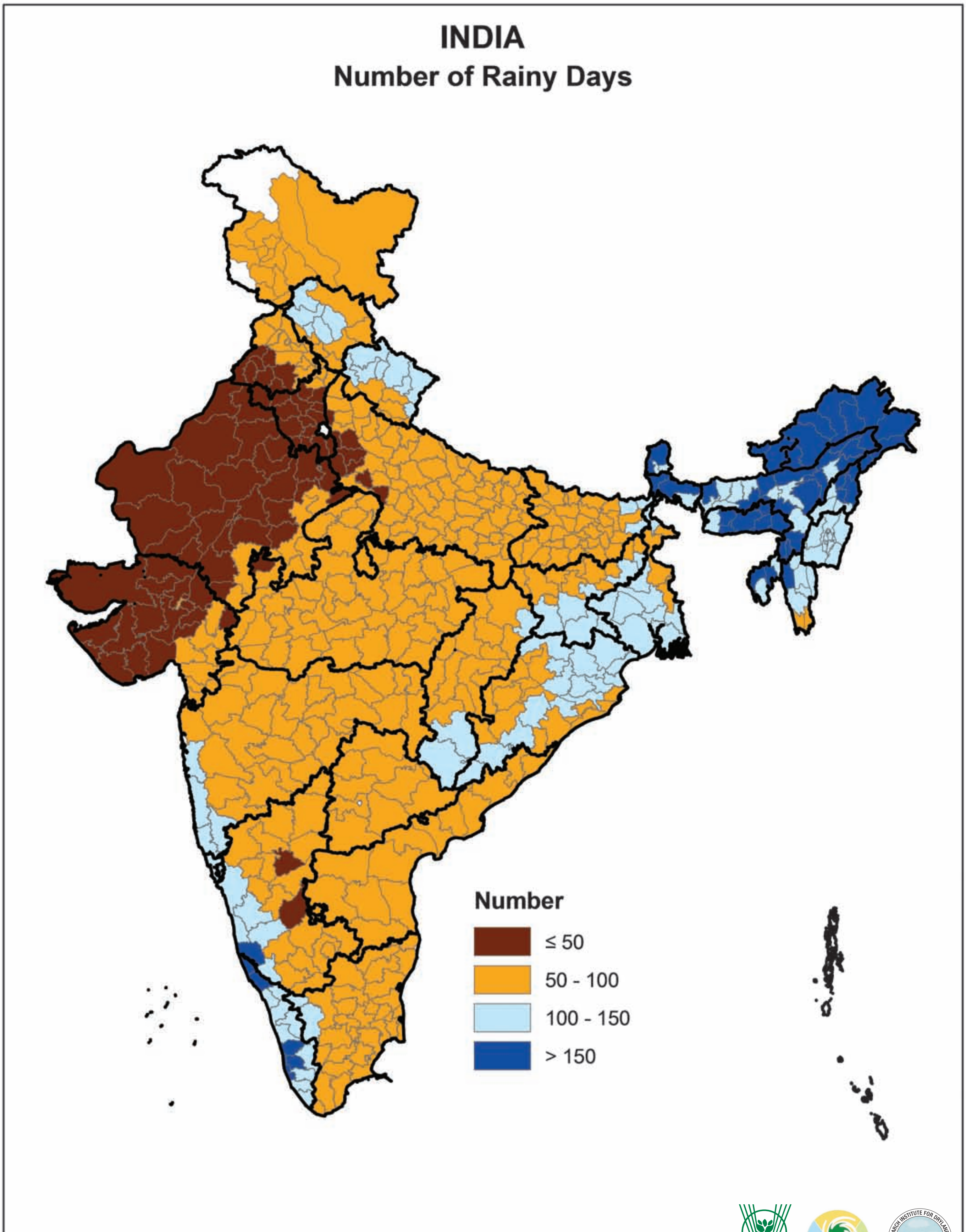
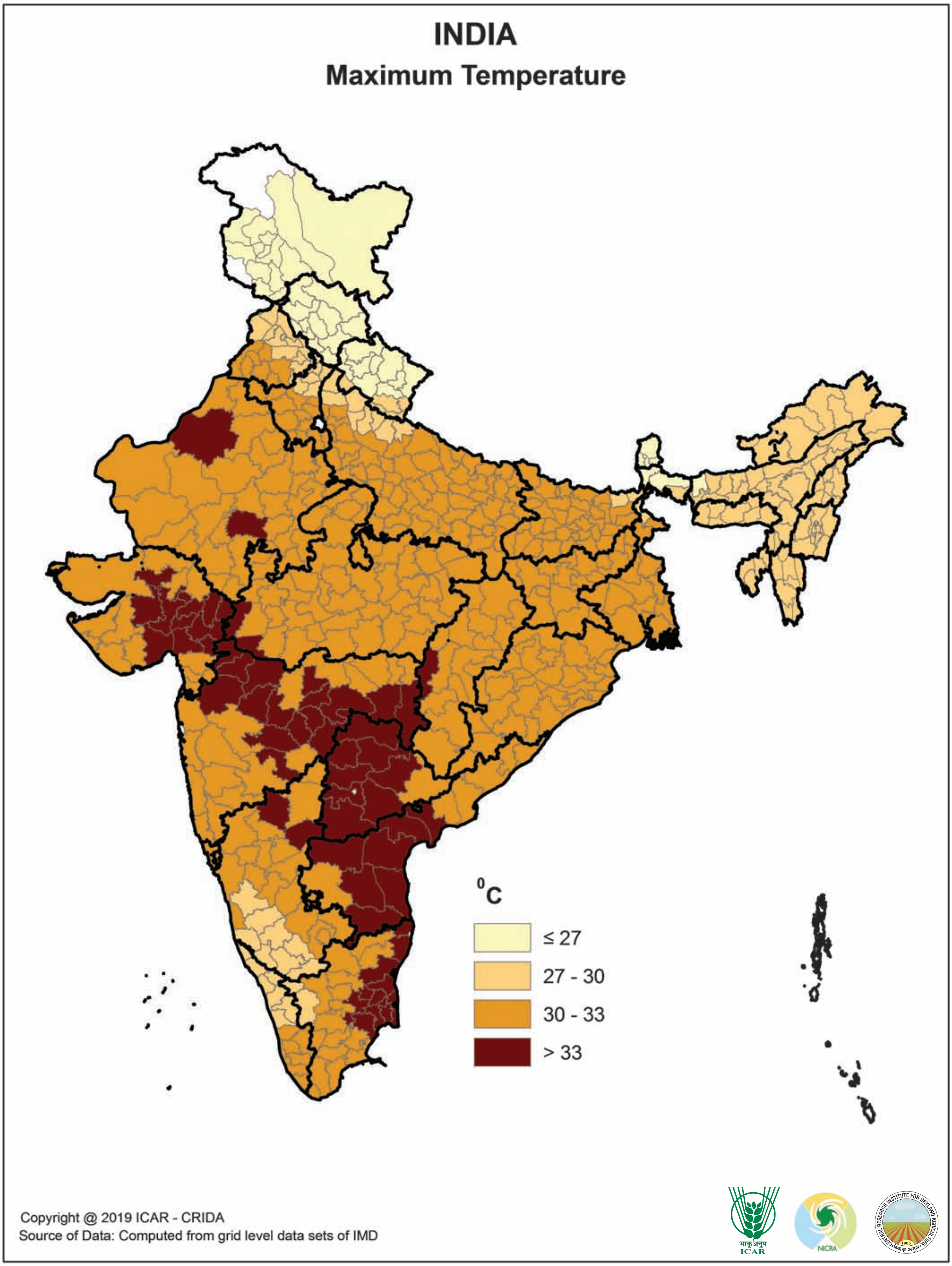

