

Rice/Wheat Atlas of South Asia

Robert and Eleanor Huke



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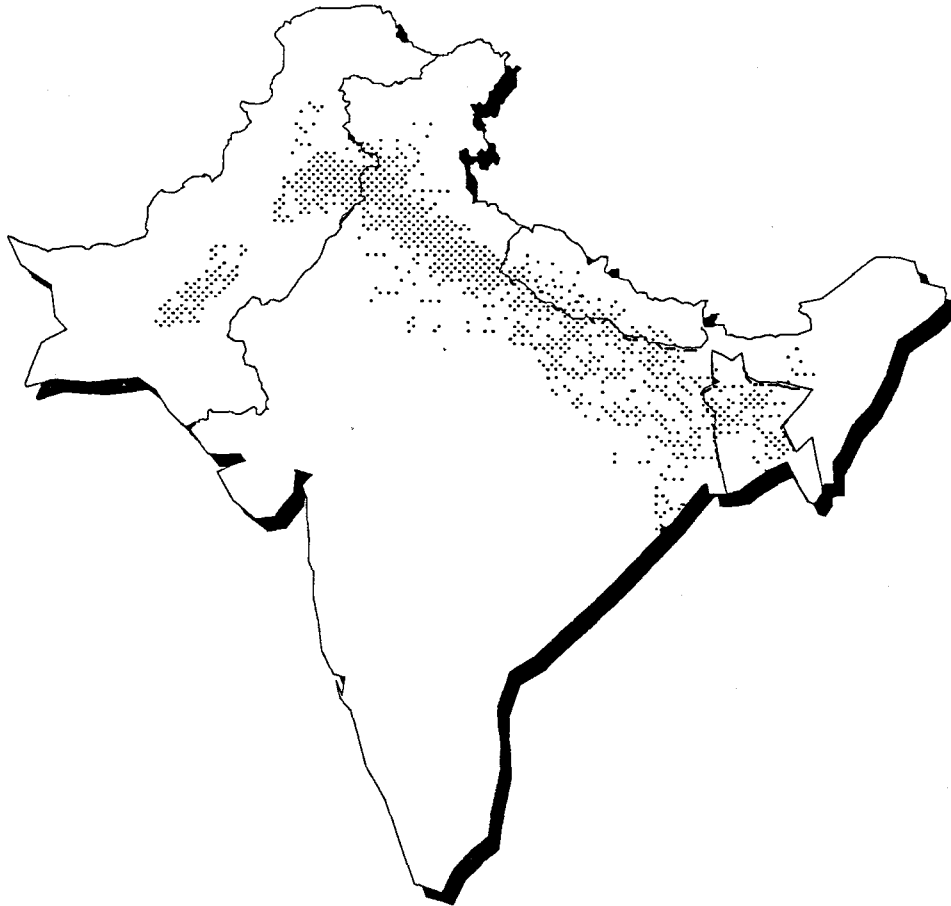
CIMMYT

International Maize and Wheat Improvement Center

National Agricultural Research System (NARS)

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1992

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Foreword

The maps included in this publication have been designed to illustrate a number of the spatial changes that have occurred in South Asia's rice-wheat farming system over the past decades. The selection of maps presented is the result of map requests from various members of the Rice-Wheat research group and interest expressed by various IRRI, CIMMYT and NARS (National Agricultural Research Service of Bangladesh, India, Pakistan and Nepal) scientists. The maps do not offer equal coverage to all parts of the rice-wheat region but concentrate heavily on the core area.

None of the maps could have been done without the help of colleagues stationed in each of the four countries concerned. This includes both a wide range of NARS personnel and CIMMYT scientists. Throughout the effort, our own associates at IRRI were strongly supportive. All NARS, CIMMYT or IRRI scientists are invited to use these maps in their publications.

Eighty-five percent of the time involved in this project has been spent in the development, justification and checking of the data bases. We have relied heavily on official agricultural and population census figures. A serious and omnipresent problem was that of adjusting historic data to that of the political boundaries as we have chosen to use them. In most, but not all, cases we have opted to use the boundaries as they existed in 1988 despite the fact that MANY districts had gone through two or even three boundary changes between 1960 and 1991. We acknowledge responsibility for errors and regret any inconvenience caused by such. On the other hand, we caution that what at first may appear to be an error often proves to be a reasonable estimate once the "ground truth " has been completed.

The maps presented in this preliminary atlas are merely an indication of the range of analysis possible with the data bases we have assembled and using the Atlas*MapMaker software on any Macintosh computer from a Plus upward. Anyone wishing to use a map not included here has three options:

1. request a copy (free) of the data base from IRRI and compose the map her/him self;
2. ask the Director of GIS at IRRI to produce the map; or
3. write to: Dr and Mrs R.E.Huke, Department of Geography, Dartmouth College, Hanover, N.H. USA.

These maps represent a preliminary output of the International Collaboration in Rice-Wheat Research for South Asia, under the leadership of Dr. T. Woodhead, IRRI. Although the maps and the data base they represent have resulted from the work of many scientists representing a wide range of institutions, it is doubtful that a tangible product would have resulted without the help of major financing from both IRRI and ADB (Asian Development Bank) for which thanks is gratefully extended.

R. & E. Huke,
Visiting Scientists, IRRI

Introduction to the Maps

The Rice-Wheat System is a farming system which utilizes a crop of rice followed by a crop of wheat. The rice is planted and grown during the high-sun period, which in most of South and East Asia corresponds with the monsoon or rainy season, while the wheat is grown during the low-sun period which is almost always the dry season. The rice crop is grown on puddled soils and perhaps as much as seventy percent of its area benefits from some sort of irrigation. The wheat crop utilizes considerable residual moisture left in the soil following the rice crop and, in many of the Himalayan intermountain valleys and on western portions of the range's piedmont, benefits significantly from gentle "winter" showers brought by cyclonic disturbances from the Mediterranean. The magnitude of these winter rains in north-western portions of the area and their decreasing volume to the south-east are shown in the table below. In response to this spatial variability of rainfall, wheat is increasingly limited to areas where at least some supplemental irrigation is possible as one moves across the area from west to east.

Winter Rainfall at Selected Sites (mm) ¹.

<u>Site</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>
Lahore, PAKISTAN	29	41	53
Parwamipur, NEPAL	15	12	6
Nawabganj, BANGLADESH	5	11	18
Parbatipur, BANGLADESH	7	16	22

A traverse of Nepal's Kathmandu Valley during the wheat season demonstrates the importance of low winter rainfall quite clearly. Here soils are moderately porous and winter rains significantly less than those at Lahore to the north-west. In this valley, wheat- sometimes alone and sometimes mixed with mustard-is strictly limited to those fields and terraces which have irrigation available. In the vicinity of Lahore by contrast, much of the wheat is produced on quite heavy soils, using residual moisture plus rainfall and without supplemental irrigation. At the eastern end of the South Asian rice-wheat area in Bangladesh a recent and major expansion of tubewell capability provides a majority of the moisture required to successfully produce a wheat crop.

Early History

In South Asia the rice-wheat system has a long history, especially in the upstream sections of the Ganges Valley in what are now the States of Punjab and Uttar Pradesh in India, and the Punjab of Pakistan. Here the system was established well before the emergence of India, Pakistan and Bangladesh as modern independent nations. At least as early as 1872 in Almora District of India's UP, a common practice on both the irrigated and the un-irrigated terraces was to sequentially crop maura (ragi) or rice with wheat or barley. In Sitapur at the turn of the century there were some 65,000 ha double cropped to rice followed by wheat, but to accomplish this it was necessary to plant an early maturing rice variety rather than "...the more valuable late rice." Not long after the District Agricultural Officer in Sitapur noted that "...there has been a 35 percent increase in cultivated area in the last 40 years and the area under double crops had tripled." The pressure on land resources was most severe "...in the lowlands west of the Chauka" where rice cultivation was expanding rapidly.

In what is now India's Punjab, similar trends were evident 80 years ago, but district reports for areas in present day Pakistan make almost no mention of rice. Thus in Amritsar and Ferozepur the rice-wheat system had been established by 1920 and in Ambala it had become important enough that the District Officer reported a "... tendency to substitute fine rice for the coarse." Jowar and bajra, perhaps?

To the east, in Bengal, the reports say little on the subject of rice-wheat sequential cropping except in Jalpaiguri where some lands along the Tista River were so planted, and in the northern portion of Gaya District where rice was planted to "1382 square miles, 249 of which were later planted to wheat." Here opium was also a very important cash crop.²

Population pressures on limited land resources, the necessity for increases in irrigation, the need for a shorter growing season rice variety, and the increasing substitution of rice for the coarse grains and the pulses were all mentioned as problems at the turn of the century as they are today. Far more discussion related to the United Provinces than to either the Punjab or Bengal. The U.P. was then, as it is now, the heartland of the rice-wheat cropping system of South Asia.

The rice-wheat area in China is probably at least as extensive as that of the Indo-Gangetic region, is concentrated spatially in the basin of the Yangtze

River, and perhaps originated earlier than that in South Asia. F.H. King, writing about China in 1905, says that, "...possibly as high as seventy-five percent [of the rice area of China] matures at least one other crop the same year and much of this may be wheat or barley, both chiefly consumed as human food."³ T.H. Shen is even more specific. He describes the "Yangtze Rice-Wheat Region" and suggests that in its 10 1/2 million ha of farmed land the majority is planted to flooded rice which is followed by winter wheat or barley. He further suggests that a similar cropping pattern is common in the "Szechwan Rice Region", but that here corn, wheat and rape are the common second crops.⁴

Thus rice and wheat have long been grown sequentially in a few limited areas of the world. Where they have been grown as an annual rotational system the productivity has been high and the population supported by the system has been at least as great as that supported by any other agricultural system. Between 1960 and 1990 the area planted to rice and wheat sequentially has increased rapidly both in China and in South Asia. This development was made possible by the package of genetic improvements in rice and wheat and the accompanying improved and intensified management strategies which all together have been called the Green Revolution. An important contributing factor was the fact that by the latter half of the Twentieth Century, new land for farming was hard to come by. Food for exponentially expanding populations had to come largely from intensification of output from land already under cultivation.

Definition of Rice Wheat System

For purposes of the maps presented in this report the extent of the Rice-Wheat System is taken as the extent of the smaller of rice area or wheat area (by district). The results of these calculations are shown in the table below.

This may possibly exaggerate the area somewhat, but is based on comments such as: "Almost [the] entire area under rice is covered under [the] rice-wheat cropping sequence."⁶ By contrast, in a report covering 20 districts of western Uttar Pradesh, the authors document that the "percentage of rice area in wheat" by district ranges from 50 percent to 95 percent.⁷ The Hukes made field observations and had discussions with local farmers and with regional agriculturalists during an extended reconnaissance survey in March of 1992. In Pakistan's Punjab State as well as in both the terai and the mid-hills region of Nepal they found that roughly eighty percent of the wheat was planted to areas that had carried

South-Asia Maximum Rice-Wheat by State 1988 ⁵.

<u>Country/State</u>	<u>Max. in Rice-Wheat</u>
Bangladesh	584,759
India:	10,087,640
Bihar	1,885,661
Harayana	462,000
Himachal Pradesh	90,174
Madhya Pradesh	852,000
Orissa	39,580
Punjab	1,717,000
Rajasthan	54,351
Uttar Pradesh	4,612,688
West Bengal	374,186
Nepal	508,220
Pakistan	<u>1,540,200</u>
TOTAL	12,720,819 ha

rice during the previous season. If we accept the observations outlined above it must be concluded that about twenty percent of the area planted to the lesser of rice or wheat by district should be excluded from the system. This twenty percent may be fallow because of water or salt problems, it may be planted to a fodder crop, to a green manure crop, to an oil crop such as mustard or it may be devoted to vegetables. Under this assumption the 12.7 m ha shown in table represents perhaps 10.2 m ha actually planted to a rice-wheat rotation. This figure, in turn, is remarkably close to the 10.3 m ha reported for China.⁸

Rice Yield Changes

Included with the maps of Uttar Pradesh are two which deal with changes in yield of rice. The first of these shows yield change between 1970 and 1988 while the second shows changes between 1960 and 1989. The two maps are strikingly similar both in their spatial aspect as well as in the magnitude of the change. Clearly, the Green Revolution in rice profitted Uttar Pradesh hardly at all in the decade of the sixties but brought major improvements during the seventies and the eighties.

The question of what has been happening to rice yields over the period covered by the maps is open to a variety of intrepertations. Frequently one reads that the rice-wheat system is showing signs of fatigue or at least that the northern and western portions of India showed a characteristic decline in yield growth during the eighties. Data designed to allow the reader to make her/his own decision regarding this point is

presented as a series of charts related to Bihar, Uttar Pradesh and the Punjab (India). These graphs, immediately following the introductory text, show the yield of rough rice by five year running means. This method was adopted to smooth out temporary perturbations caused by local climatic catastrophe or by temporary economic conditions such as the sudden rise of fertilizer prices brought about by oil embargos or similar events.

In the case of Bihar there has been scant improvement in rice yields over the 36 year period and a study of the net yield change in yield from pentad to pentad shows extreme fluctuation between gains and losses. However, it may be significant that during the the final seven periods of record all show gains over the preceeding period.

Data for Uttar Pradesh is treated in the same manner and shows a rice yield average of 0.8 t/ha, even lower than that for Bihar during the initial pentad. Progress has been almost steadily upward, except for a slight dip in the mid-sixties, and by the 1985-89 pentad, has achieved yields roughly 0.6 t higher than those of Bihar. In addition, for the final ten periods Uttar Pradesh's rice yields have increased consistently. The curve described by the 5 year running means hints of the early stage of an "S" shaped adoption curve.

The case of the Punjab is entirely different. Here yields were high at the start of the period and increased remarkably. The "plateauing" effect is clear; yields are no longer increasing at the rate they achieved during the seventies and early eighties. The graph of net yield change shows this even more strikingly with major gains from 1966 through 1977. Following that period the gains have been more modest and showed a decline for one period. The Punjab is well known for its adoption of all aspects of the Green Revolution. Seeds, fertilizers, tractors and pest controls were all adopted widely and used effectively. The yield curve is very similar to the expected "S" curve and illustrates well the diminishing returns expected from increased inputs at a high level.

Map Coverage

For each of the seven units mapped, coverage of the Changes in Per Capita Availability of Rice plus Wheat over the period of the data base is included. Total rice production and total wheat production have been added together by district and have been divided by the population of the district for the year concerned. This was done for the first year of the data base and for the final year. The map presented results from subtracting the first

year from the final year. In all cases changes in district boundaries between these years has been taken into account. This map is included for all units mapped because analyzing both production change (combining yield with area harvested) and population growth is considered to be of paramount importance. The reader will observe that for some states, Bangladesh, Bihar and Nepal for example, the picture is discouraging as population growth has outstripped some impressive gains in grain output. In other states such as Uttar Pradesh, India's Punjab and Pakistan major gains in per capita production have far outstripped population growth.

There is also universal coverage of maps to show Changes in the Rice-Wheat System Area. These show change from the earliest year of data available until the latest, usually 1960 to 1989. Gains in area are shown as solid dots and losses in area as hollow dots. The scale relative to dot size is constant for the entire series of maps at 5000 ha. Thus one can easily recognize, by comparing the respective maps, that the gain in area planted to the rice-wheat system has been far more profound in the U.P. and in Northwest India than has been the case in Bangladesh or Pakistan. Clearly the original core area has grown more rapidly than have more peripheral regions.

Dot maps should be used with caution. The number of dots within a district is always a function of unit size chosen for mapping (5000 ha in most cases) with the default that any residual between 2500 ha and 7499 ha will be represented by a single dot. A residual of less than 2500 ha will be ignored. The distribution of dots within a district is random and should not be taken as indicative of most favorable location.

Conclusion

Maps are a valuable tool for the analysis of data. Almost any information that can be presented and analyzed in the form of a table gains an additional dimension when presented as a map. With a cartographic presentation, similarities and differences from place to place become immediately obvious - a spatial perspective has made the figures come alive. This was never more clear to the authors than on a recent field trip where we presented a lecture-demonstration of the Atlas*MapMaker software for 14 district and lead center agricultural scientists. On the computer screen we brought up a map showing Rice-Wheat System as a Percent of Net Cropped Area. There was an immediate outbreak of discussion among the observers, clearly a searching for an explanation of the patterns on the screen. One district among a dozen in the same ecosystem stood out as having a markedly lower percentage of rice-wheat

than was the case for ANY ONE of the surrounding districts. Why? Several sound explanations were advanced, but finally one scientist, only half in jest, suggested that the map "proved that we must improve our methods of data collection."

1. Bangladesh data from: E.B.Manalo (1976). Agro-Climatic Survey of Bangladesh,BRRI and IRRI, Los Banos, Philippines. p.46. Nepal data from: Agro-Ecology, Climate Section, IRRI, Los Banos, Philippines. Pakistan data from: Meteorological Department, Government of Pakistan, Lahore, Pakistan.

2. Data contained in the above paragraphs has been distilled from: Imperial Gazetteer of India, Oxford, Clarendon Press, 1907-31. (The microfilm version.) Individual volumes deal with each of the Districts of British India.

3. F.H. King. 1911. Farmers of Forty Centuries. reprinted by Rodale Press, Emmaus, PA. USA. p272.

4. T.H. Shen. 1951. Agricultural Resources of China. Cornell University Press, Ithaca, NY.

5. Taken as the maximum of rice area or wheat area for 1988 by District. Data for India from: Agricultural Situation in India; for Pakistan from: Agricultural Statistics of Pakistan; for Nepal: Agricultural Statistics of Nepal 1990; and for Bangladesh from: Statistical Yearbook of Bangladesh. The actual area planted to the Rice-Wheat System is somewhat less than shown in the table - perhaps by as much as 20 percent as stated in the text

6. Report of November 1991. Haryana Rice-Wheat Lead Center, to T.Woodhead. p1.

7. Director of Research, G.B. Pant. Univ of Agri. & Tech. Pantnagar, India. Personal communication.

8. Fei Huai-Lin. 1989. The Reformation and Development of Rice-Wheat Cropping Systems in China. internal publication of: China National Rice Research Institute. 1991

RICE/WHEAT ATLAS OF SOUTH ASIA

Robert & Eleanor Huke

FOREWORD

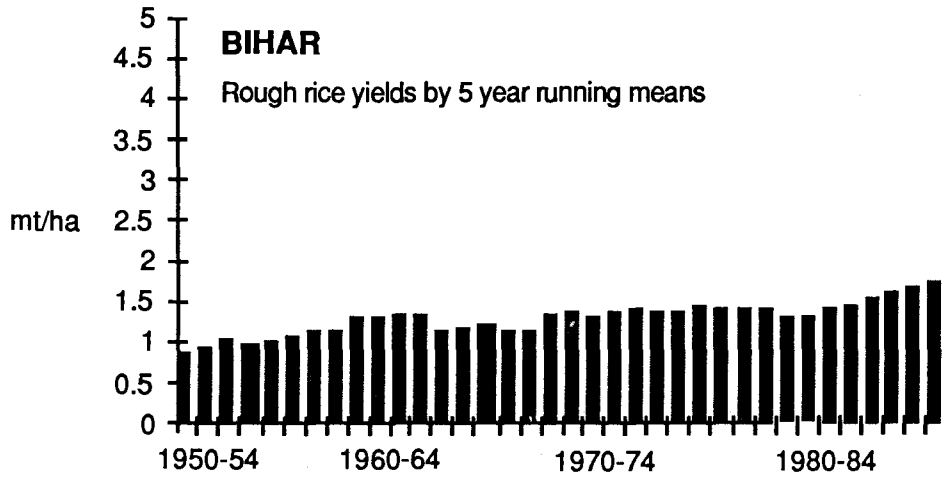
INTRODUCTION TO MAPS

CHARTS:

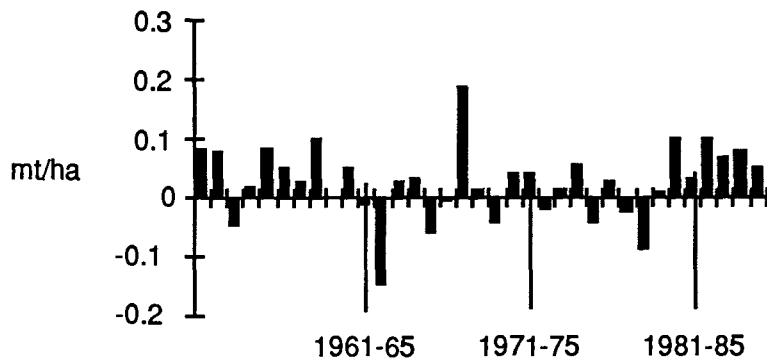
UTTAR PRADESH-	Net yield change, rough rice, 5 yr mean and Rough rice yields, 5 yr mean
BIHAR-	Net yield change, rough rice, 5 yr mean and Rough rice yields, 5 yr mean
PUNJAB-	Net yield change, rough rice, 5 yr mean and Rough rice yields, 5 yr mean