INDIA
July Rainfall
mm
≤ 100
100 - 200
200 - 300
300 - 400
> 400
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed from grid level data sets of IMD

Fig. BL3



Source of Data: Computed from grid level data sets of IMD

Fig. BL4


INDIA
Maximum Temperature
^{0}C
≤ 27
27 - 30
30 - 33
> 33
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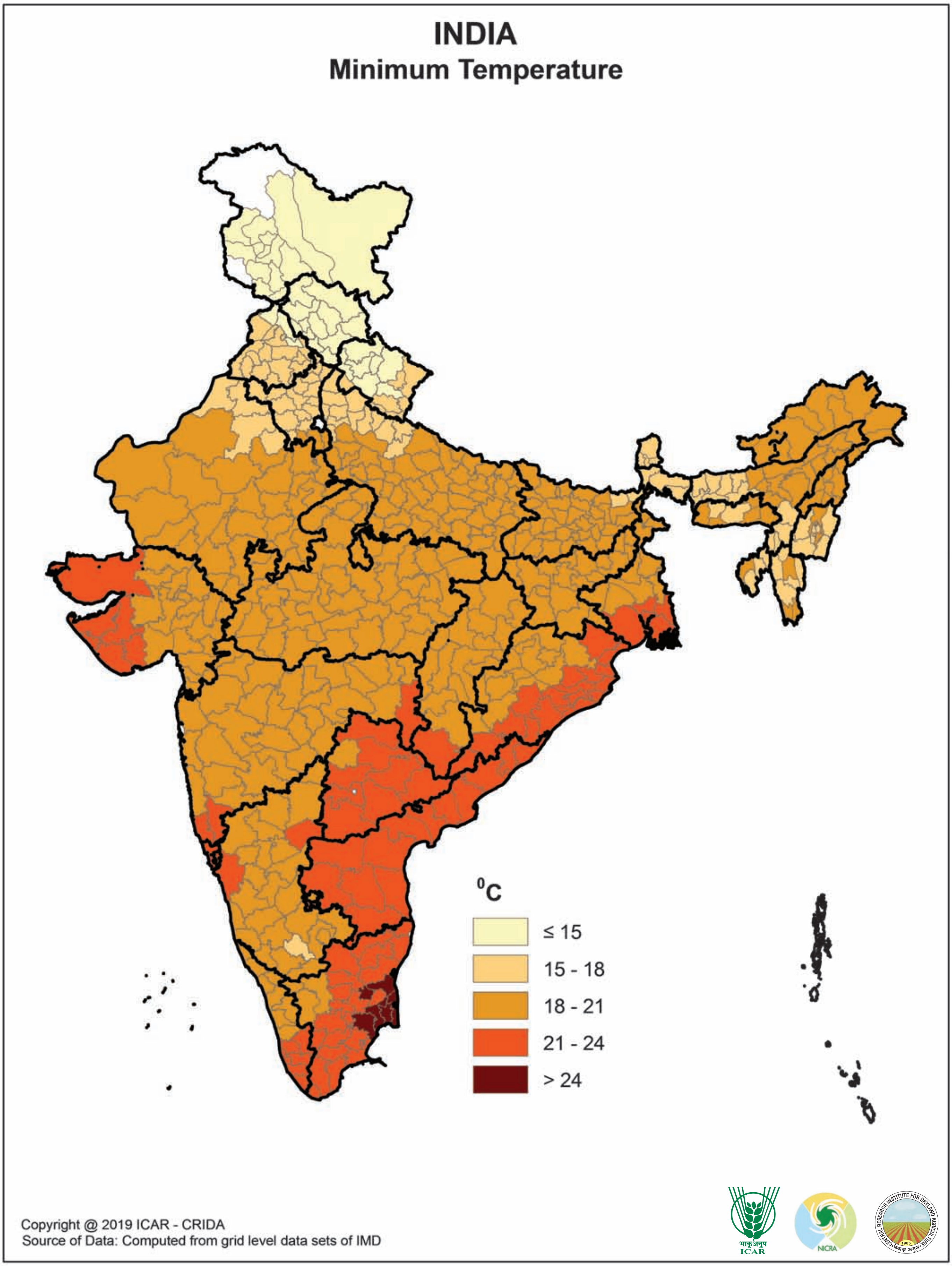
Source of Data: Computed from grid level data sets of IMD
NICRA