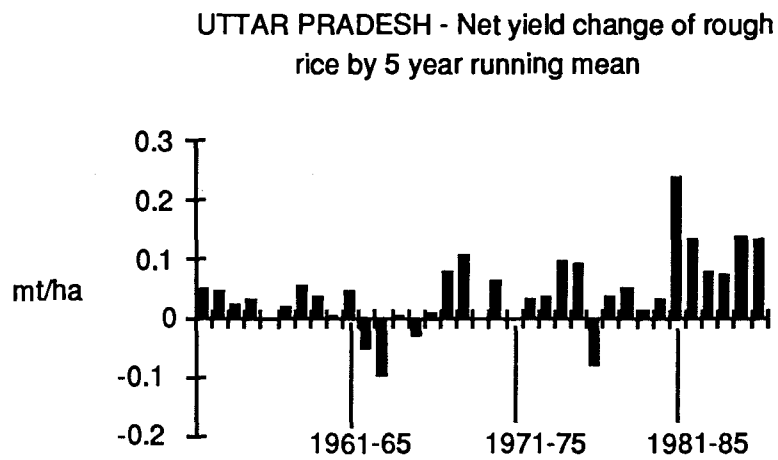
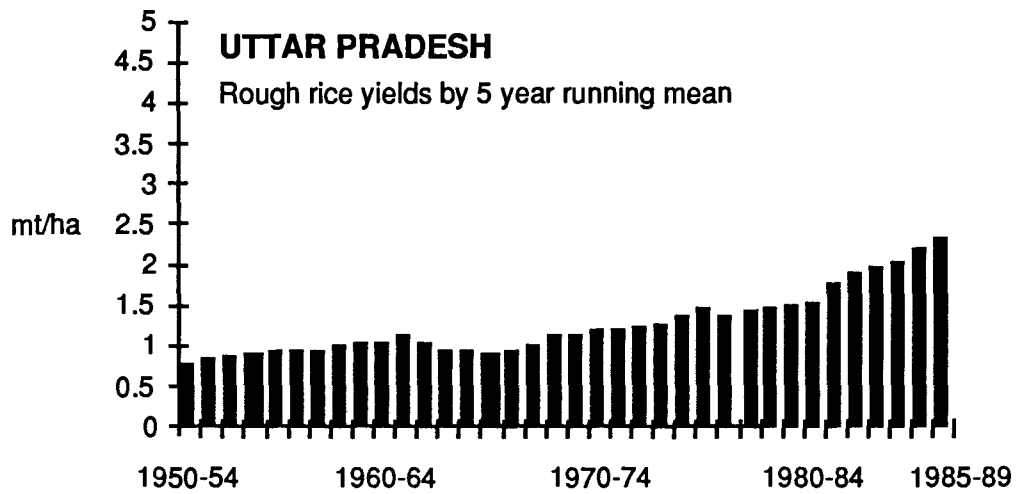
MAPS:

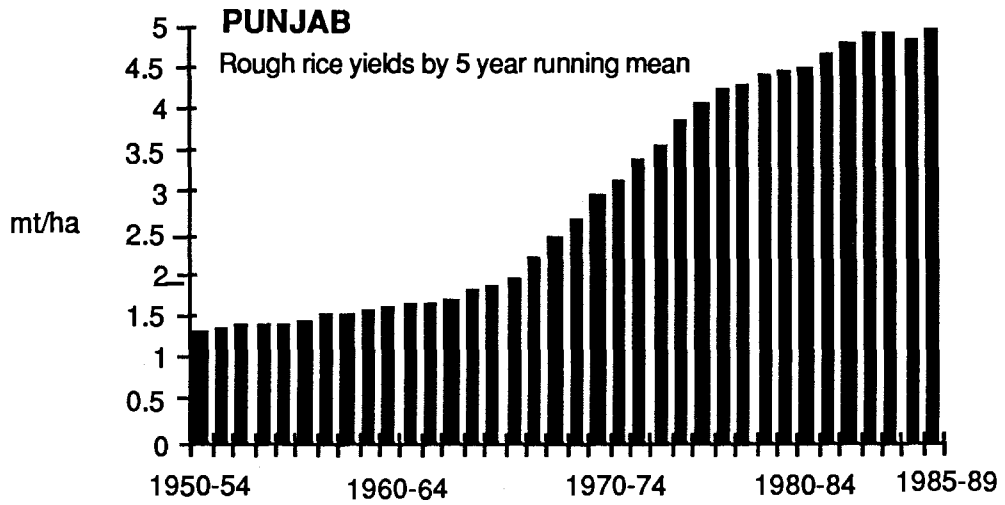
<u>BANGLADESH-</u>	Rice-wheat area changes ('60-'88) Changes in R-W availability ('61-'87)
<u>INDIA:</u>	
BIHAR-	Rice-wheat area changes ('60-'89) Changes in R-W availability ('61-'88)
NW INDIA-	Changes in rice area ('60-'89) Changes in rice yield ('60-'88) Changes in wheat area ('60-'89) Changes in wheat yield ('60-'88) R-W system as percent of NCA (1988) R-W system as percent of total area (1988) Availability of R-W in kg/cap (1988) Changes in R-W availability ('61-'88)
UTTAR PRADESH-	Rice-wheat area changes ('60-'89) R-W system as percent of total area ('87-'88) R-W system as percent of NCA('87-'88) Population estimate, 1988 Changes in R-W availability ('61-'88) Change in area planted to rice('60-'89) Changes in rice yield ('70-'88) Changes in rice yield ('60-'89) Change in area planted to wheat ('60-'89) Changes in wheat yield ('60-'88) Rice-wheat area changes ('60-'89)
WEST BENGAL-	Rice-wheat area changes('60-'88) Changes in R-W availability ('61-'88)
<u>NEPAL-</u>	Rice and wheat area(ha), 1988 R-W system, by district, 1988 R-W system as percent of NCA Changes in rice area ('75-'88) Changes in wheat area ('75-'88) Changes in R-W availability ('75-'88) Rice-wheat area changes ('75-'88)
<u>PAKISTAN-</u>	Population, 1981 Change in area planted to rice('80-'88) R-W system as percent of farmed land Percent of net area in net sown area (1988) Rice plus wheat per capita ('85-'86) Changes in R-W availability ('70-'88) Rice-wheat area changes ('70-'88)



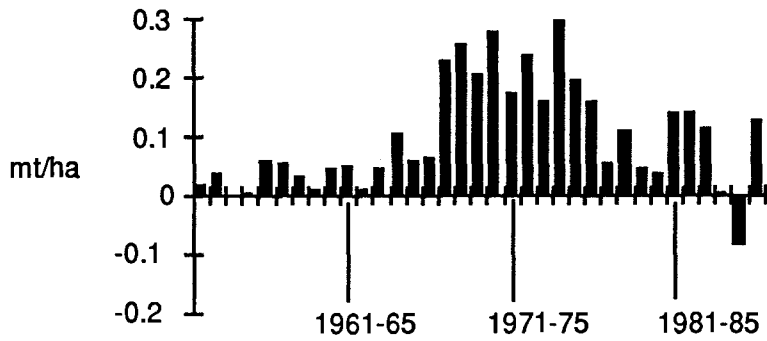
BIHAR - Net yield change of rough rice by 5 year running mean







PUNJAB - Net yield change of rough rice by 5 year running means



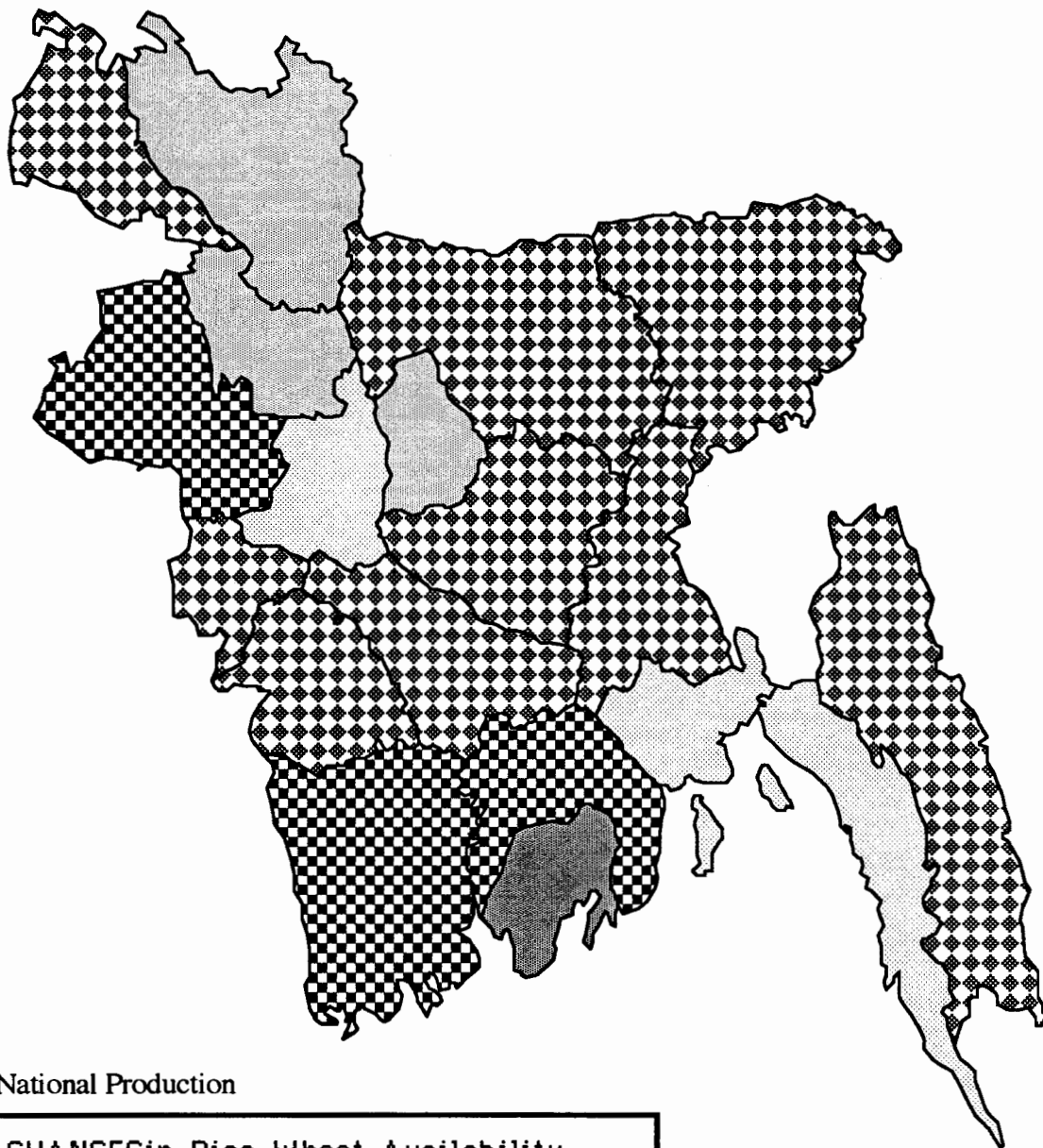
BANGLADESH



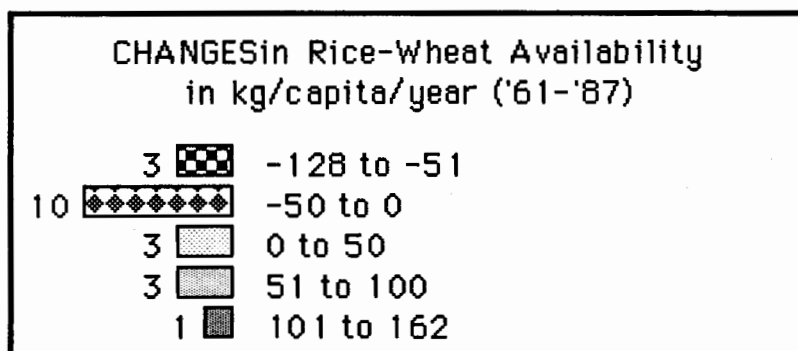
RICE-WHEAT SYSTEM AREA
Changes 1960-1988 (ha)
Each Dot ● = 5000

IRRI, CIMMYT, NARS '92 R&EH

BANGLADESH



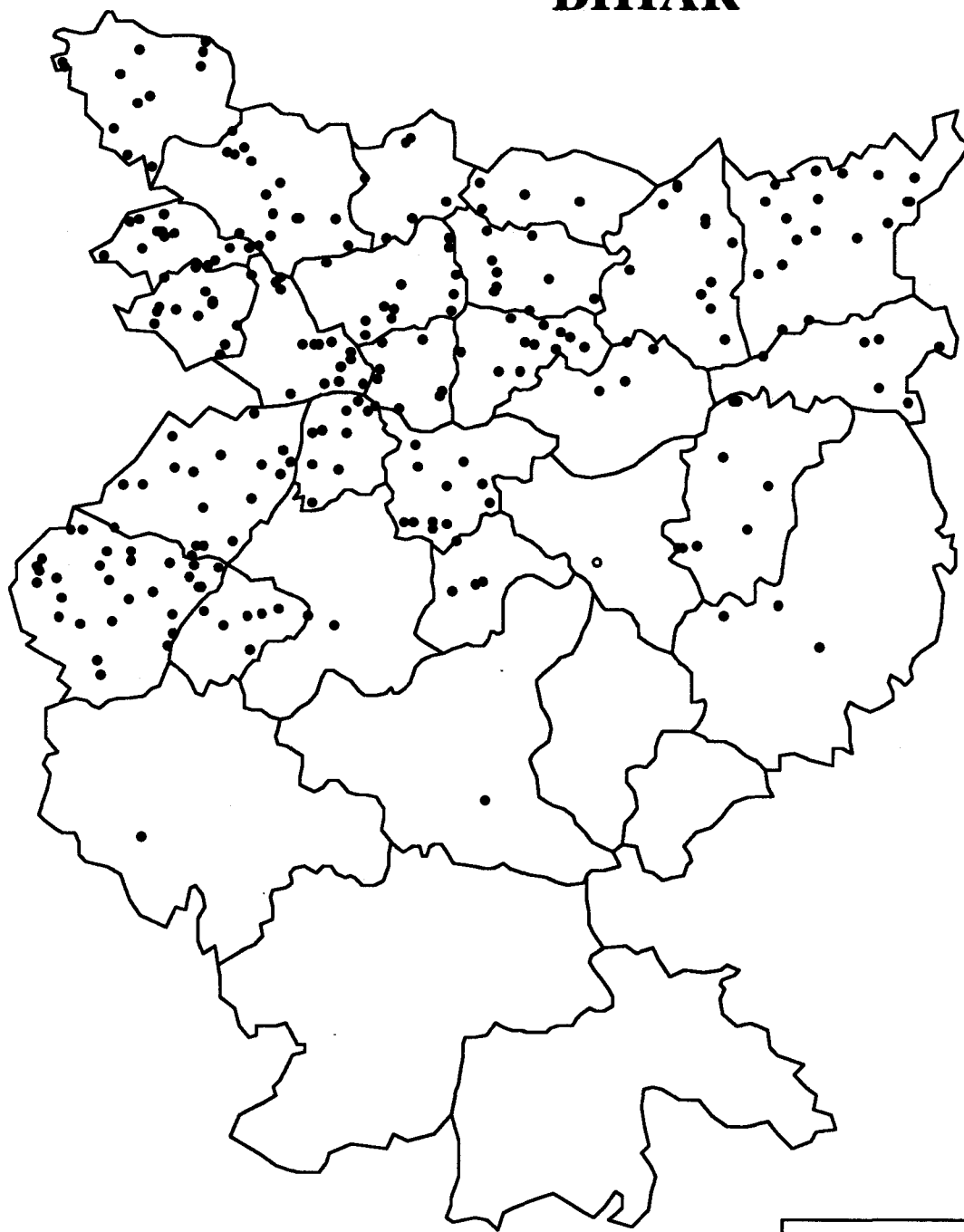
From National Production



1987 mean availability 146 kg
DOWN 17 kg from 1961

IRRI, CIMMYT, NARS '92 R&EH

BIHAR

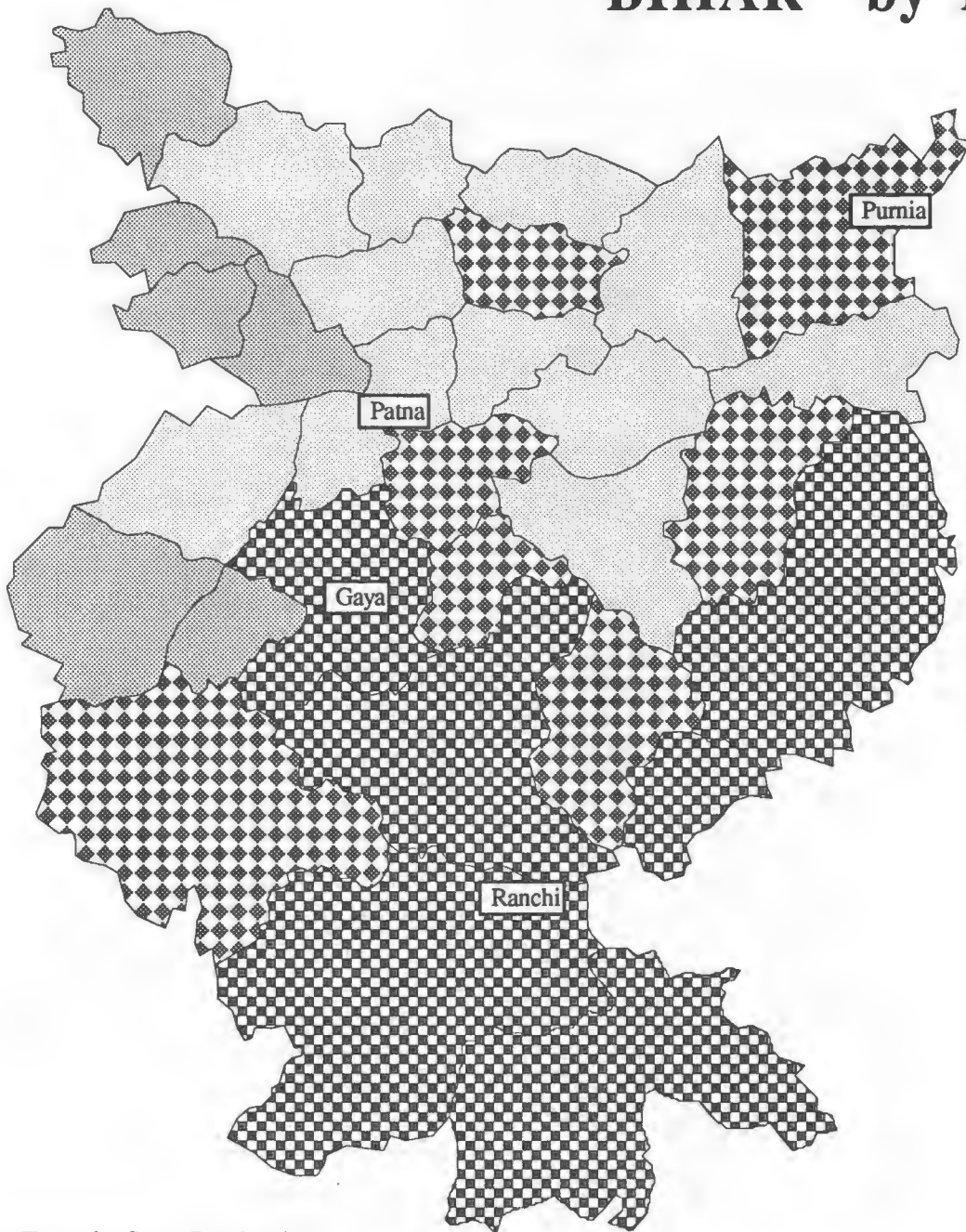


Solid dots = area gain
Hollow dots = area loss

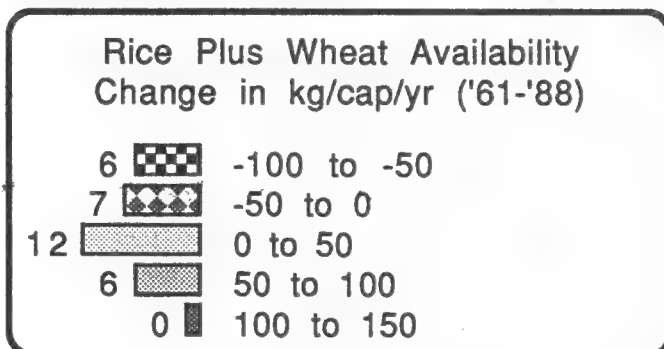
RICE-WHEAT SYSTEM AREA
Changes 1960-1989 (ha)
Each Dot ● = 5000