Fig. BL5


INDIA
Minimum Temperature
^0C
≤ 15
15 - 18
18 - 21
21 - 24
> 24
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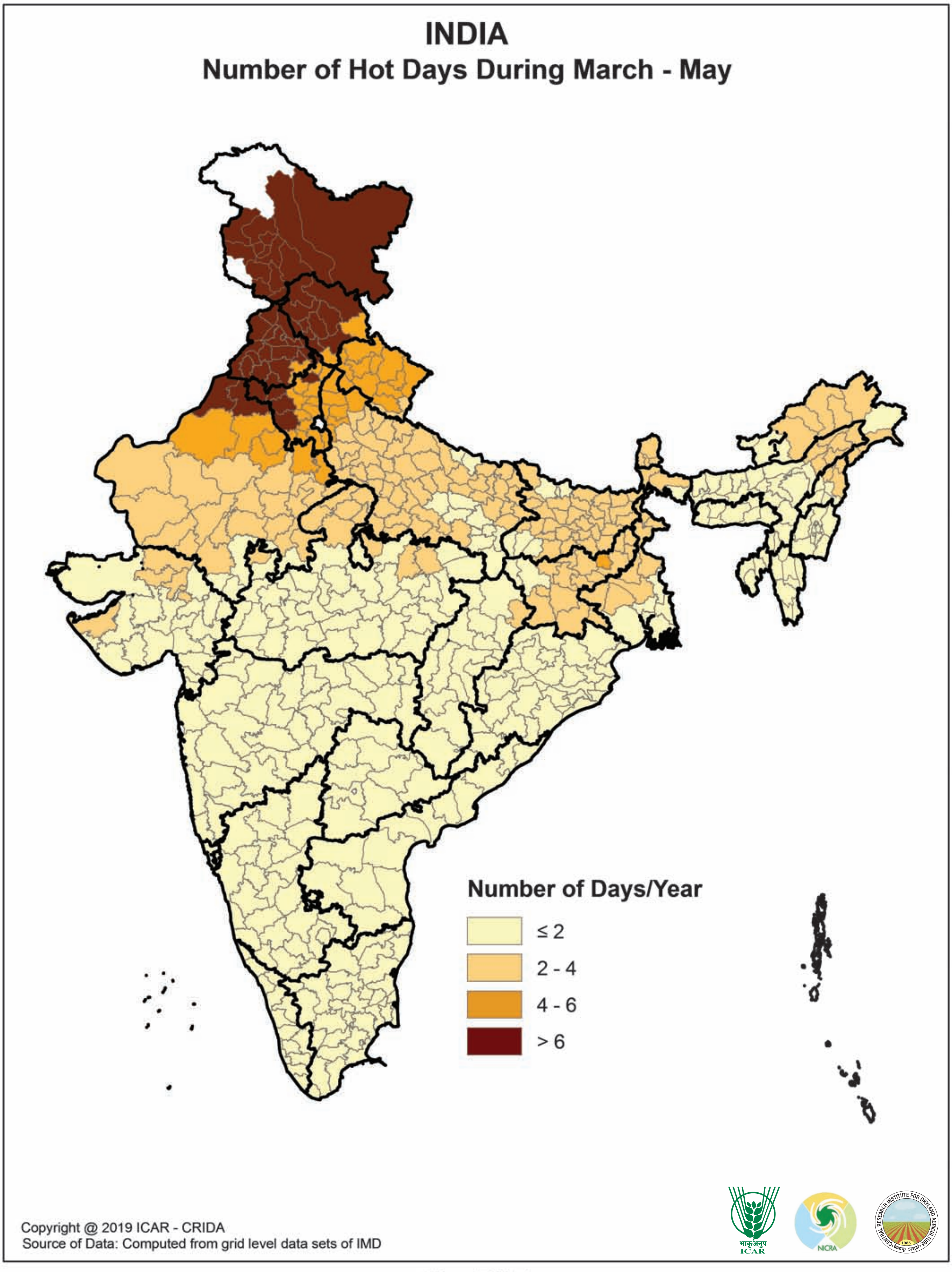
Source of Data: Computed from grid level data sets of IMD
NICRA

Fig. BL6


INDIA
Number of Hot Days During March - May
Number of Days/Year
≤ 2
2 - 4
4 - 6
> 6
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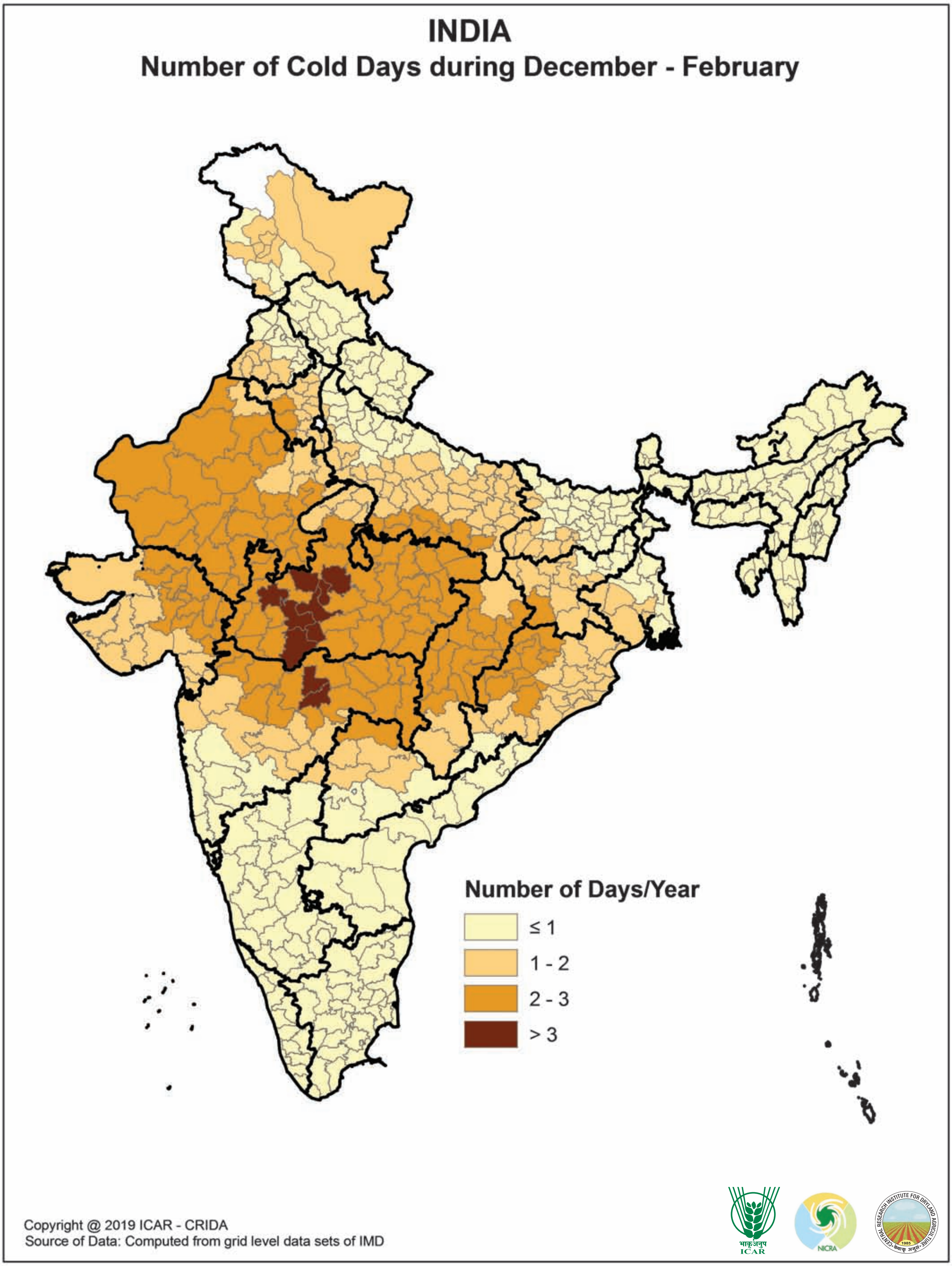
Source of Data: Computed from grid level data sets of IMD

Fig. BL7


INDIA
Number of Cold Days during December - February
Number of Days/Year
≤ 1
1 - 2
2 - 3
> 3
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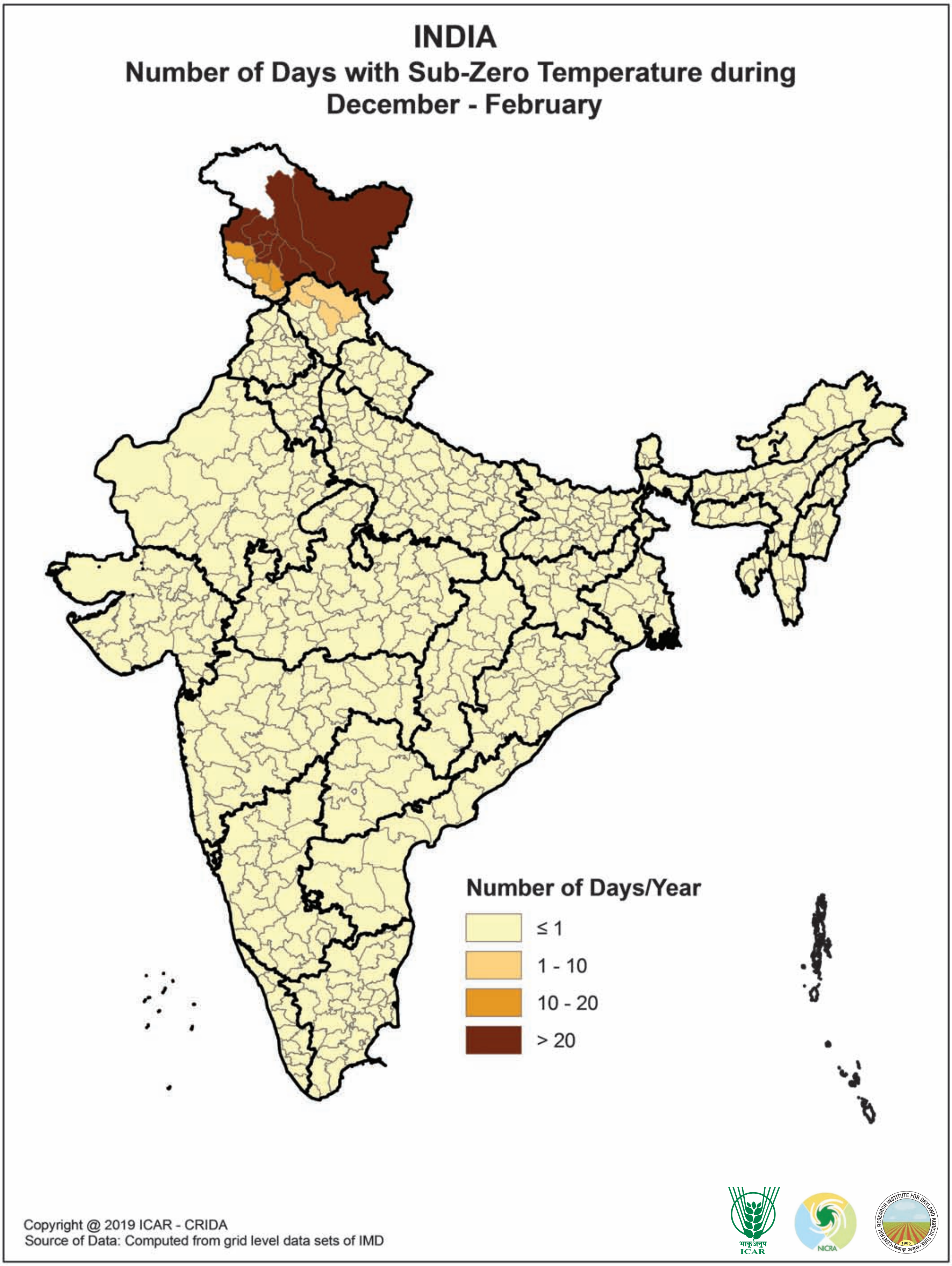
Source of Data: Computed from grid level data sets of IMD

Fig. BL8


INDIA
Number of Days with Sub-Zero Temperature during
December - February
Number of Days/Year
≤ 1
1 - 10
10 - 20
> 20
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Source of Data: Computed from grid level data sets of IMD