IRRI, CIMMYT, NARS '92 R&EH

BIHAR by District

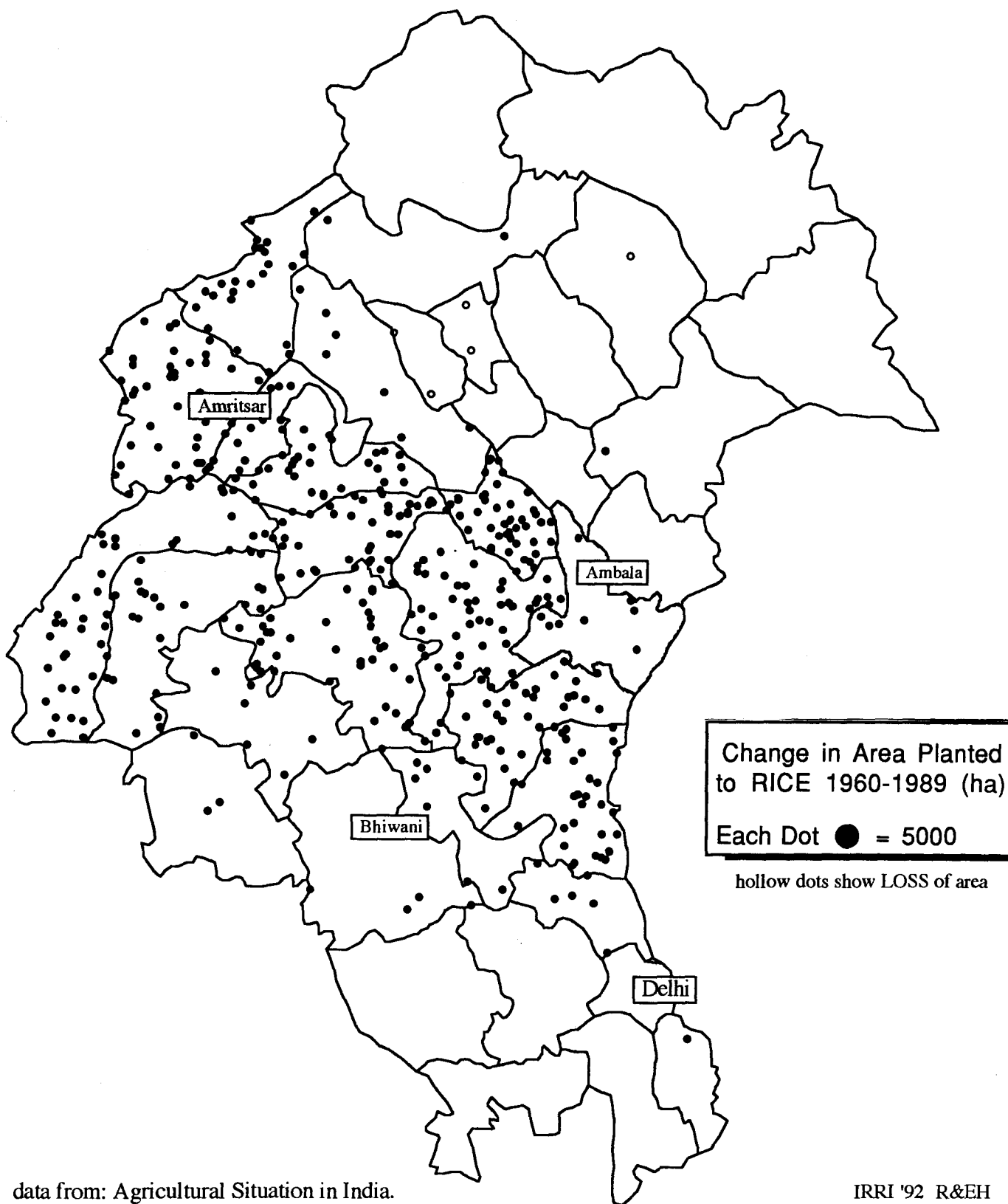


From in-State Production



Availability in 1961 = 90/kg/capita
 Availability in 1988 = 91 kg/capita
 Up 1 kg/capita/year

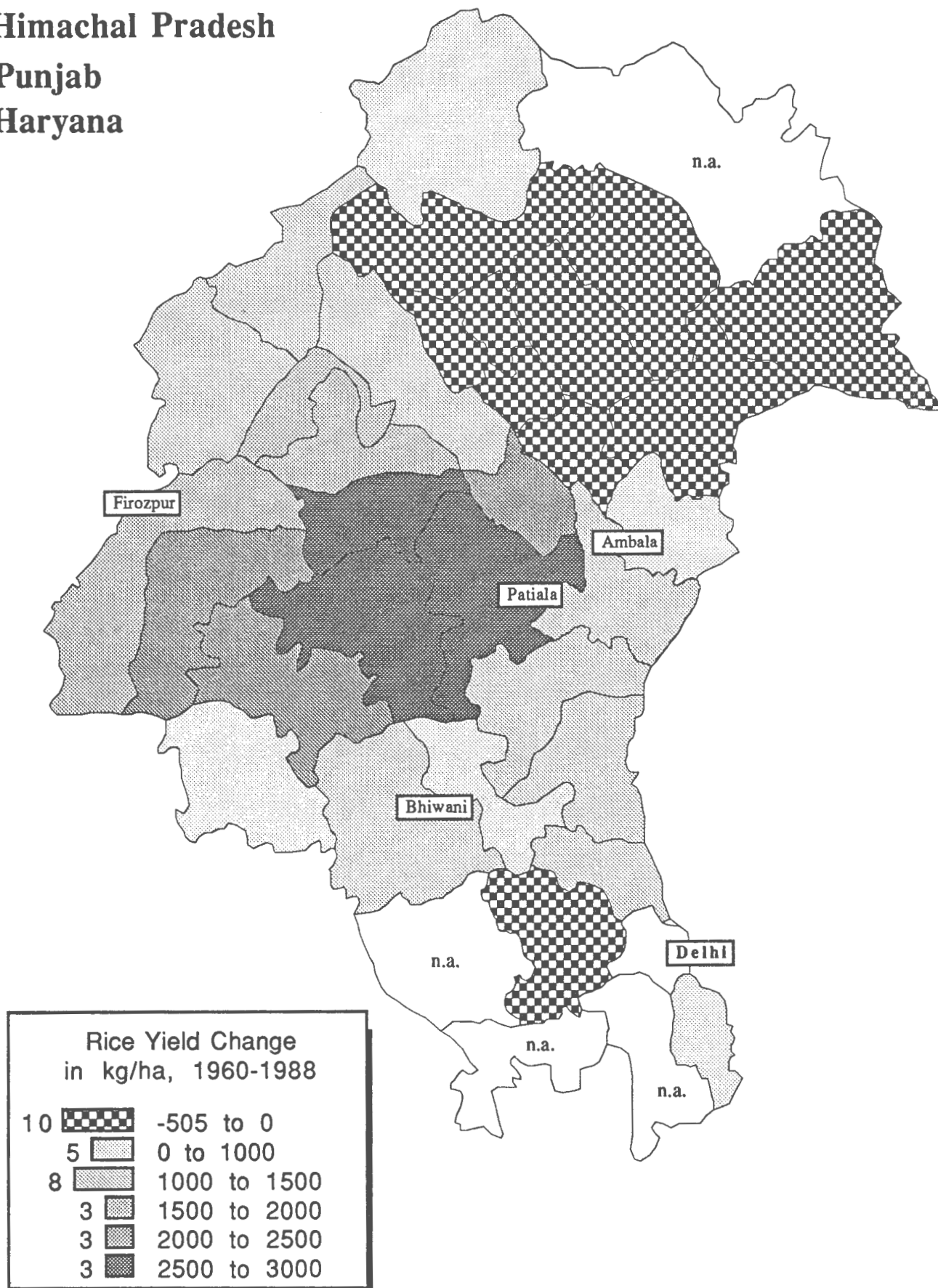
Himachal Pradesh, Punjab and Haryana



data from: Agricultural Situation in India.

IRRI '92 R&EH

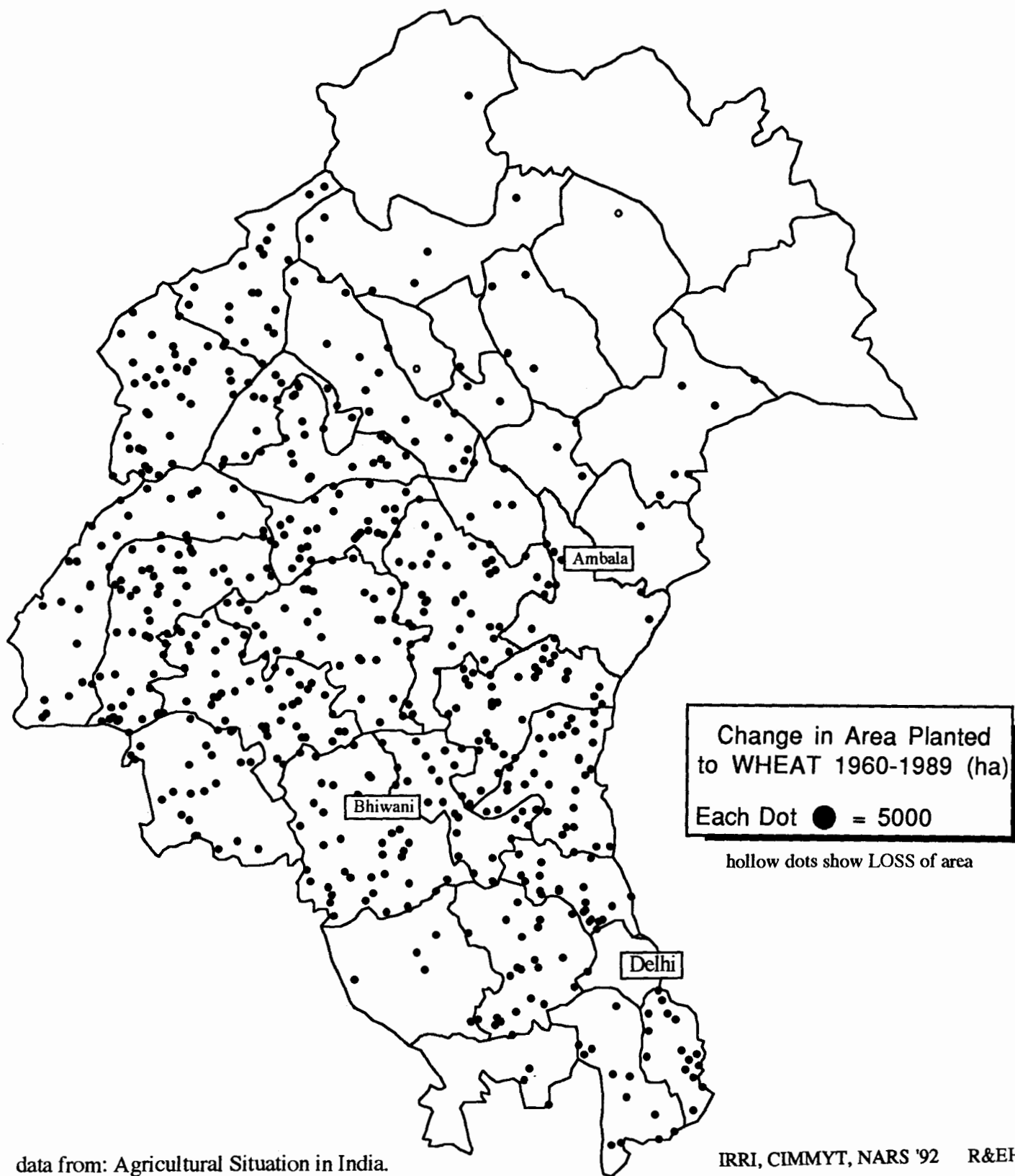
Himachal Pradesh
 Punjab
 Haryana



data from: Agricultural Situation in India

IRRI, CIMMYT, NARS R&EH

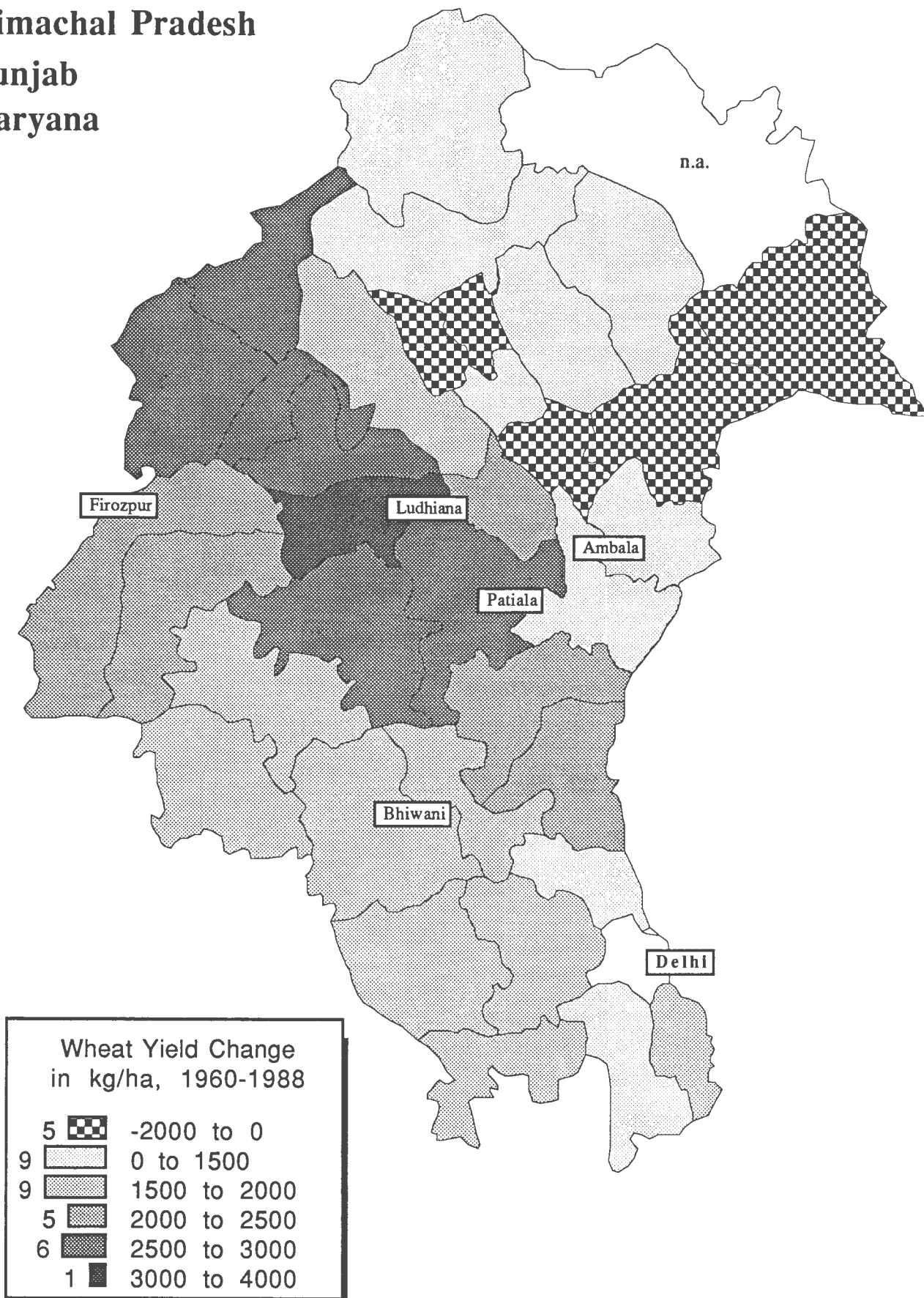
Himachal Pradesh, Punjab and Haryana



data from: Agricultural Situation in India.

IRRI, CIMMYT, NARS '92 R&EH

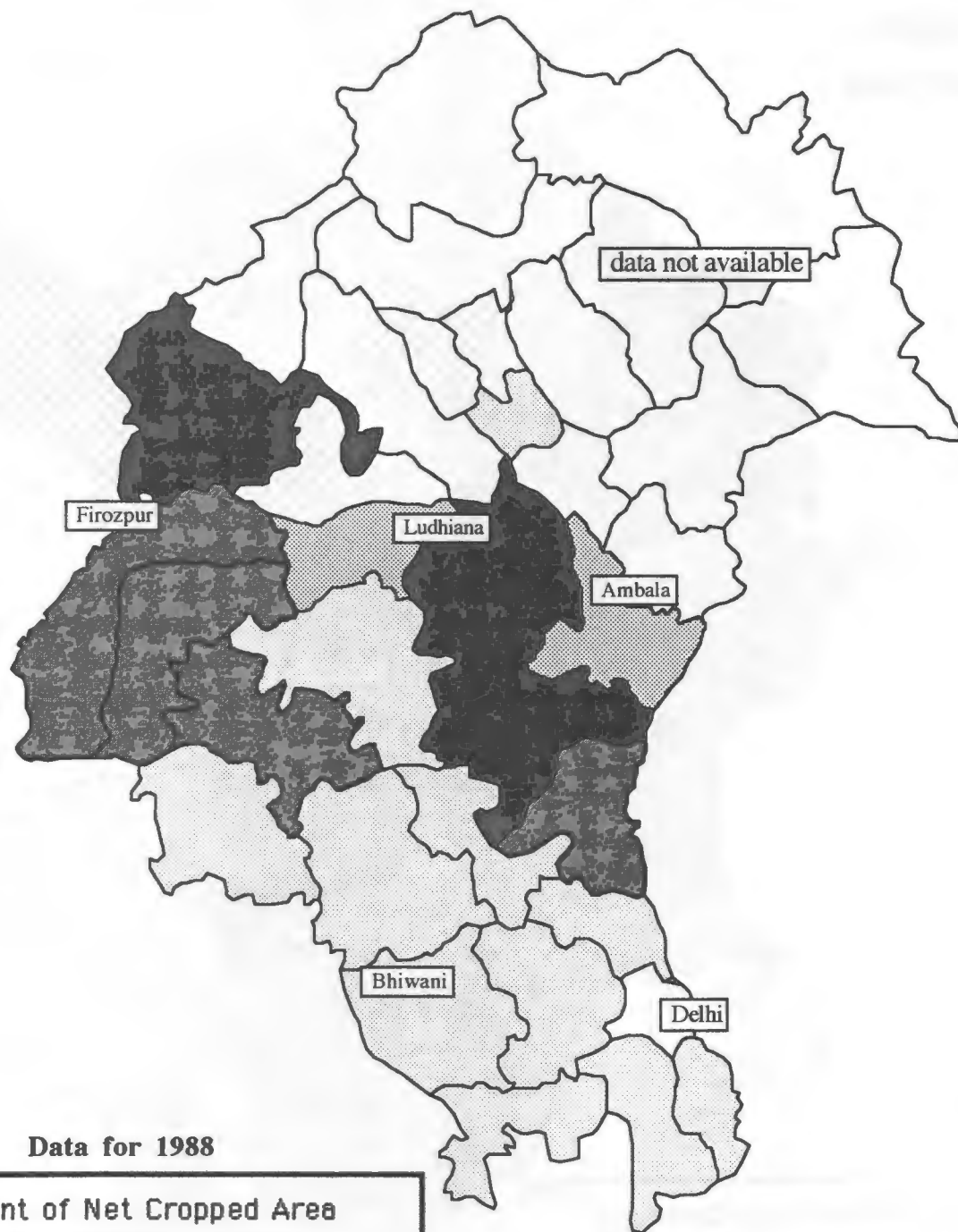
Himachal Pradesh
Punjab
Haryana



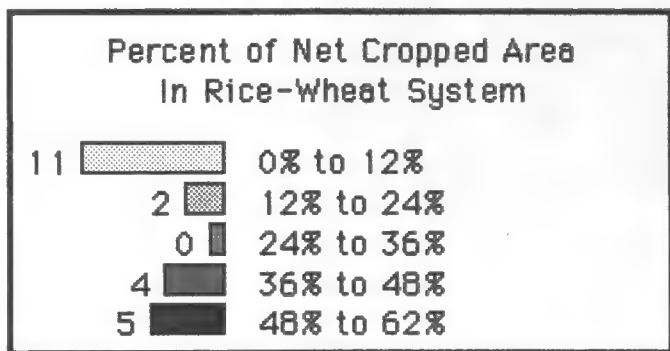
data from: Agricultural Situation in India