Fig. BL9

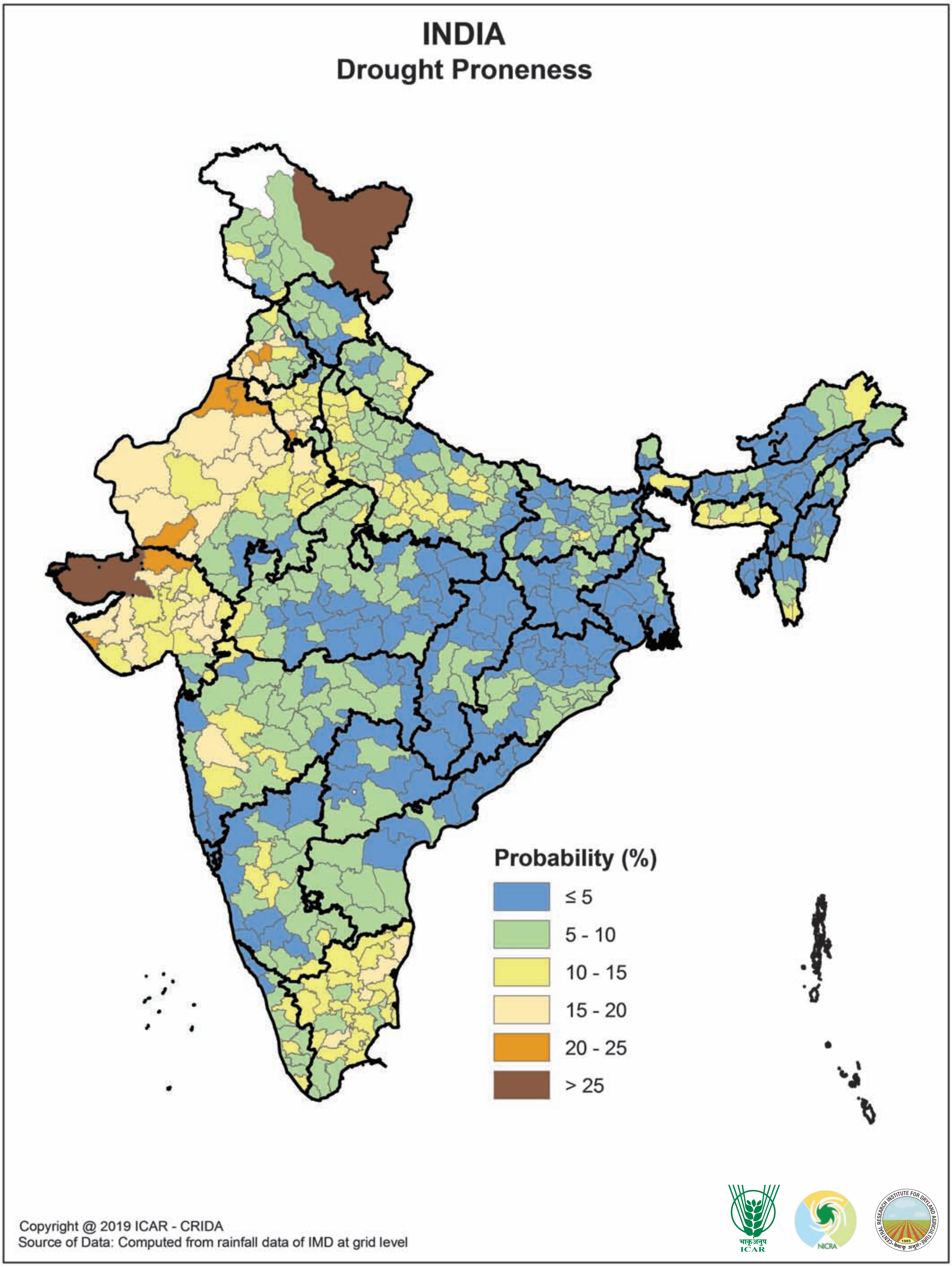
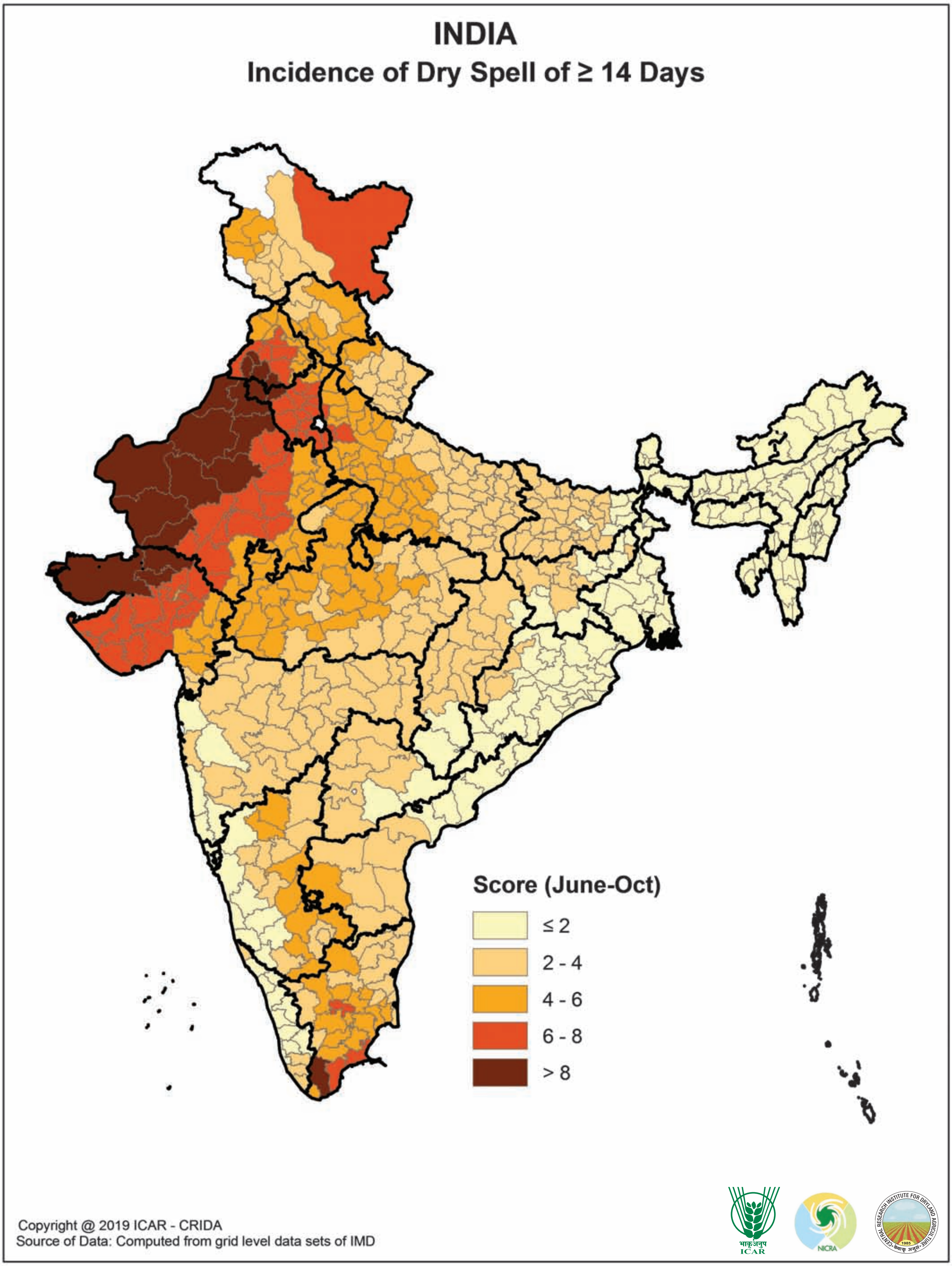

INDIA
Drought Proneness
Probability (%)
≤ 5
5 - 10
10 - 15
15 - 20
20 - 25
> 25
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed from rainfall data of IMD at grid level

Fig. BL10


INDIA
Incidence of Dry Spell of ≥ 14 Days
Score (June-Oct)
≤ 2
2 - 4
4 - 6
6 - 8
> 8
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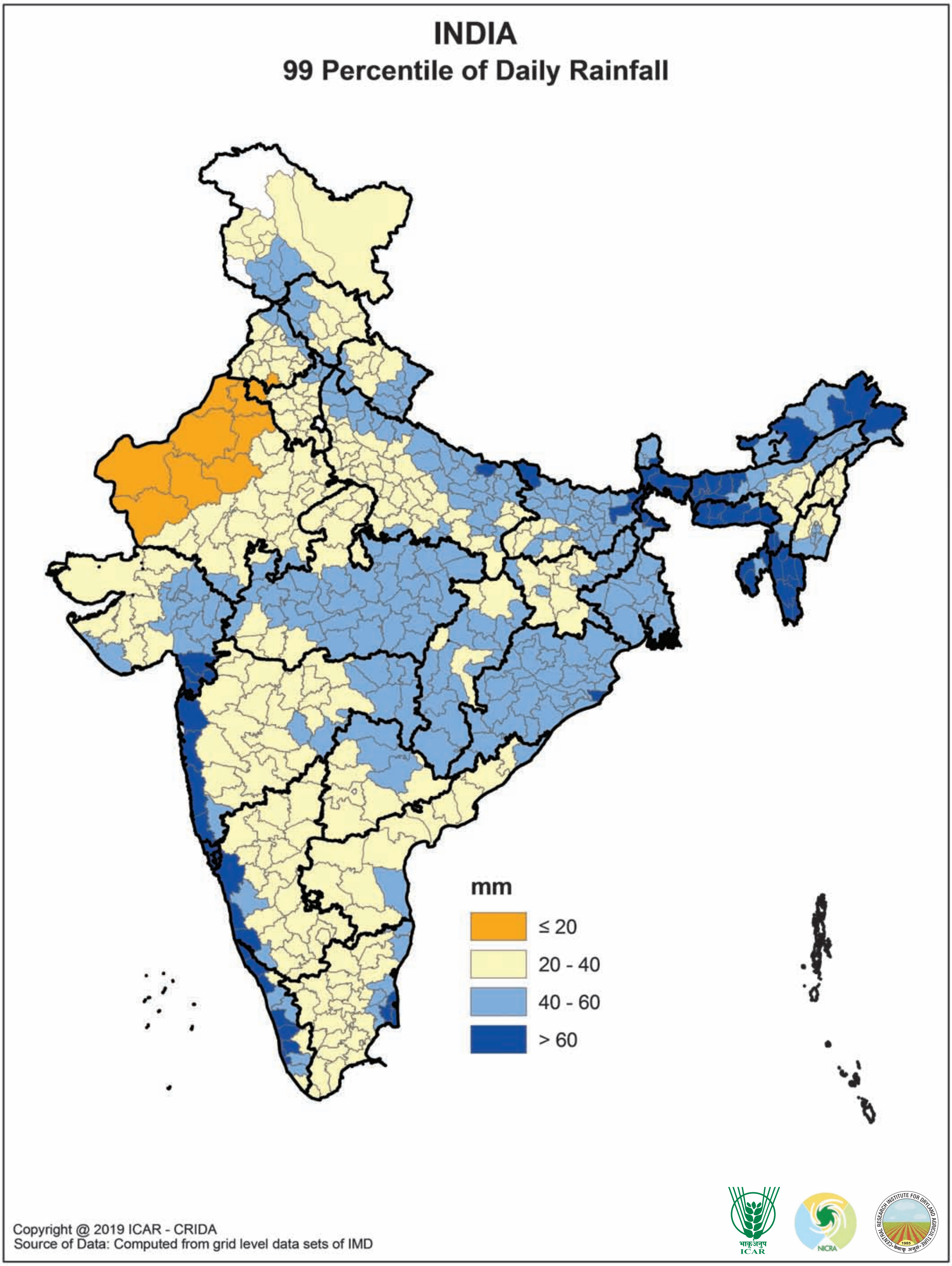
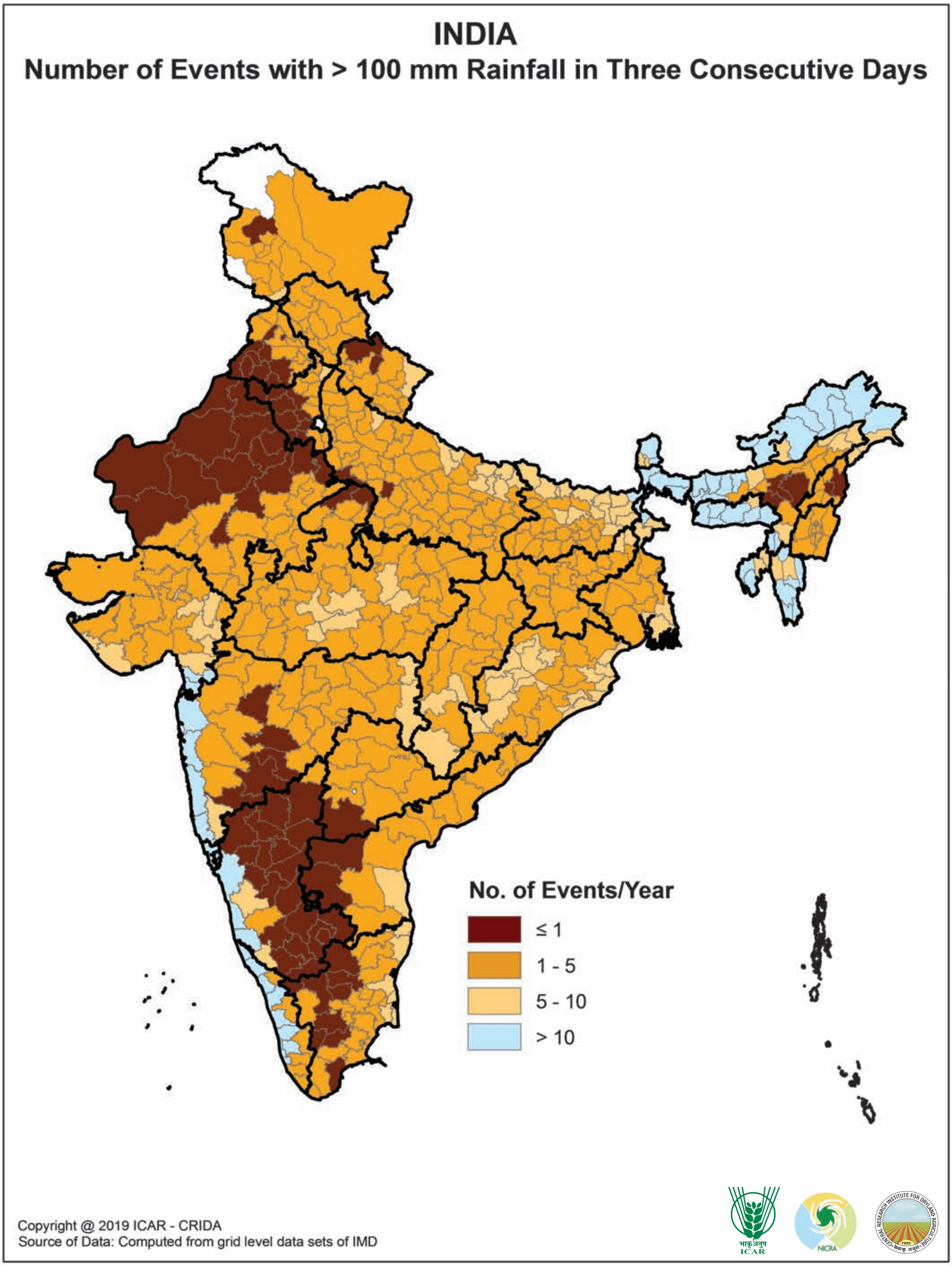
Source of Data: Computed from grid level data sets of IMD