IRRI, CIMMYT, NARS R&EH

Himachal Pradesh, Punjab, Haryana

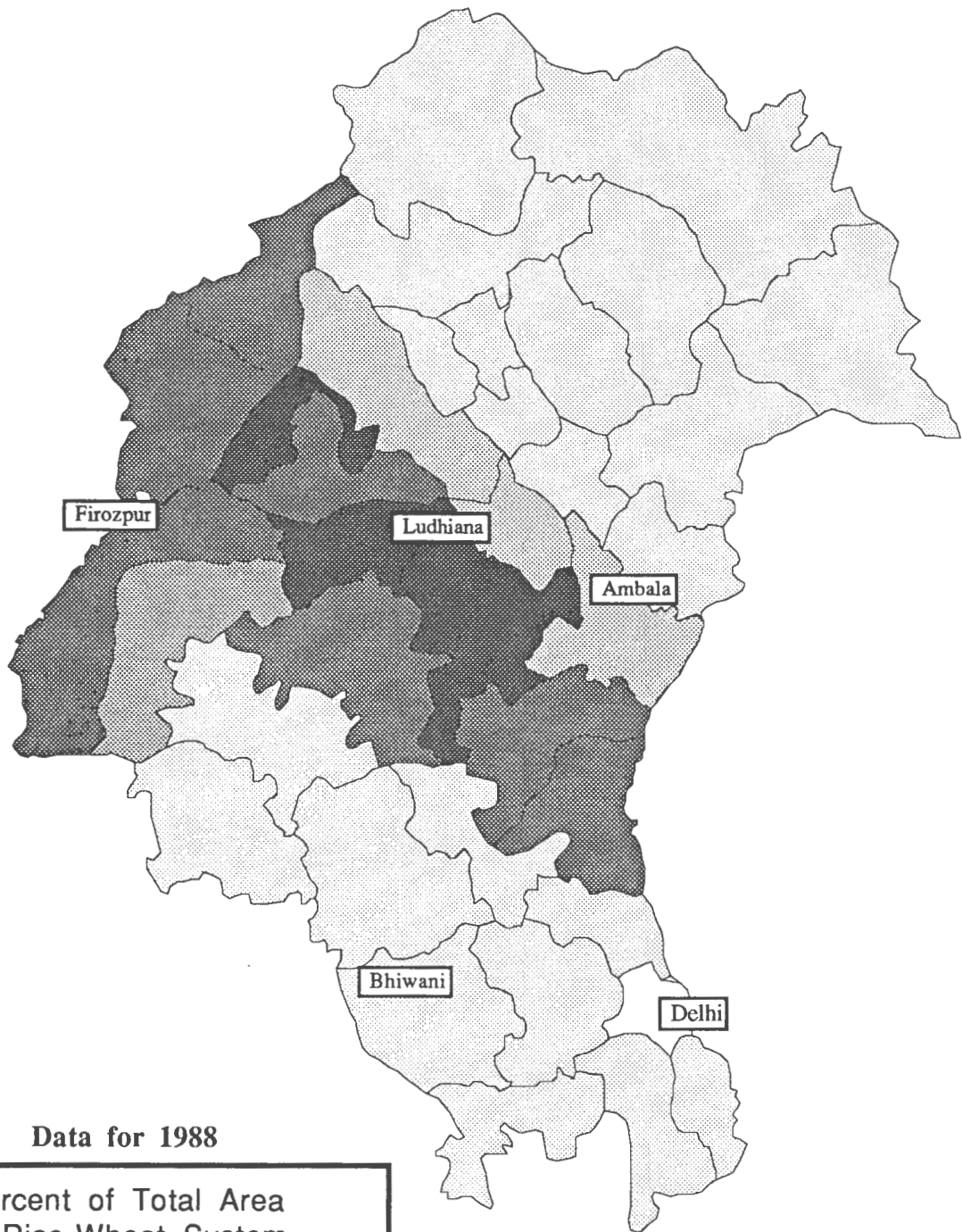


Data for 1988








IRRI, CIMMYT, NARS '92 R&EH

Himachal Pradesh, Punjab, Haryana

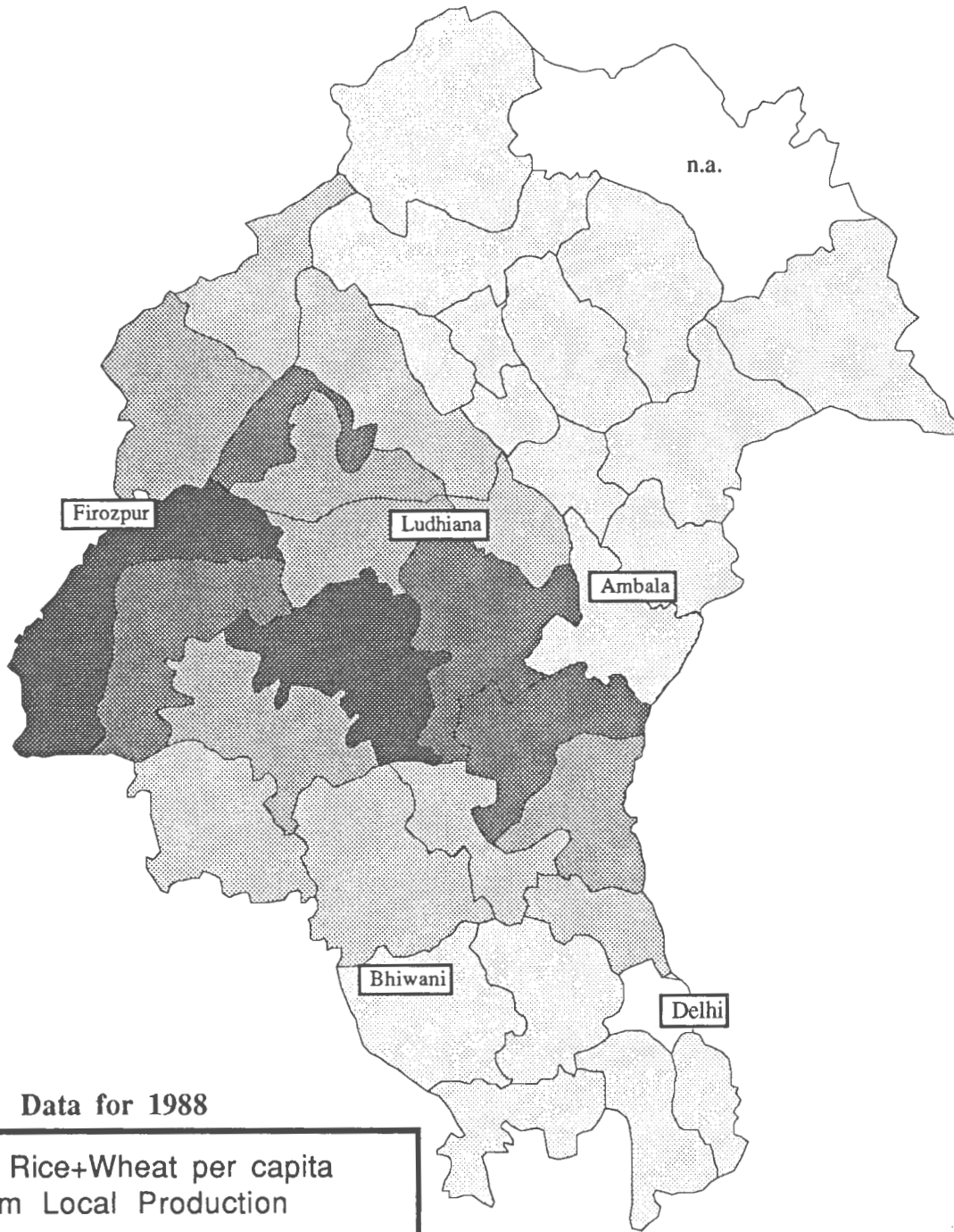


Data for 1988

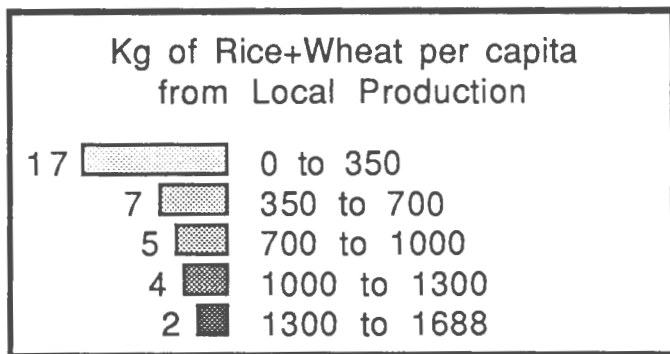
Percent of Total Area In Rice-Wheat System		
22		0% to 12%
3		12% to 24%
1		24% to 36%
7		36% to 48%
3		48% to 62%

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Himachal Pradesh, Punjab, Haryana

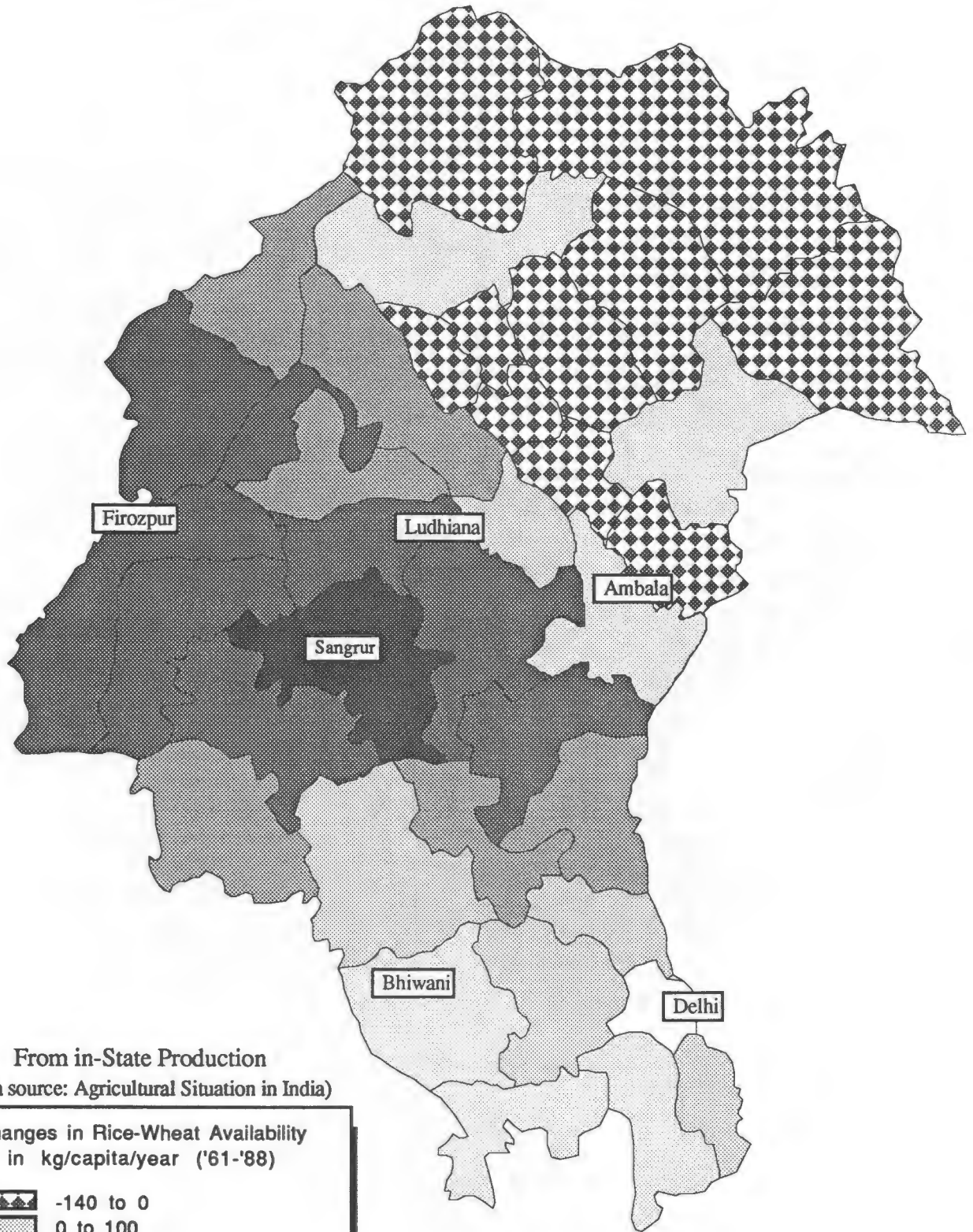


Data for 1988



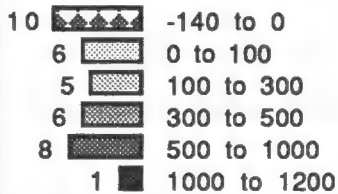
IRRI, CIMMYT, NARS '92 R&EH

Himachal Pradesh, Punjab, Haryana



From in-State Production
(data source: Agricultural Situation in India)

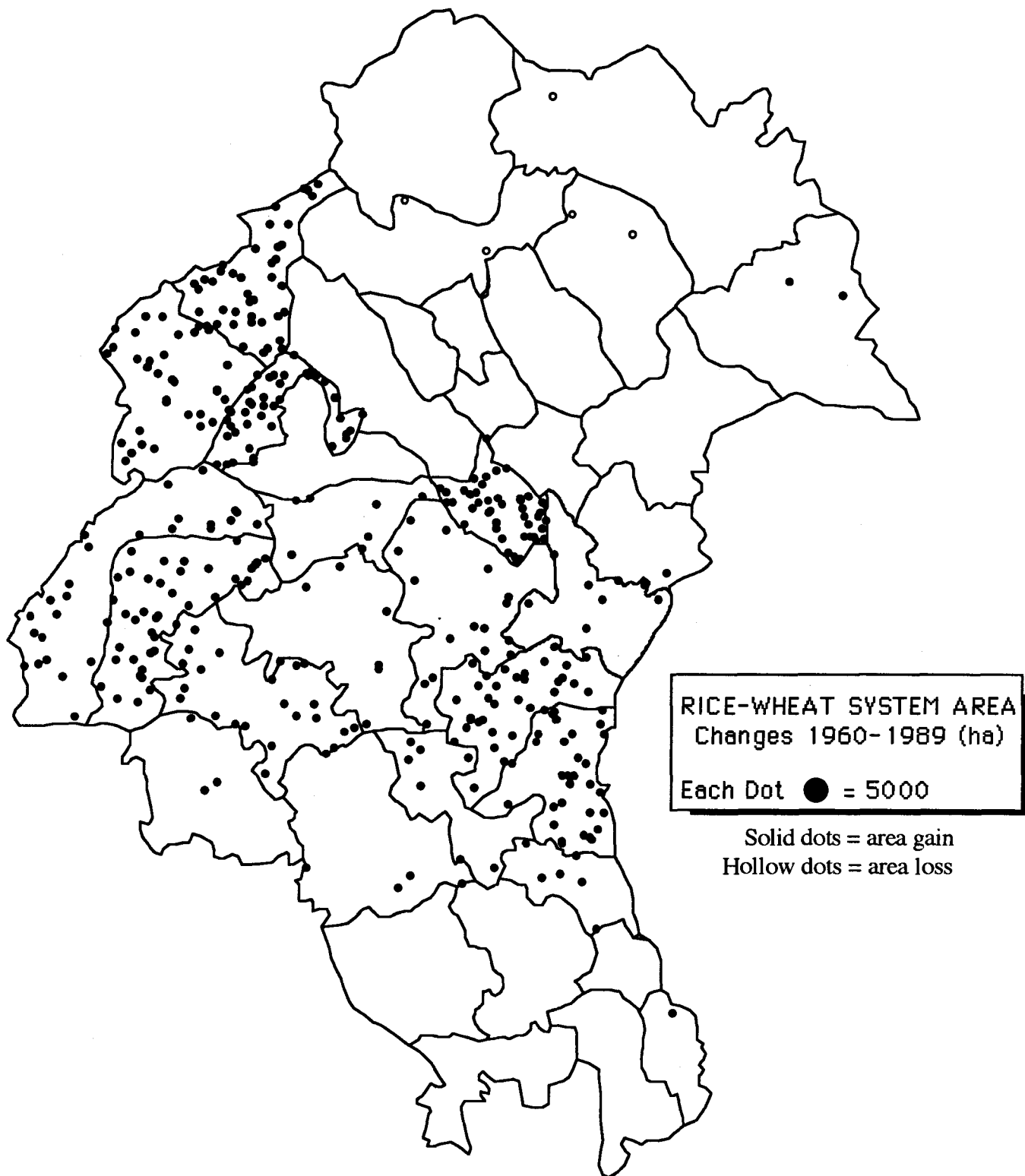
Changes in Rice-Wheat Availability
in kg/capita/year ('61-'88)



Availability in 1961 = 127kg/cap
Availability in 1988 = 450 kg/cap
Up 323 kg/capita