Fig. BL11



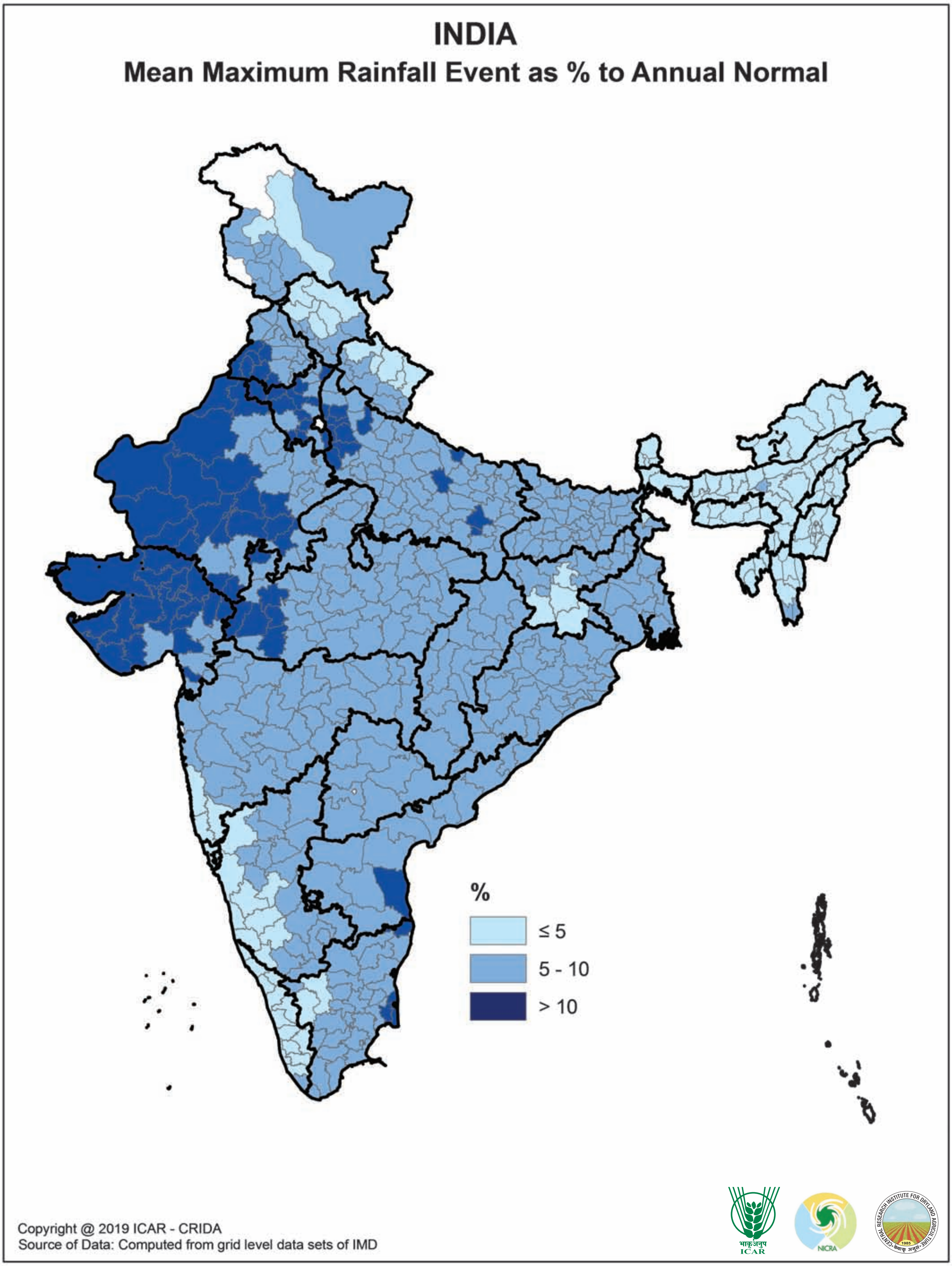
Source of Data: Computed from grid level data sets of IMD