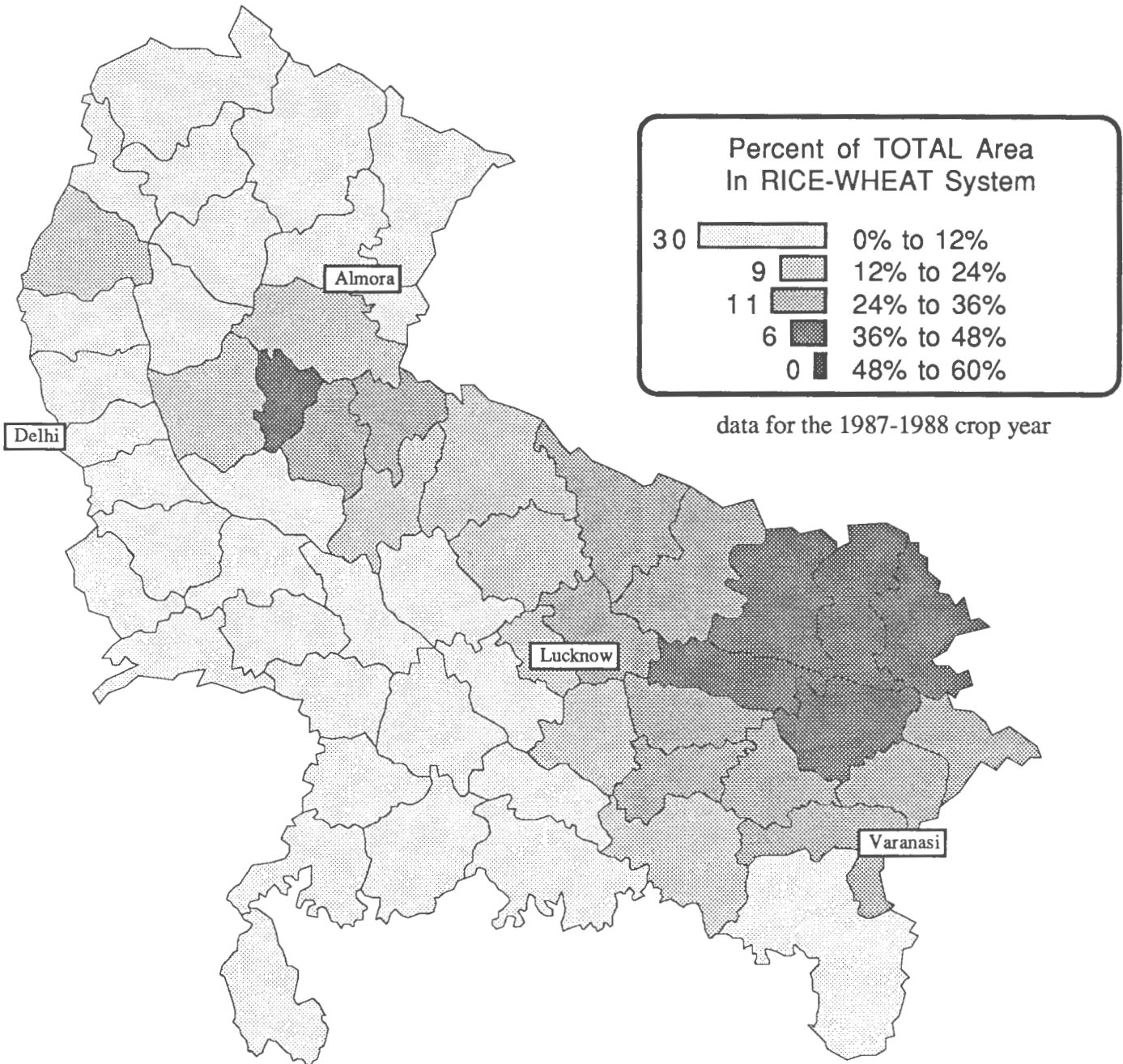
IRRI, CIMMYT, NARS '92 R&EH

Himachal Pradesh, Punjab, Haryana

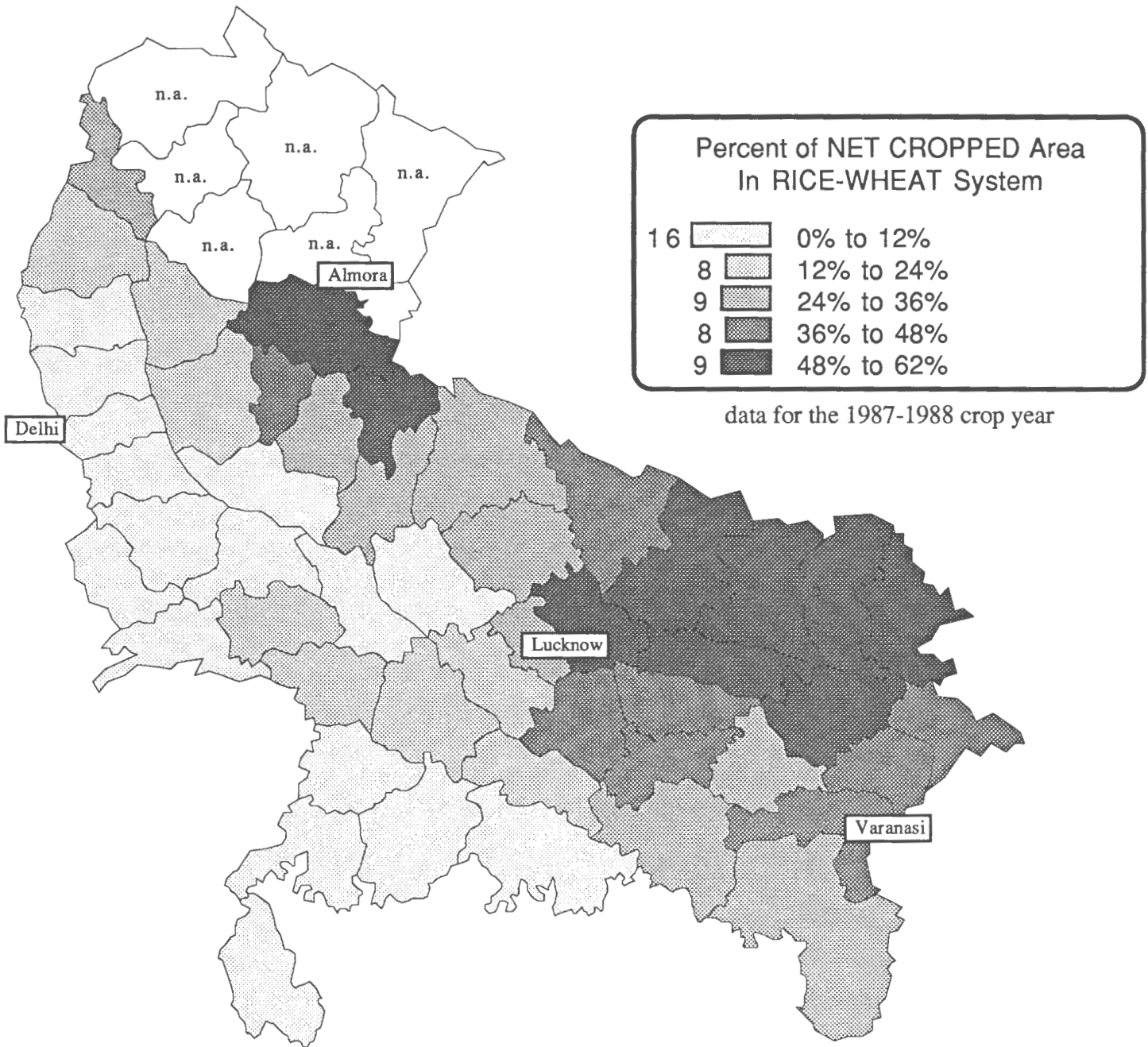


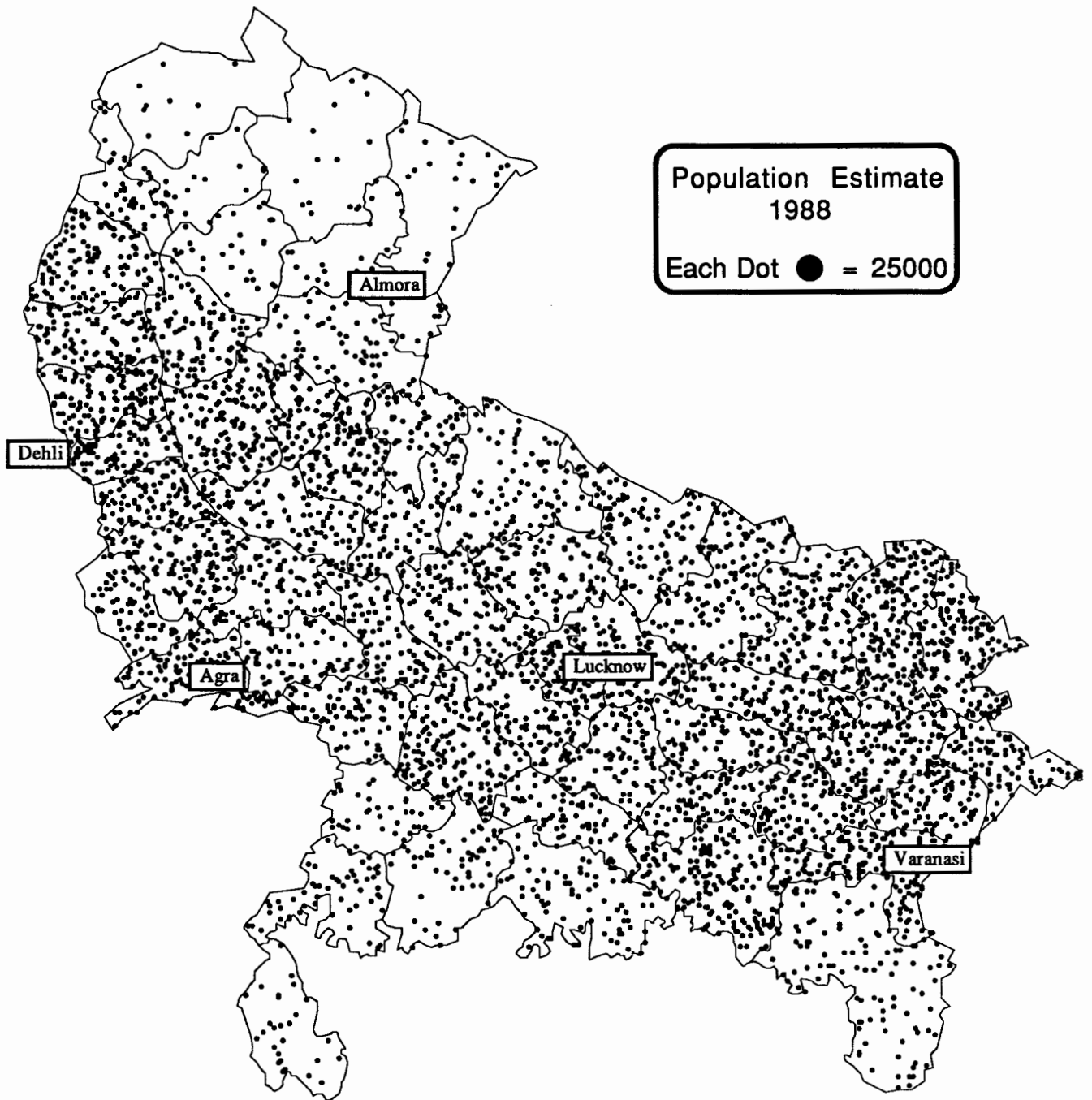
IRRI, CIMMYT, NARS '92 R&EH

UTTAR PRADESH



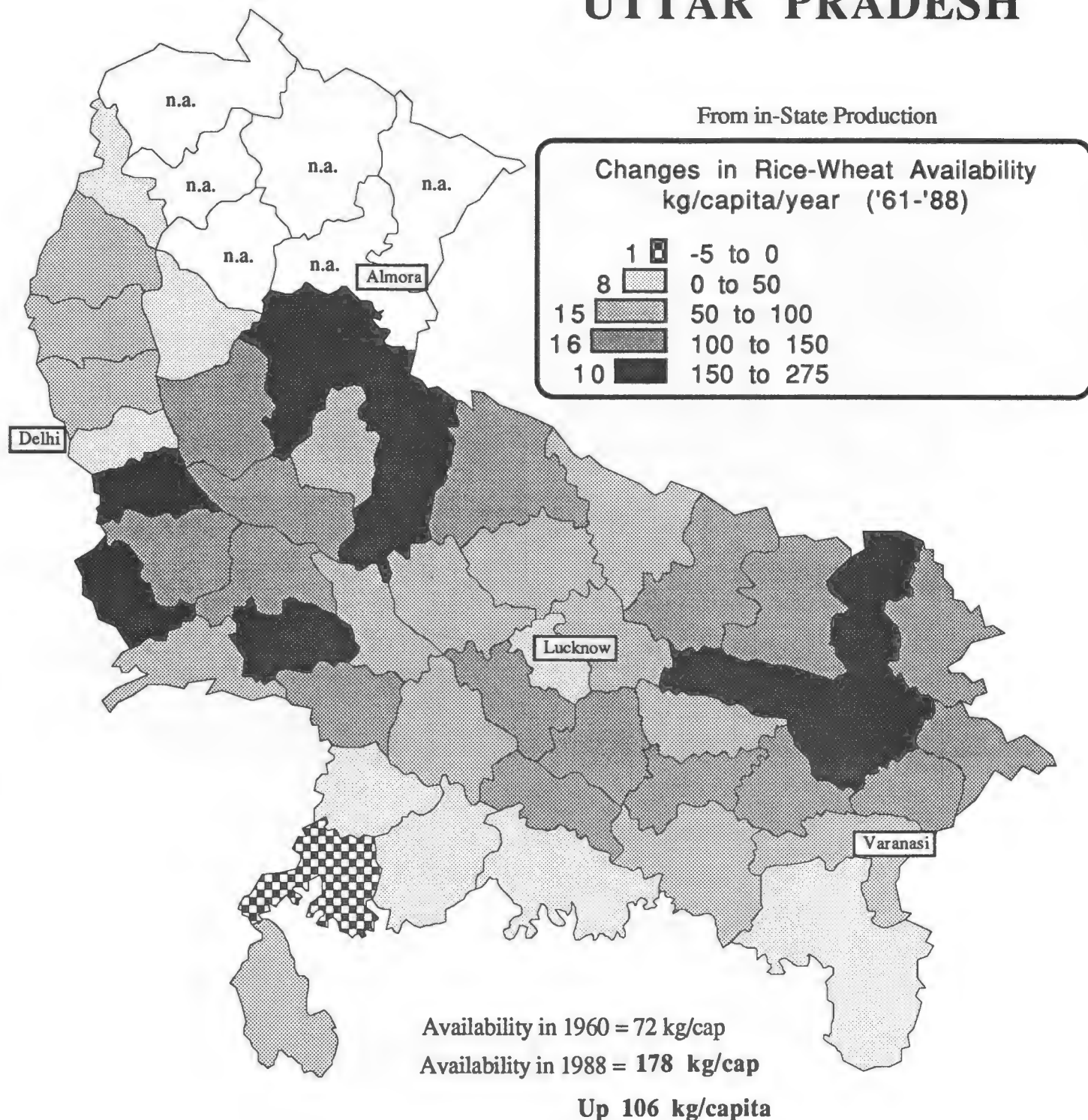
UTTAR PRADESH





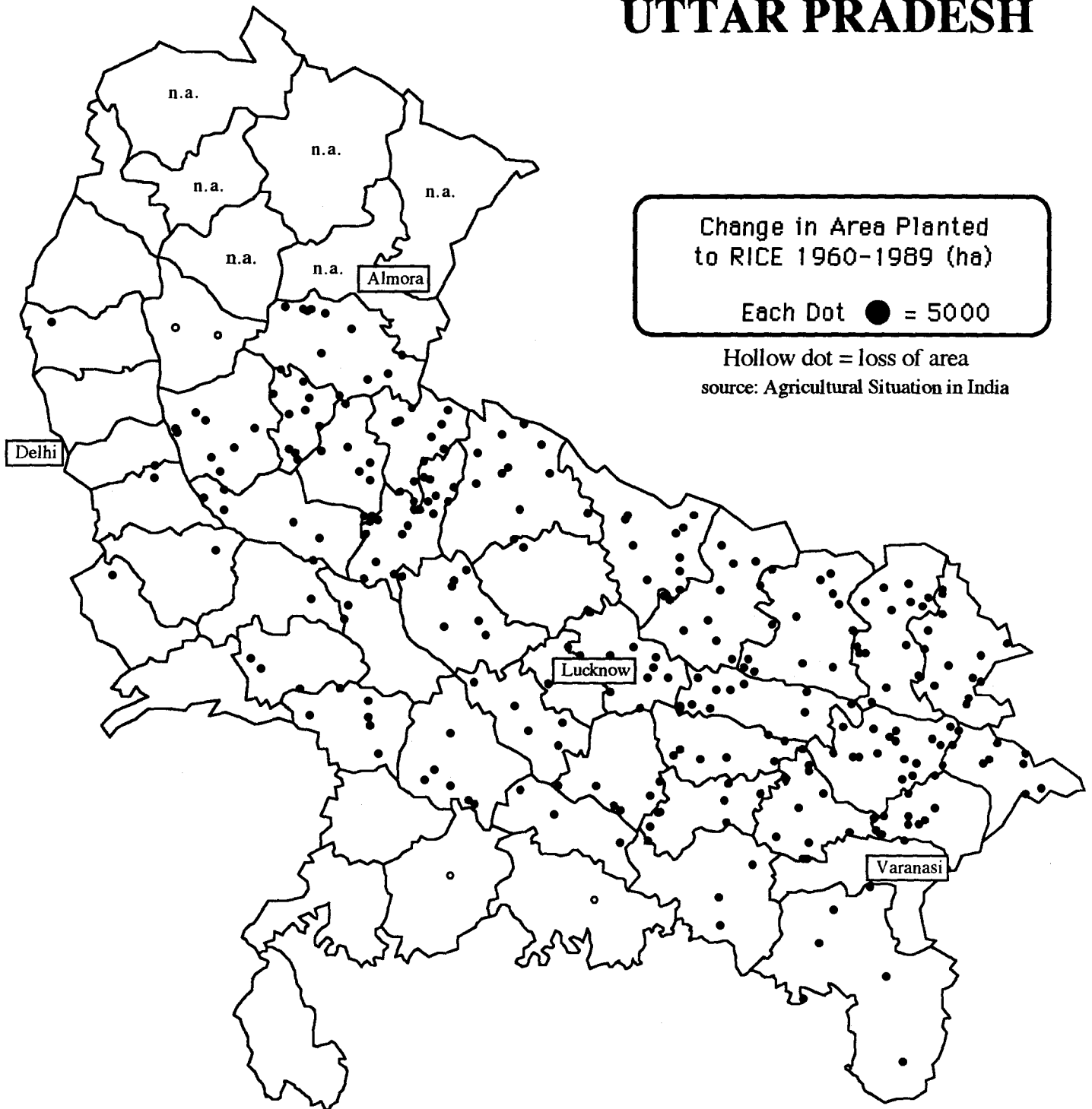
UTTAR PRADESH

UTTAR PRADESH

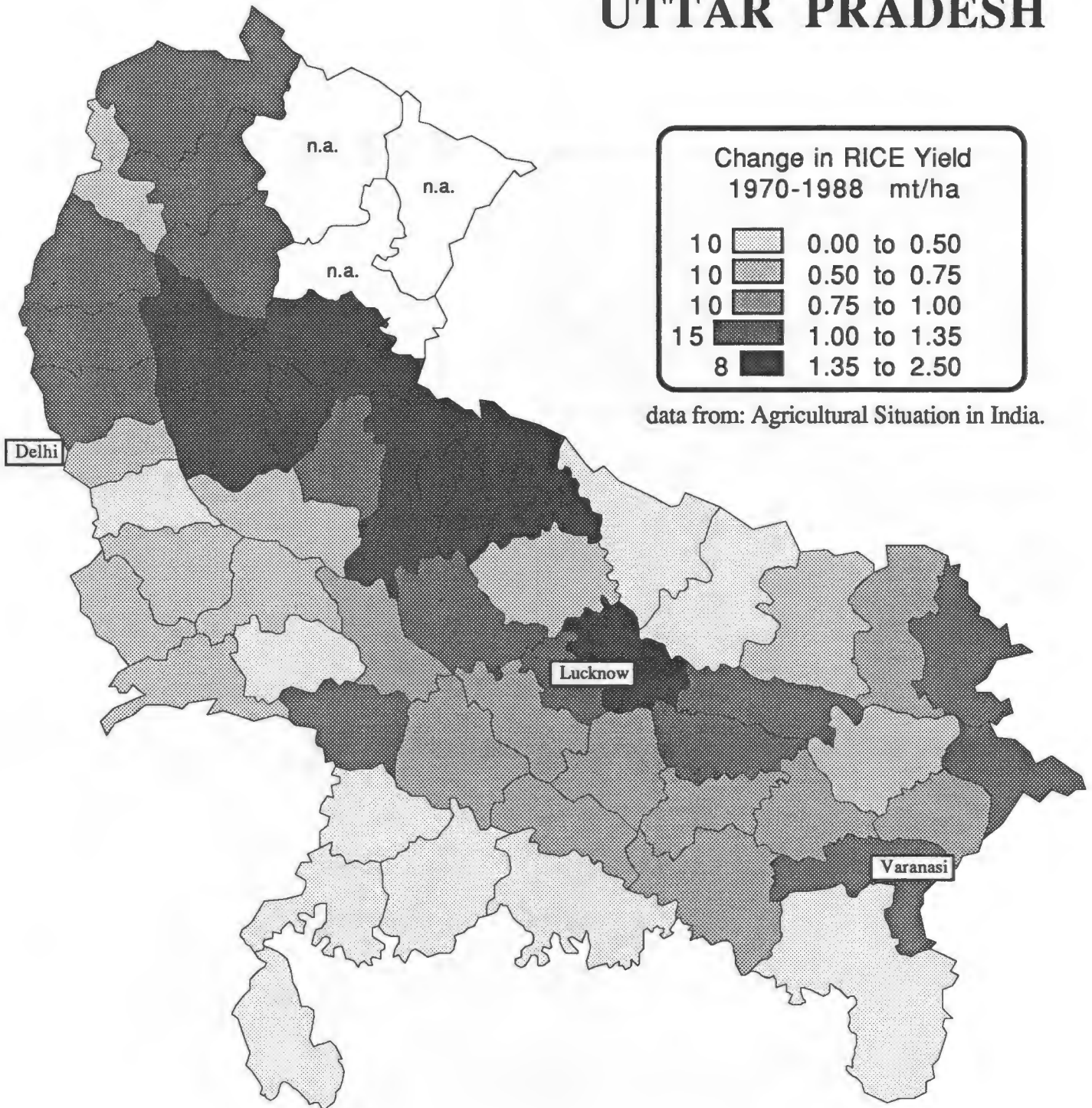


IRRI, CIMMYT, NARS '92 R&EH

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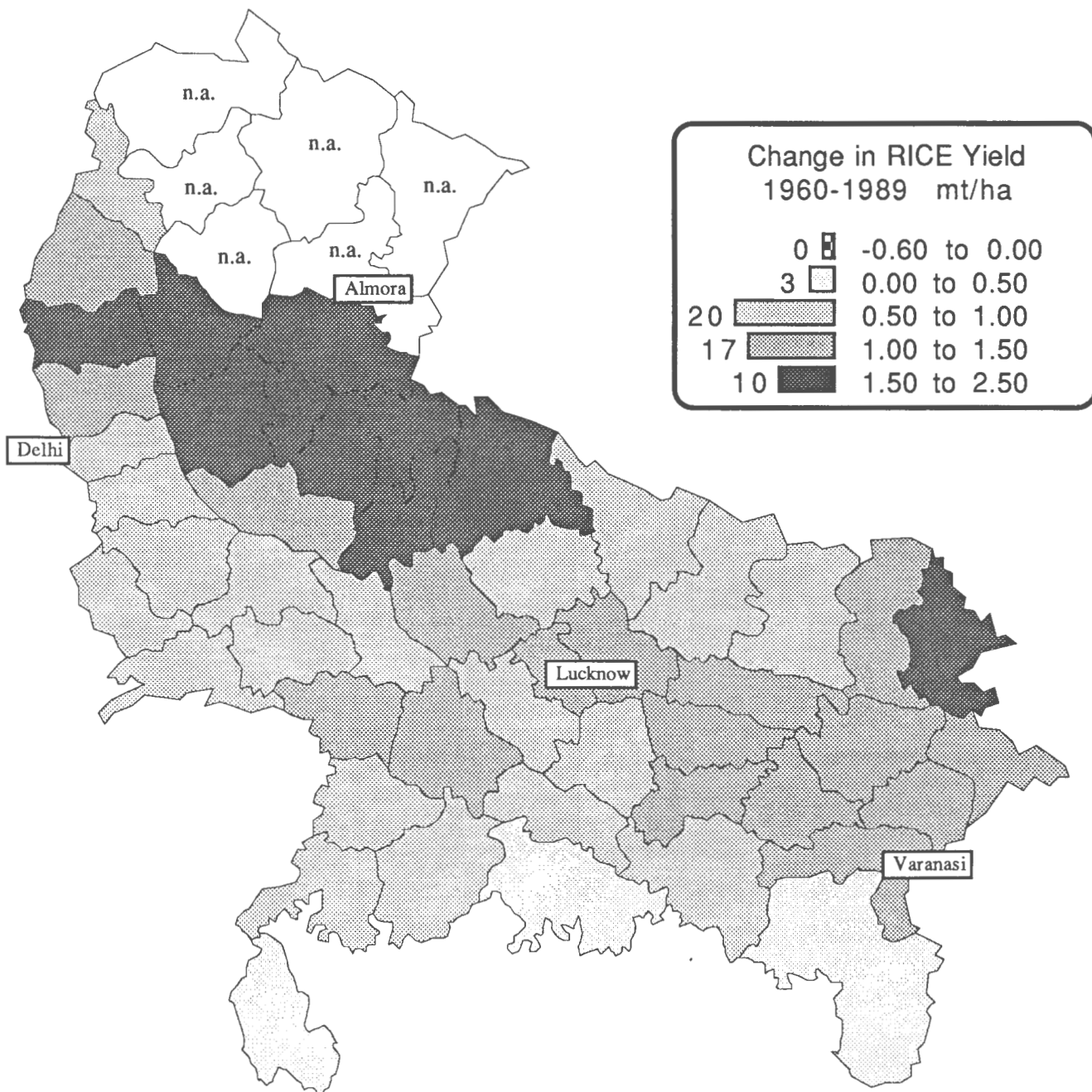