Fig. BL12



INDIA
Number of Events with > 100 mm Rainfall in Three Consecutive Days
No. of Events/Year
≤ 1
1 - 5
5 - 10
> 10
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed from grid level data sets of IMD

Fig. BL13


INDIA
Mean Maximum Rainfall Event as % to Annual Normal
%
≤ 5
5 - 10
> 10
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Source of Data: Computed from grid level data sets of IMD

Fig. BL14

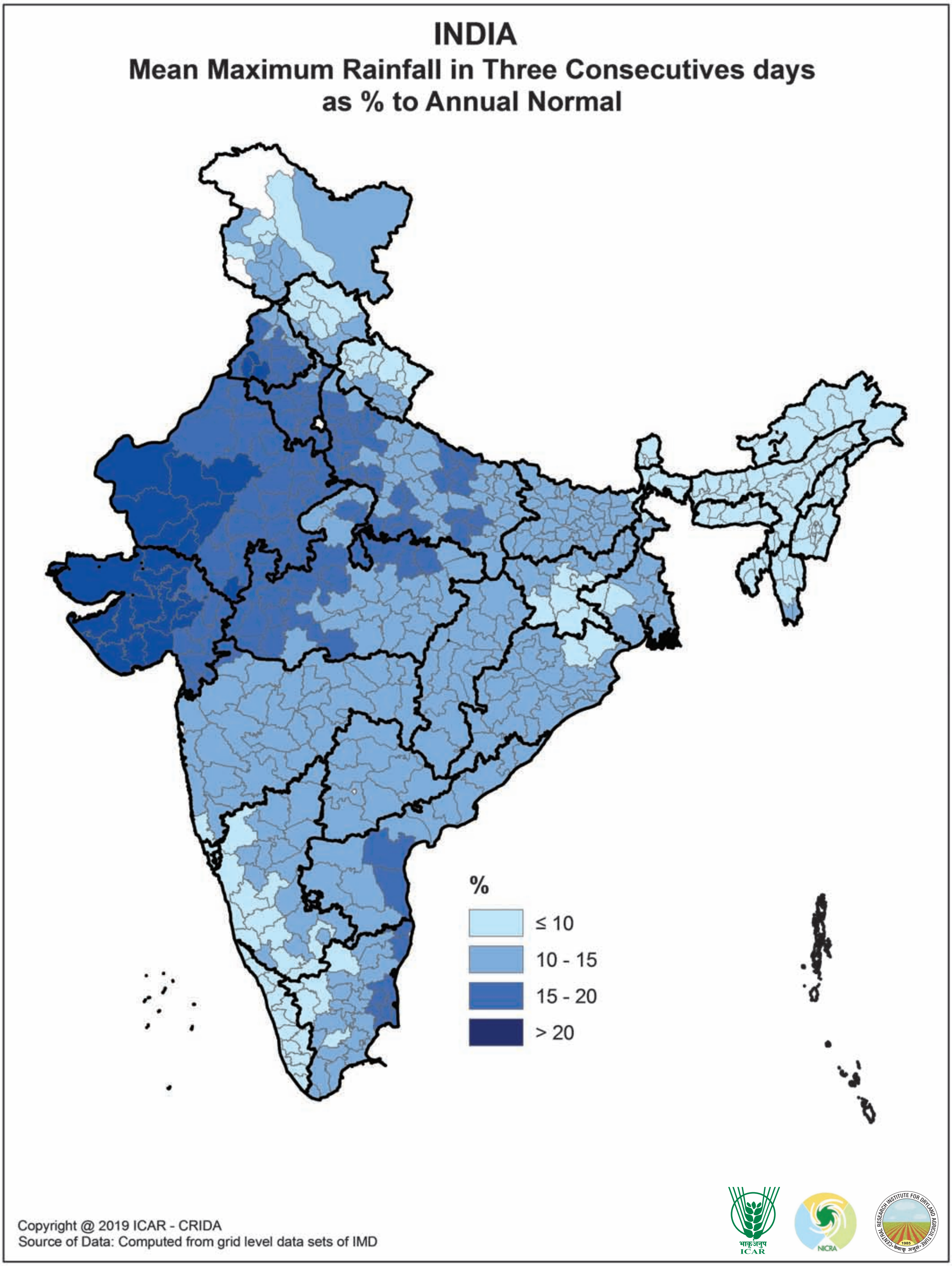
INDIA
Mean Maximum Rainfall in Three Consecutives days
as % to Annual Normal
%
≤ 10
10 - 15
15 - 20
> 20
Copyright @ 2019 ICAR - CRIDA
Source of Data: Computed from grid level data sets of IMD

Fig. BL15