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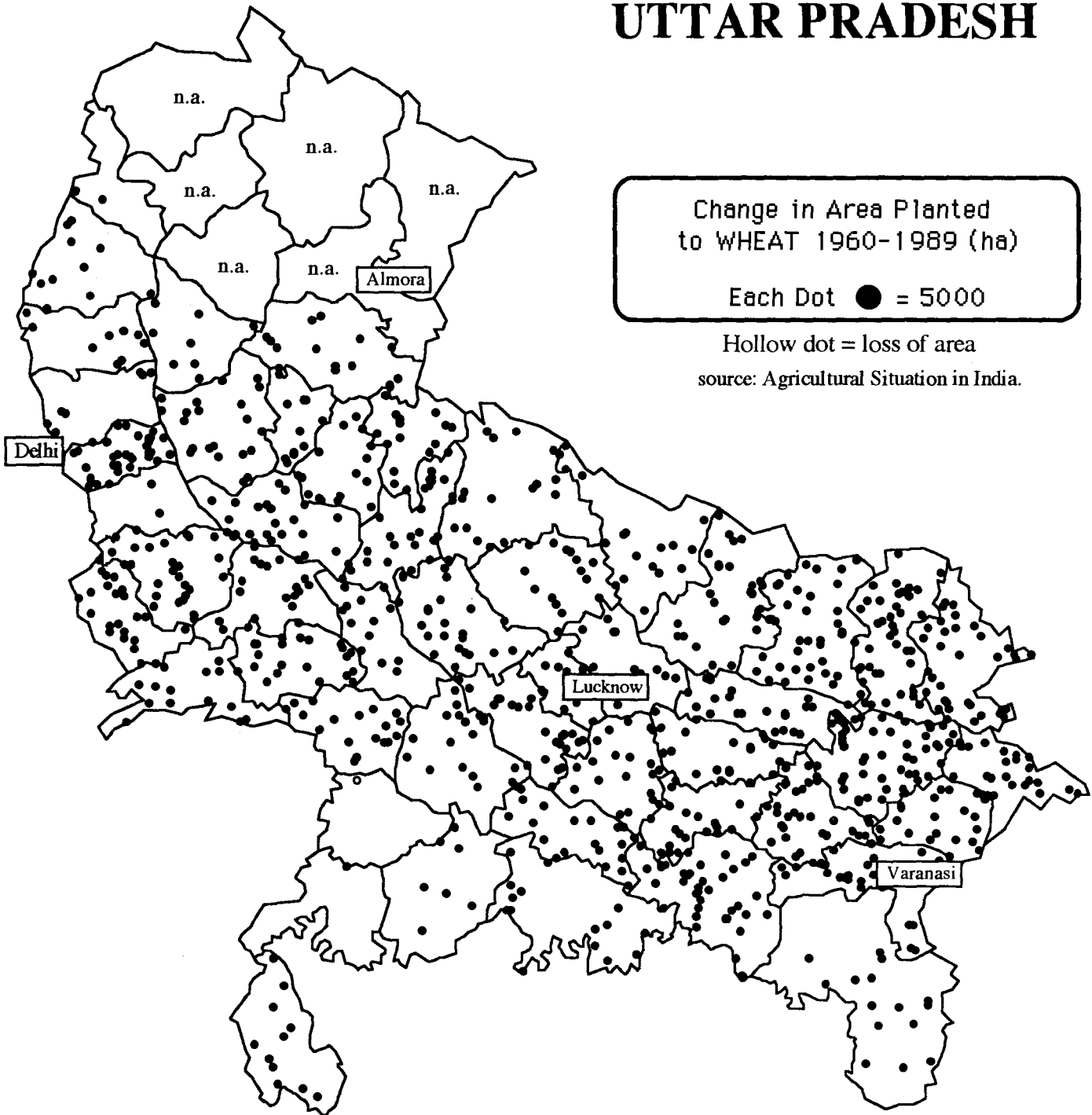


IRRI, CIMMYT, NARS '92 R&EH

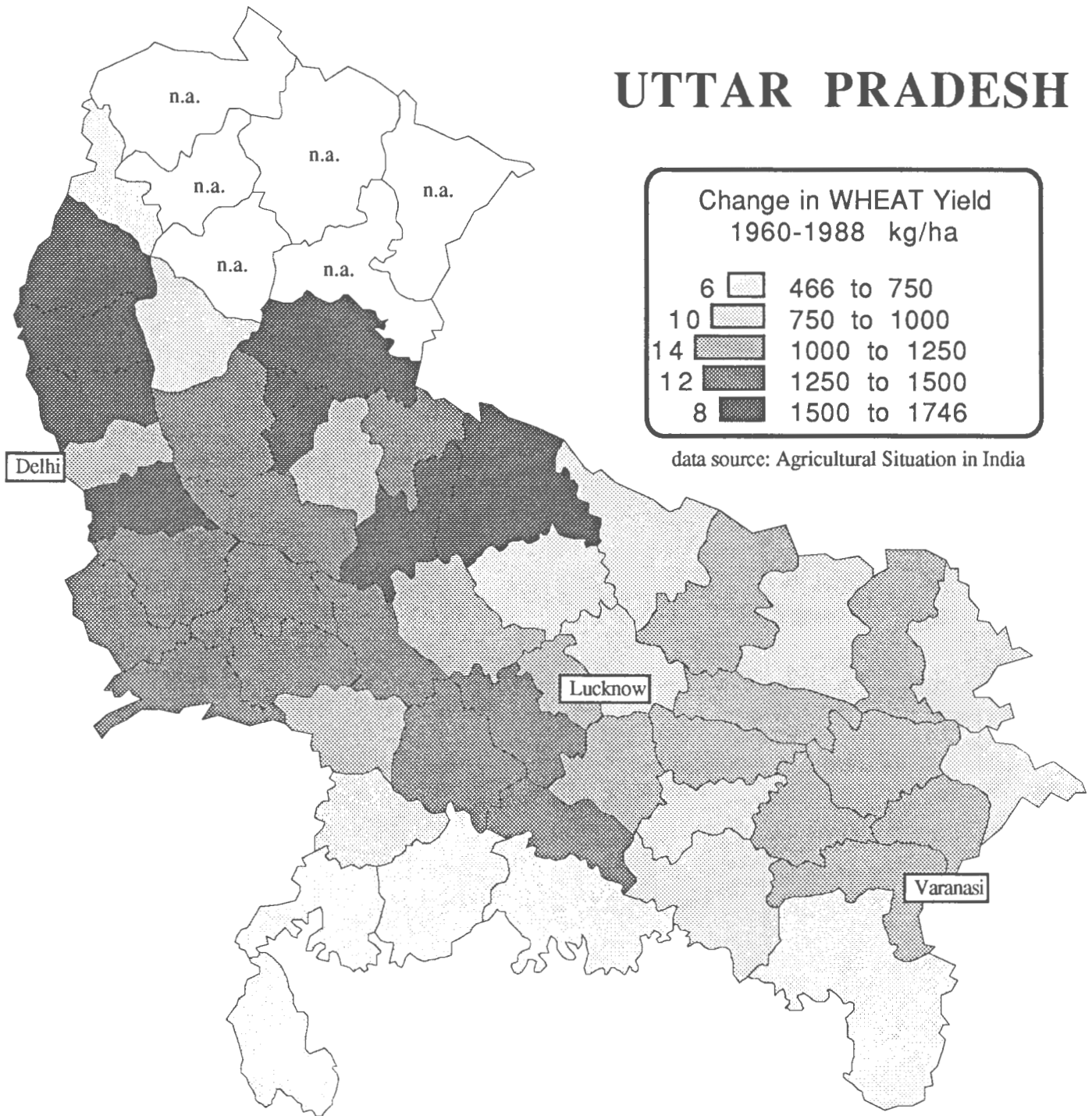
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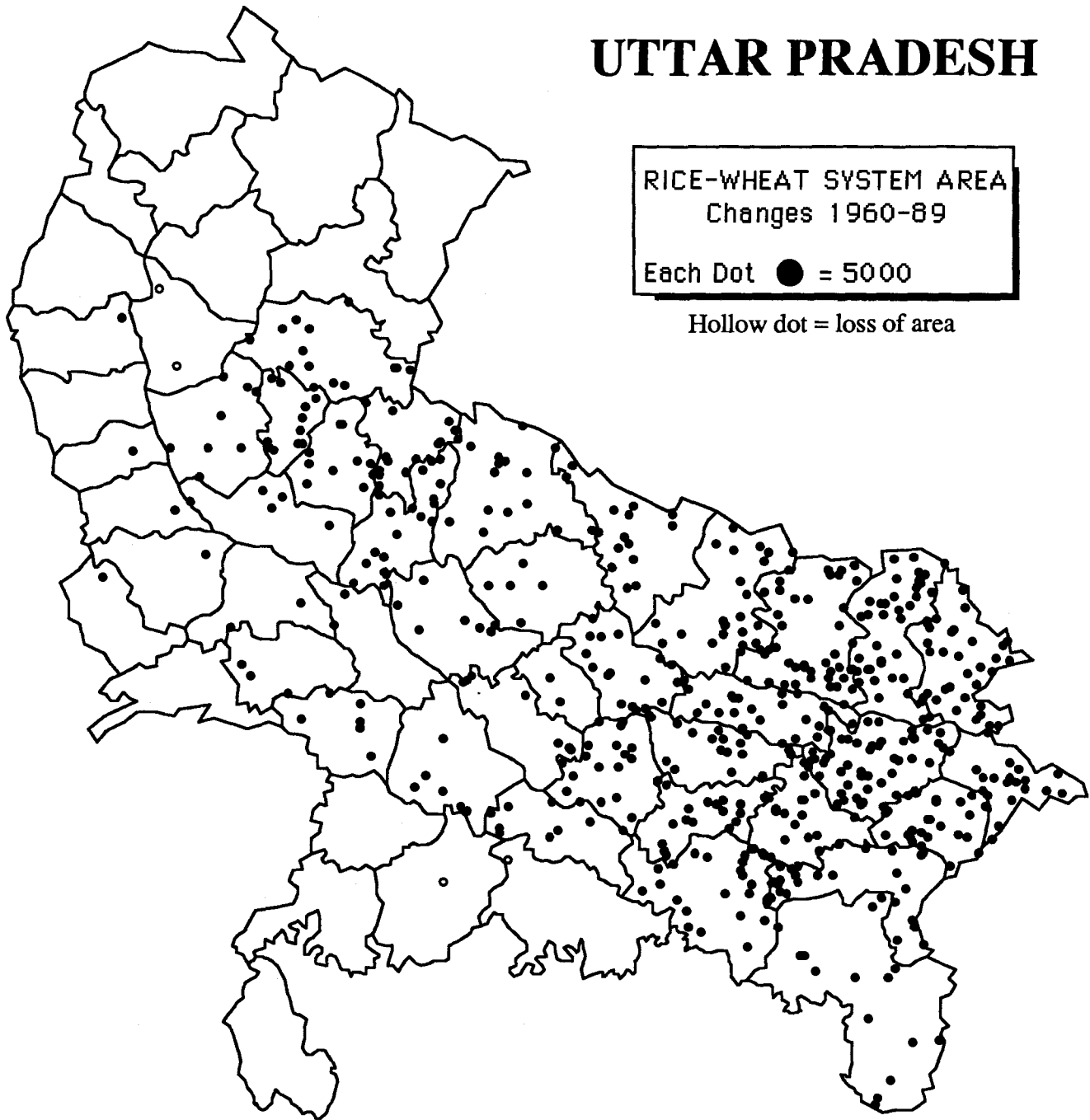
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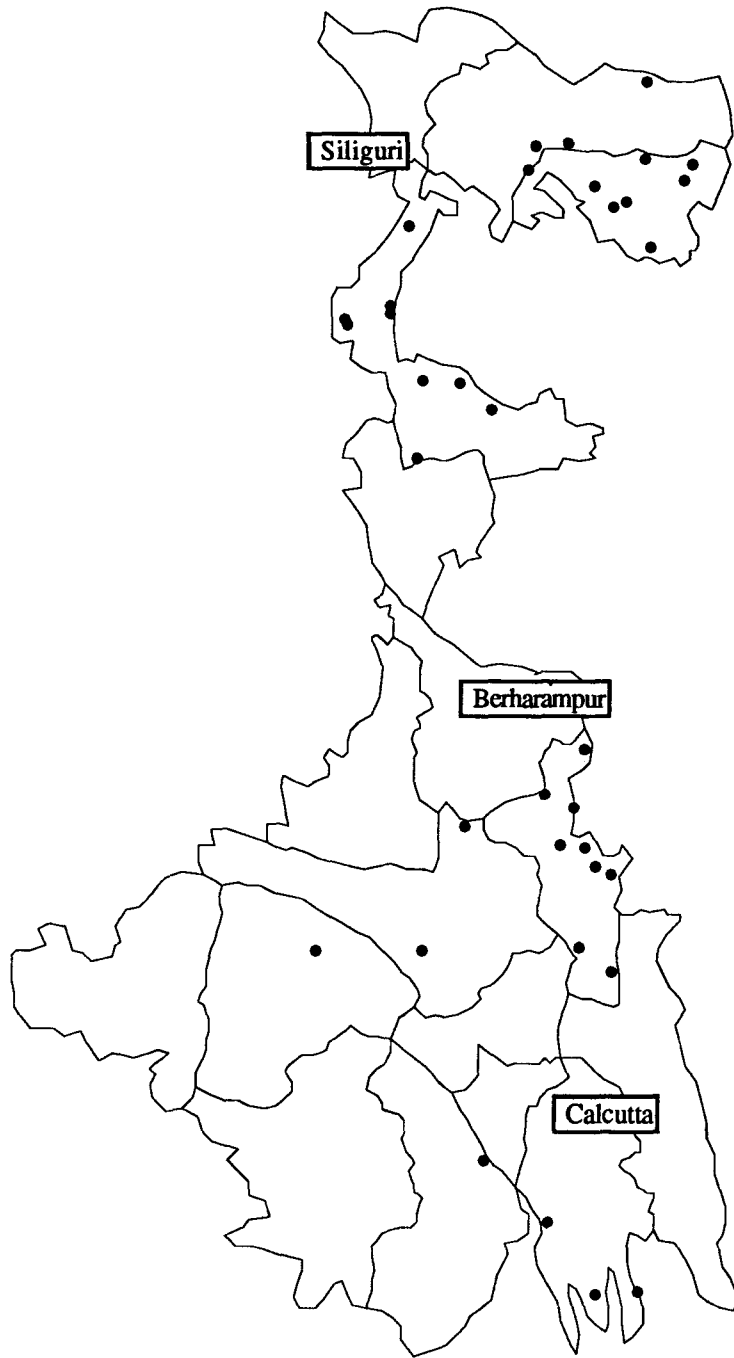
UTTAR PRADESH



UTTAR PRADESH



IRRI, CIMMYT, NARS '92 R&EH

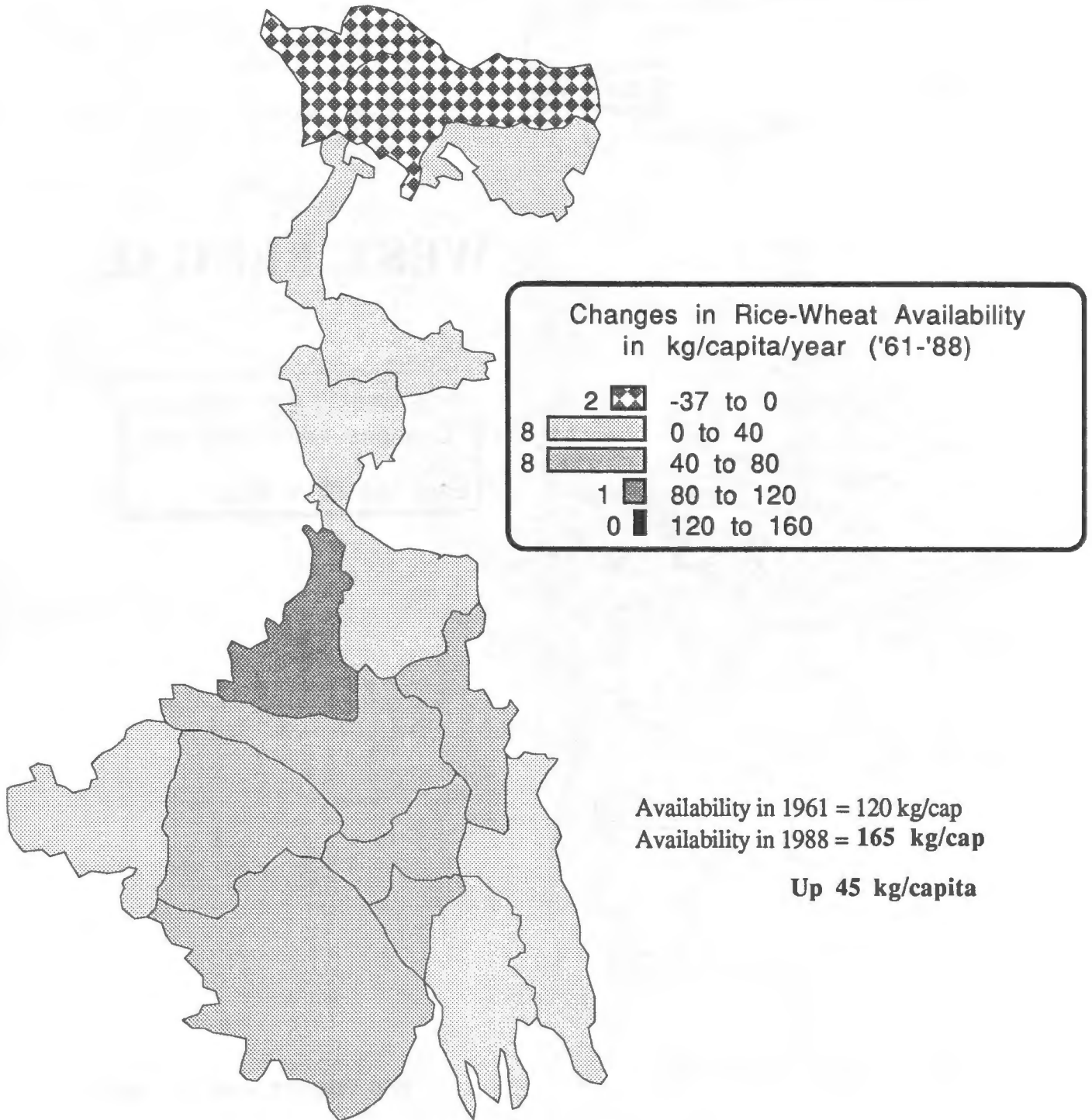


WEST BENGAL

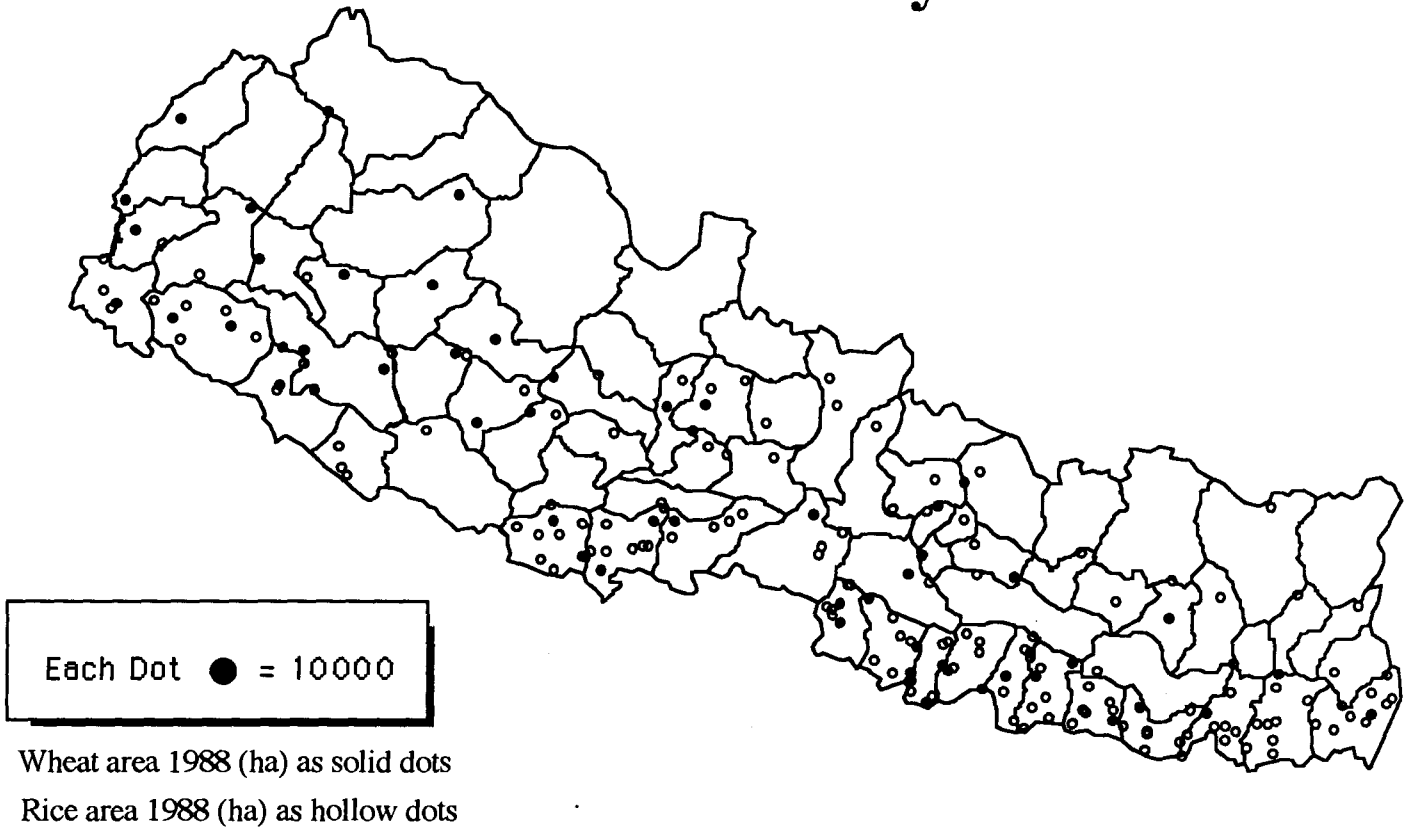
RICE-WHEAT SYSTEM AREA
Changes 1960-1988 (ha)

Each Dot ● = 5000

WEST BENGAL



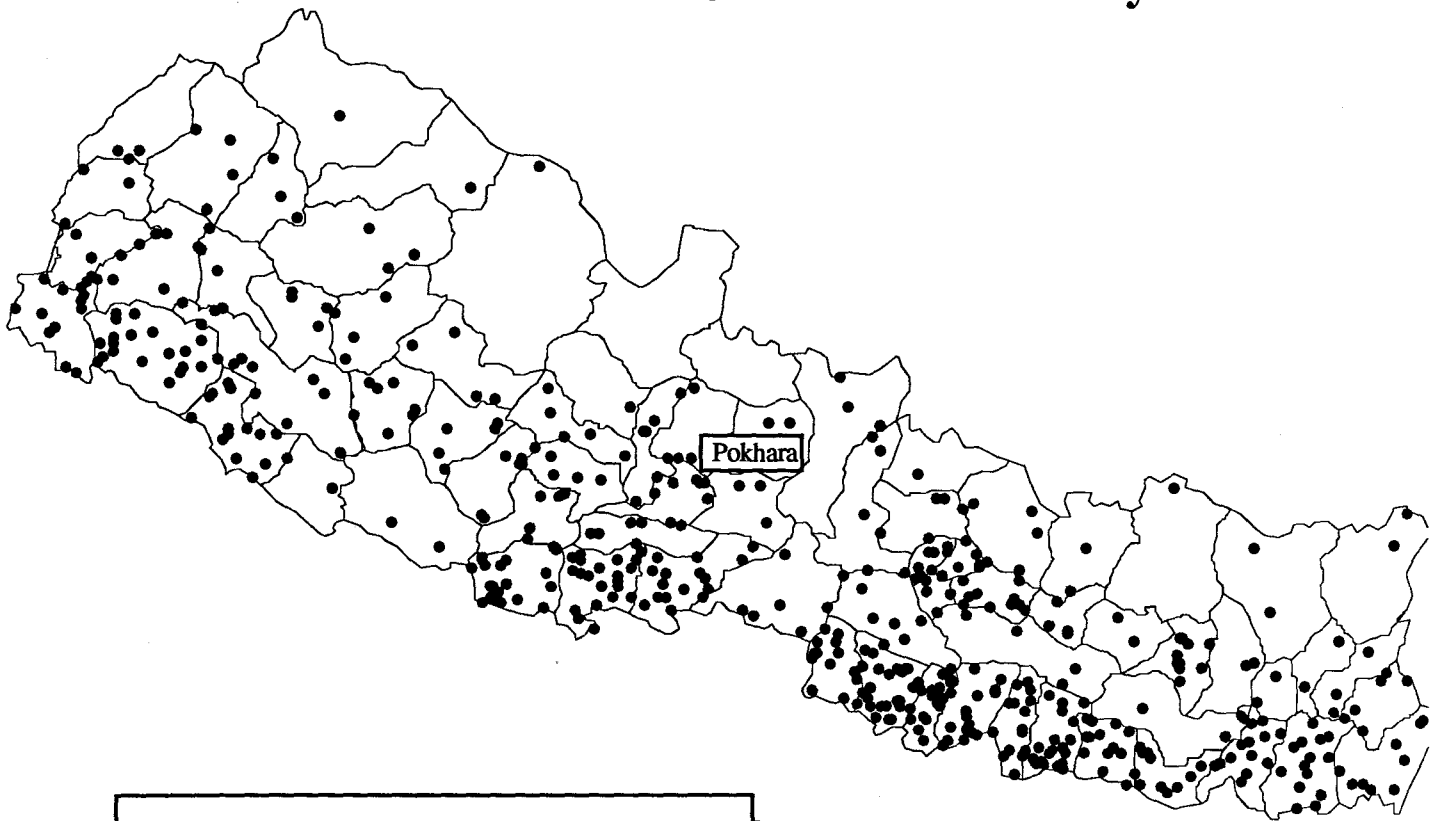
NEPAL - by District



IRRI, CIMMYT, NARS '92 R&EH

NEPAL - by District

Domestic Rice-Wheat System

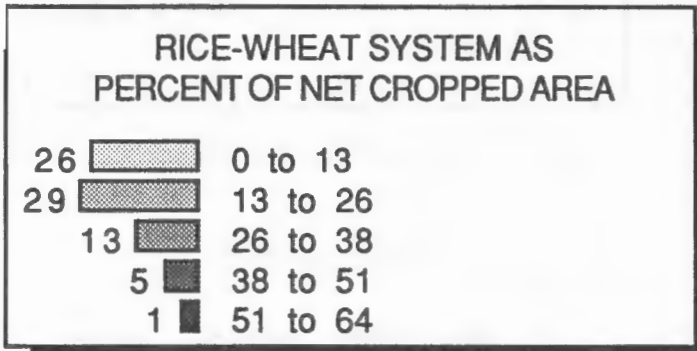
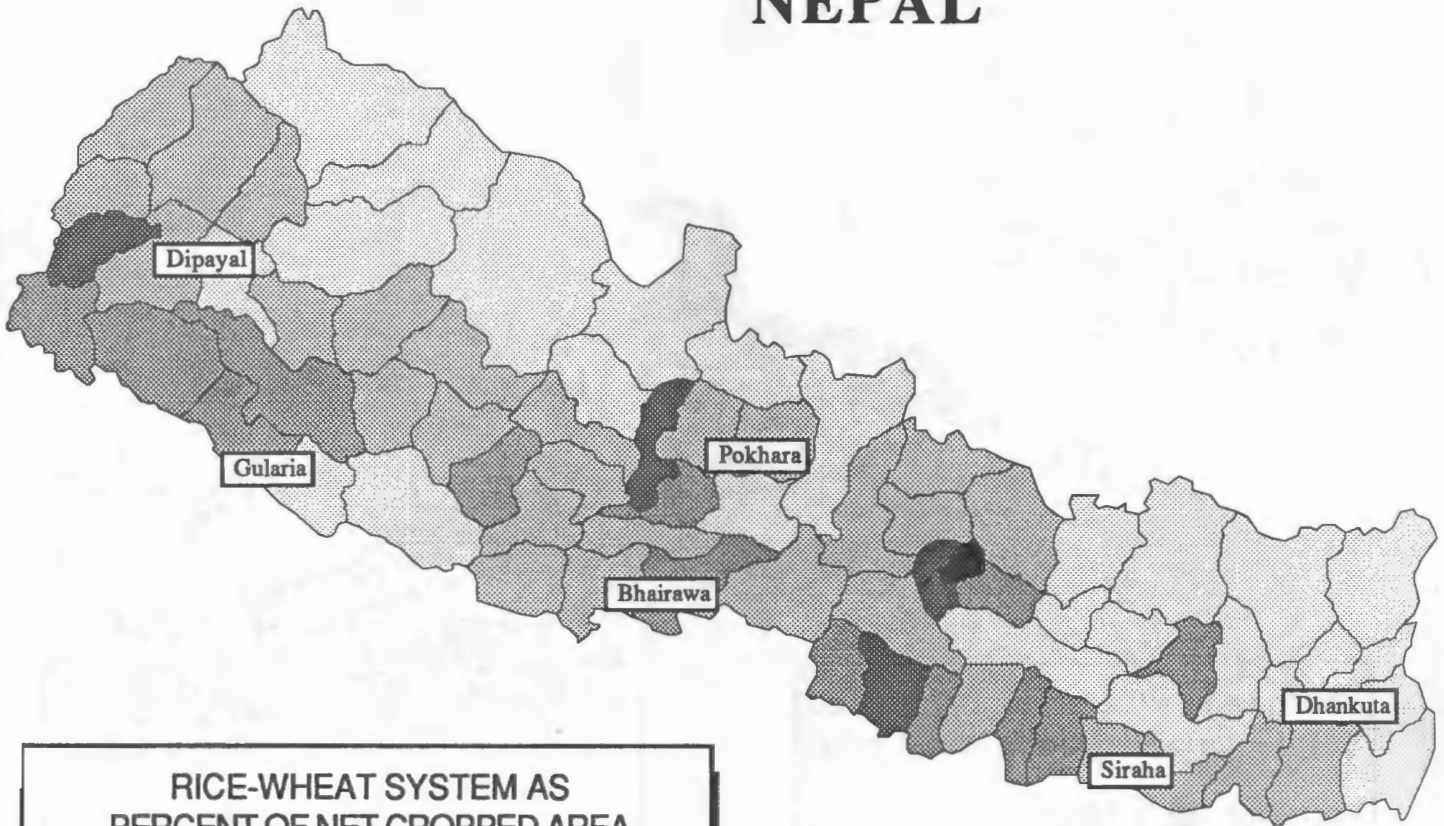


AREA IN RICE-WHEAT (ha)
1988
Each Dot ● = 1000

data source: Agricultural Statistics of Nepal 1990

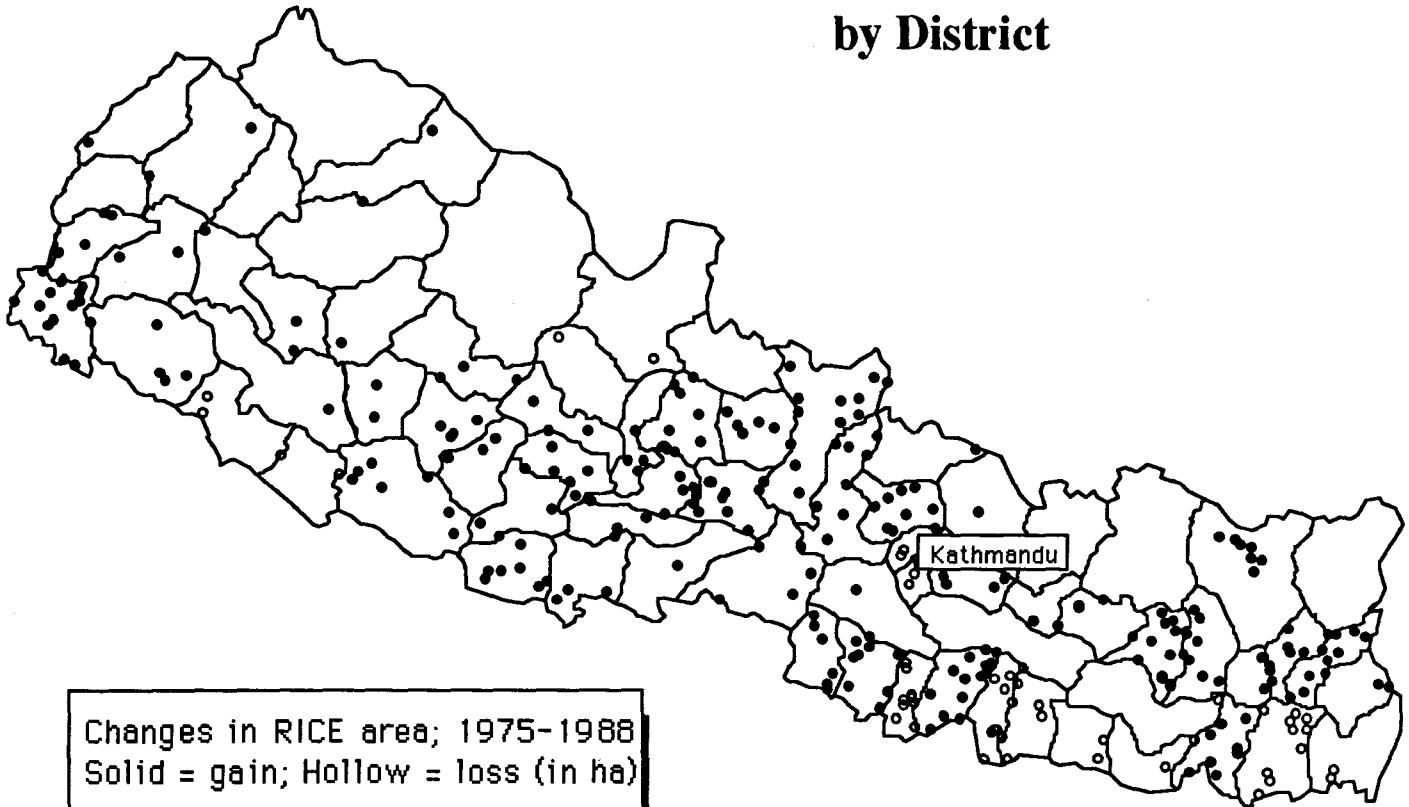
IRRI, CIMMYT, NARS '92 R&EH

NEPAL



data source: Agricultural Statistics of Nepal 1990,
Ministry of Agriculture, Lalitpur, Nepal.

NEPAL by District



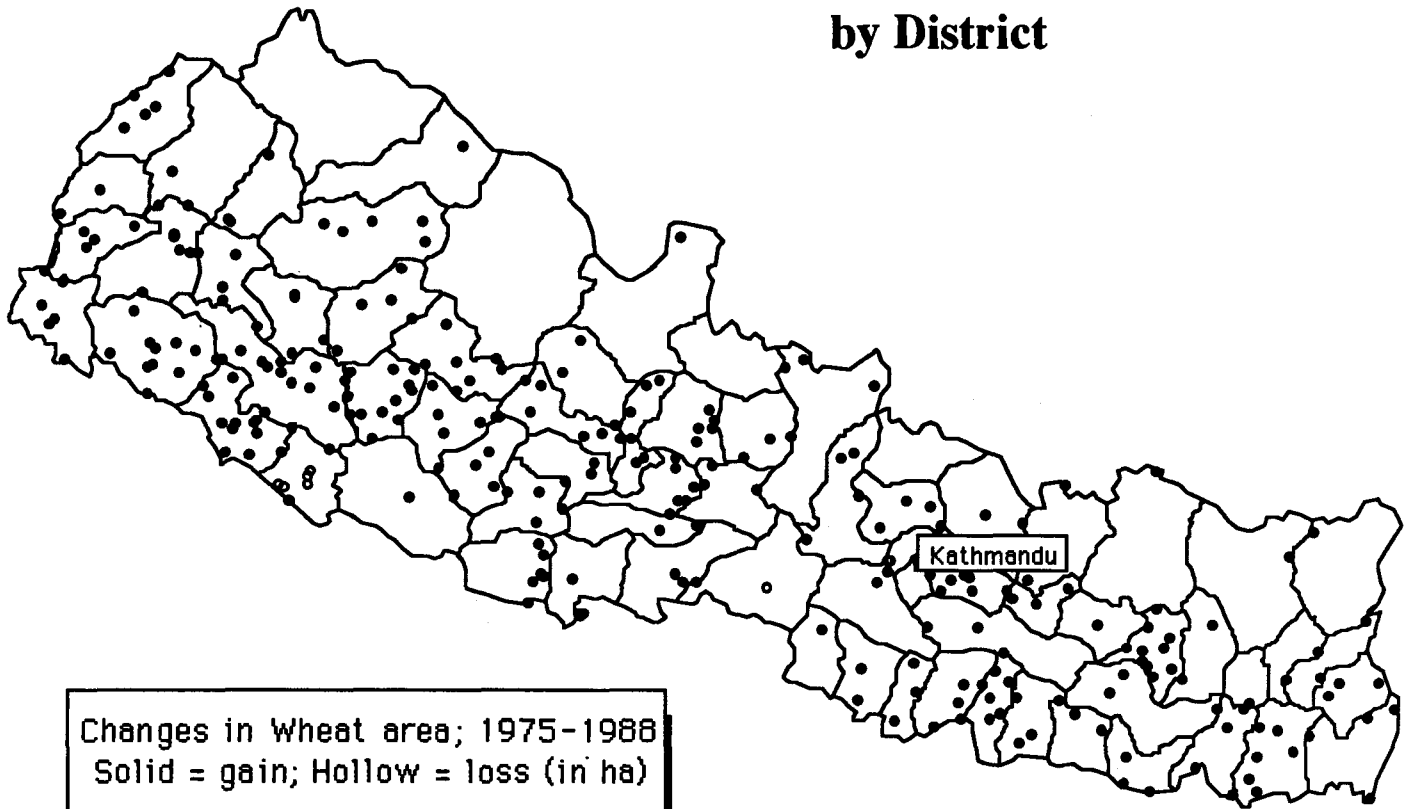
Changes in RICE area; 1975-1988
Solid = gain; Hollow = loss (in ha)

Each Dot ● = 1000

Source: Agricultural Statistics of Nepal 1990

IRRI, CIMMYT, NARS '92 R&EH

NEPAL by District

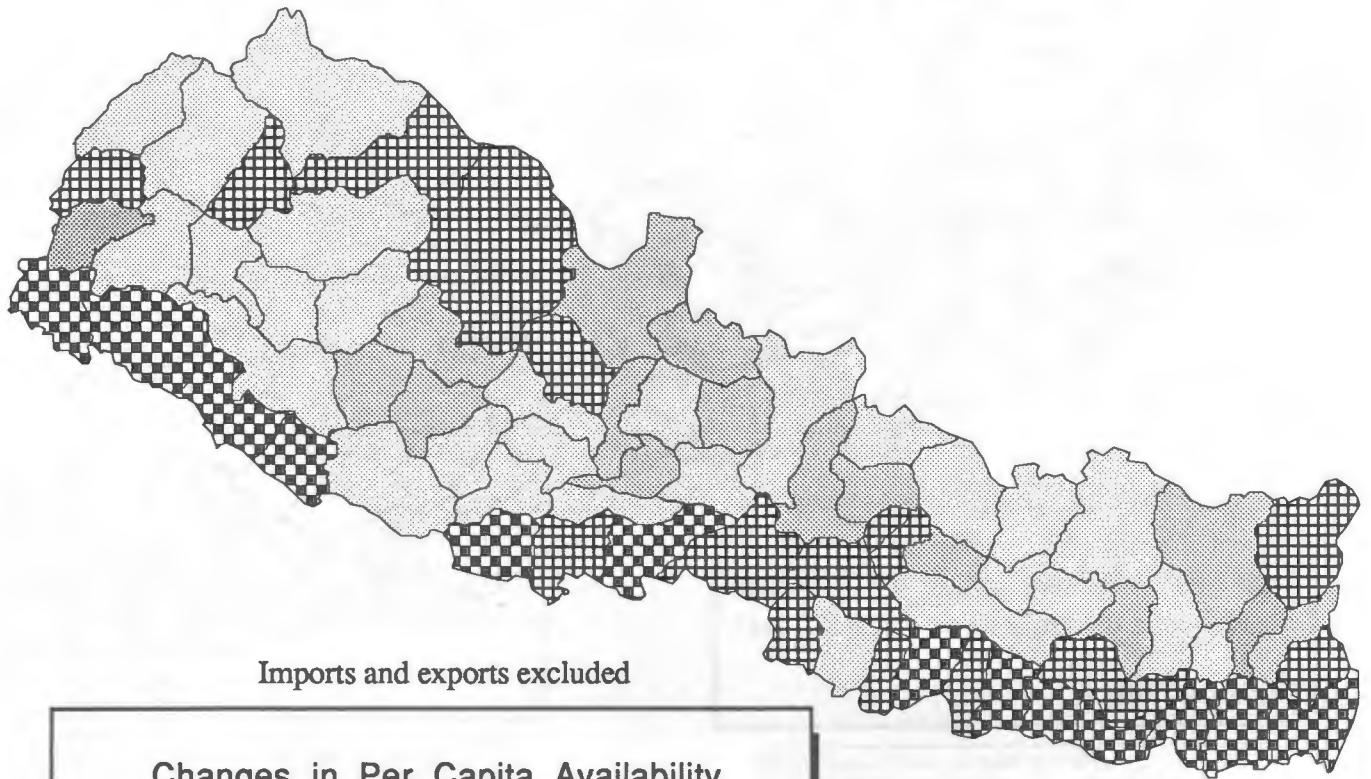


Changes in Wheat area; 1975-1988
Solid = gain; Hollow = loss (in ha)
Each Dot ● = 1000

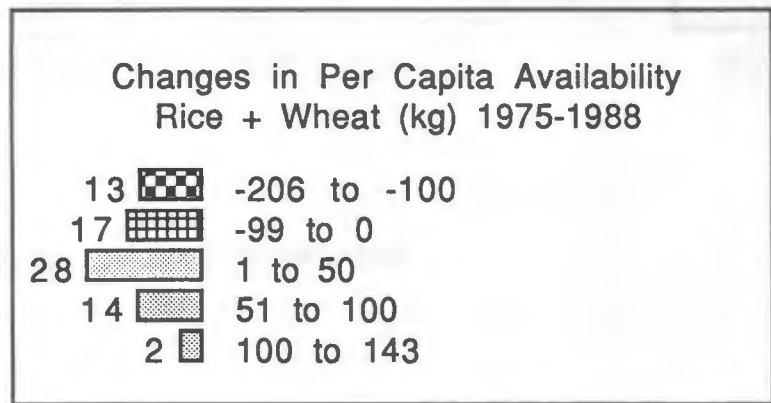
Source: Agricultural Statistics of Nepal 1990

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NEPAL - by District



Imports and exports excluded



source: Agricultural Statistics of Nepal 1990

Per capita availability 1975 = 156kg

Per capita availability 1988 = 136kg

Down 20 kg/capita

NEPAL



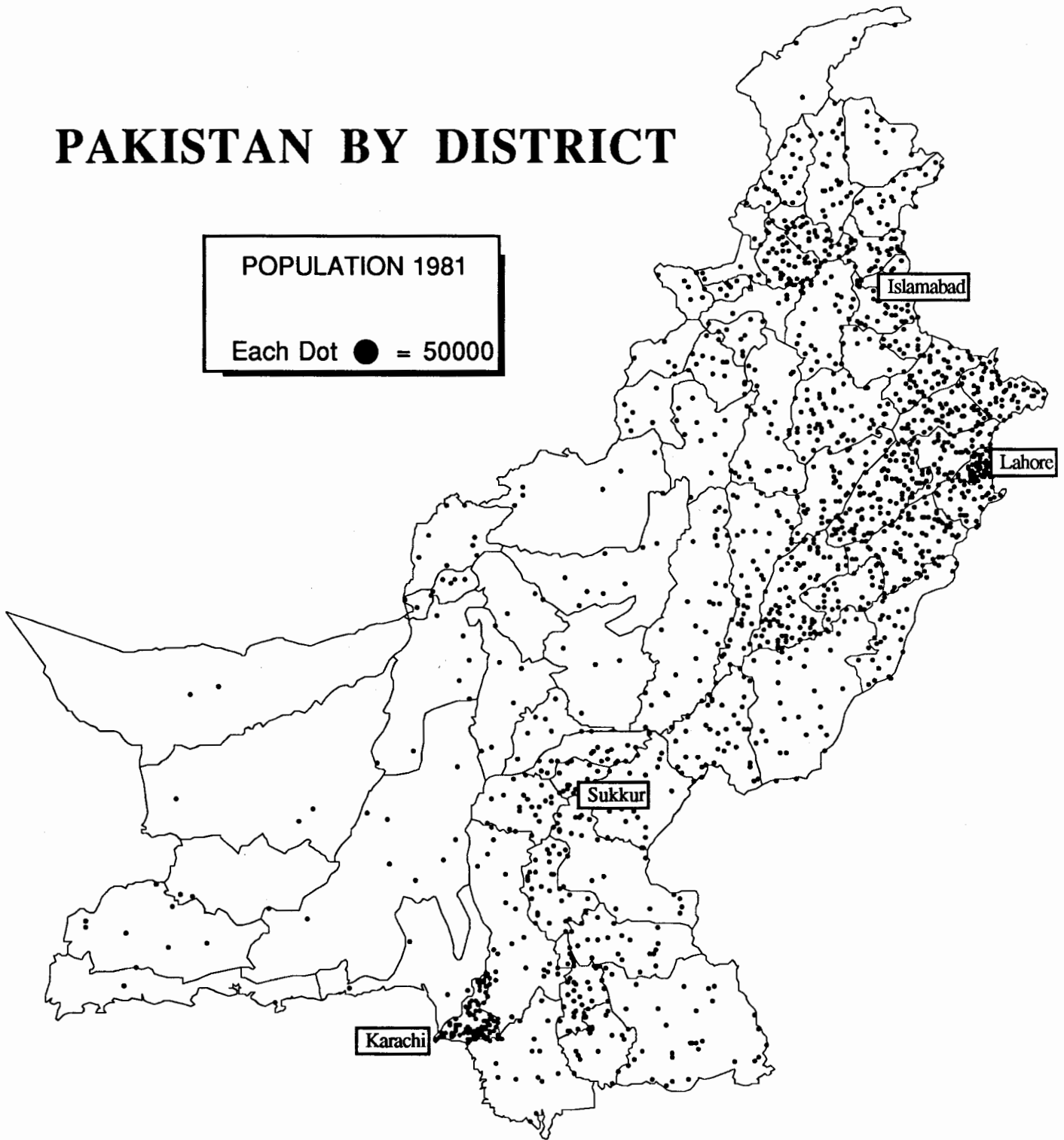
RICE-WHEAT SYSTEM AREA
Changes 1975-1988 (ha)
Each Dot ● = 5000

IRRI, CIMMYT, NARS '92 R&EH

PAKISTAN BY DISTRICT

POPULATION 1981

Each Dot ● = 50000

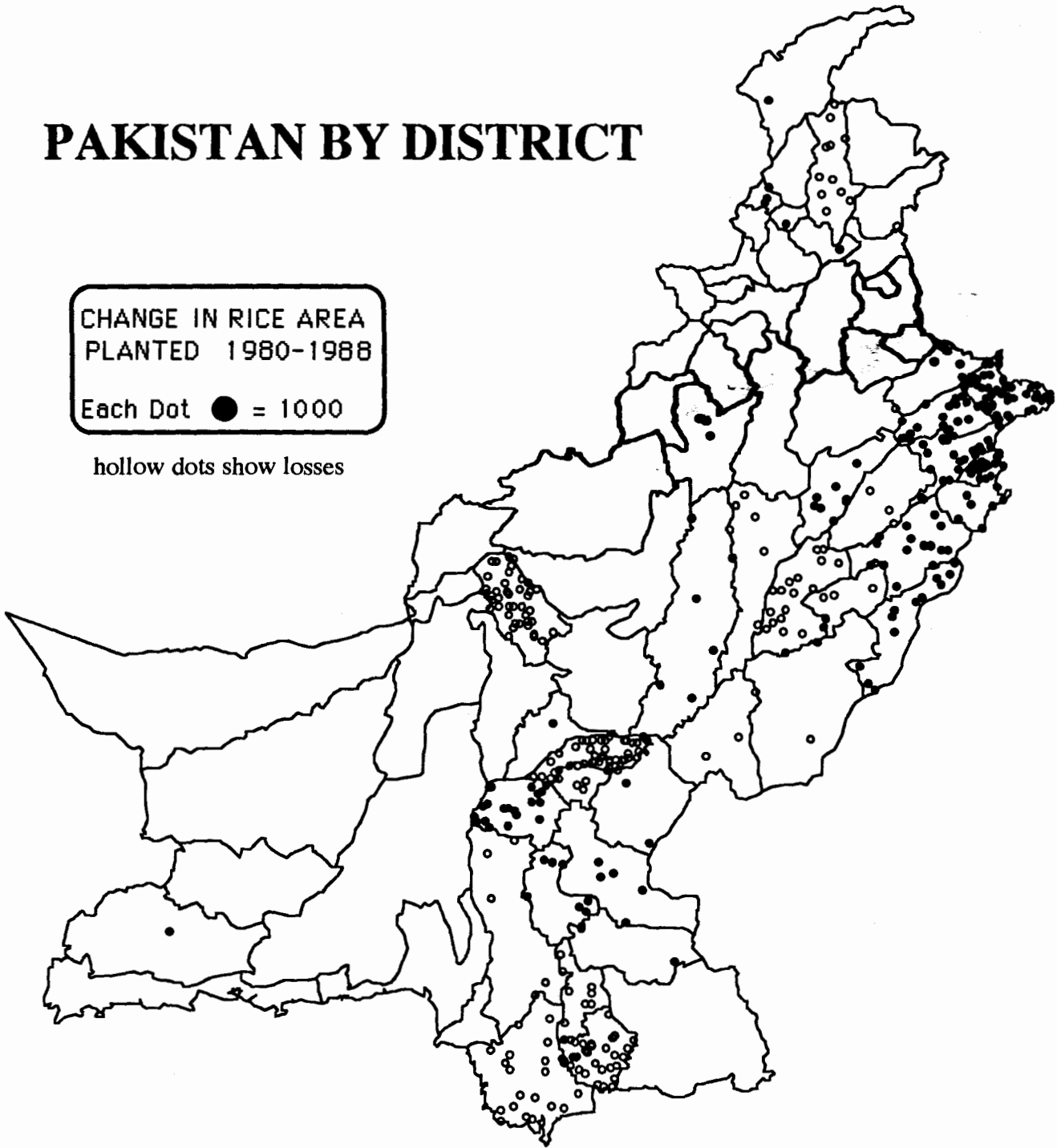


PAKISTAN BY DISTRICT

CHANGE IN RICE AREA
PLANTED 1980-1988

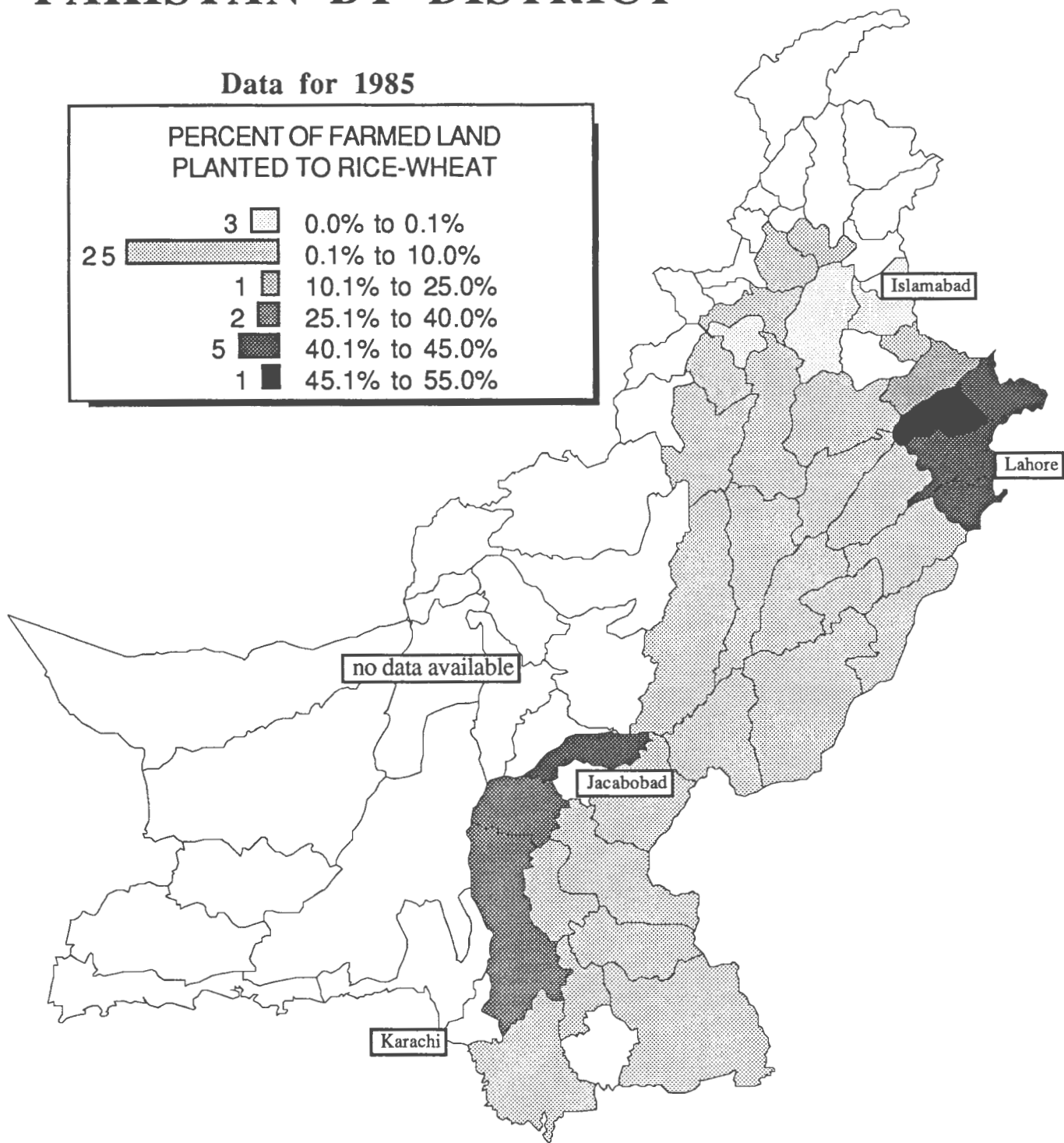
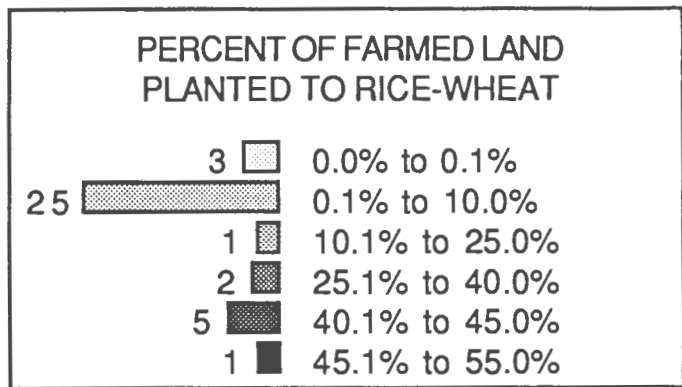
Each Dot ● = 1000

hollow dots show losses

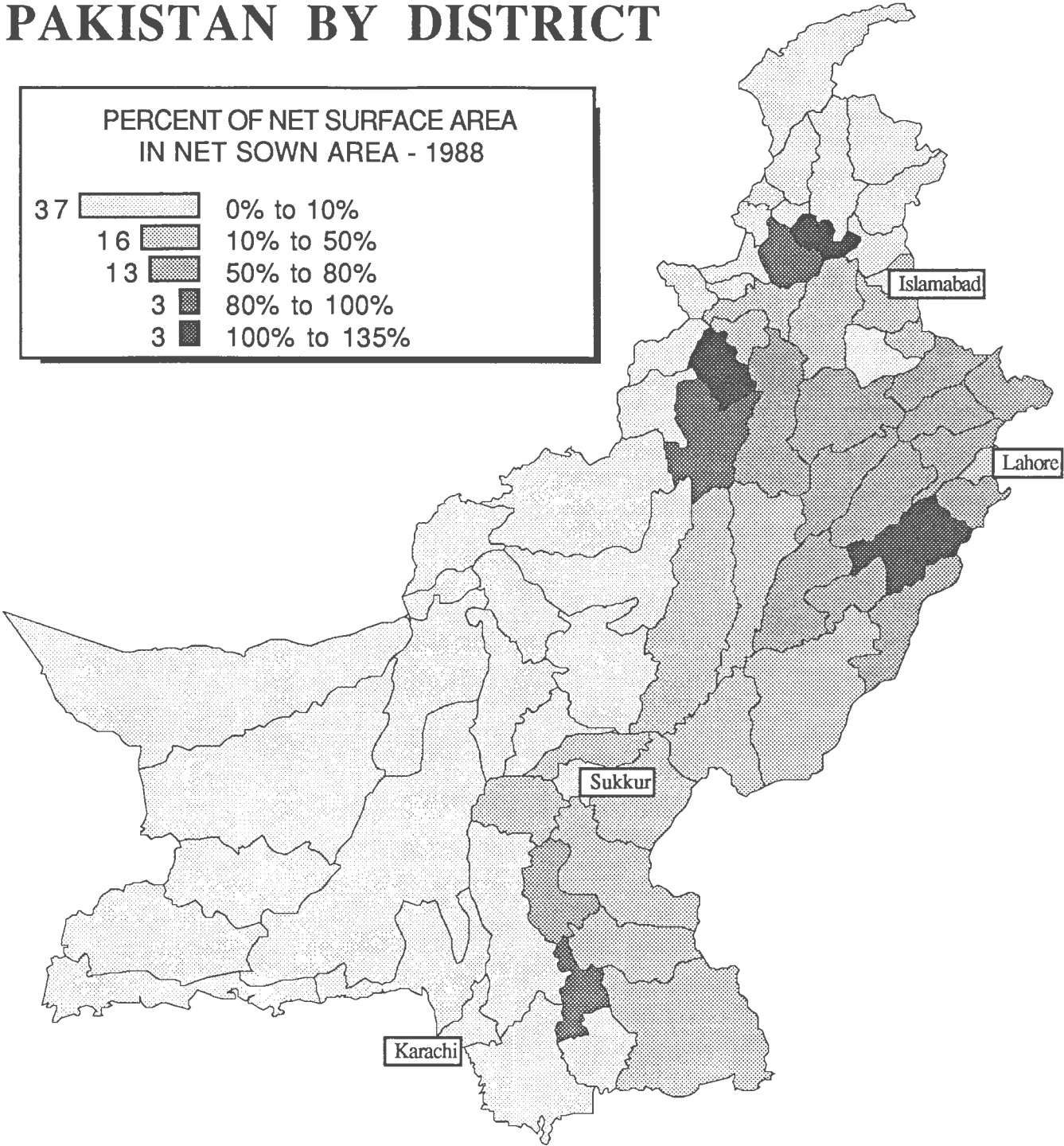
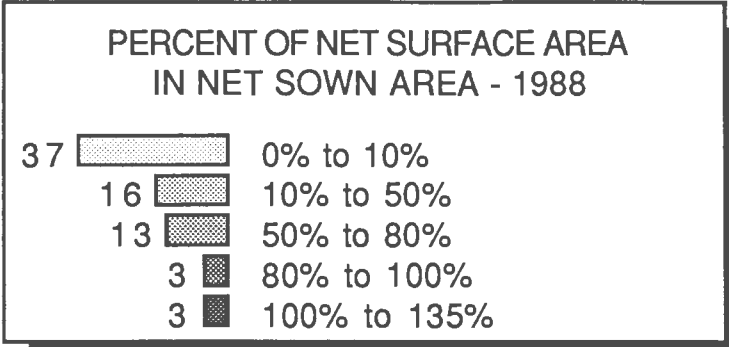


PAKISTAN BY DISTRICT

Data for 1985

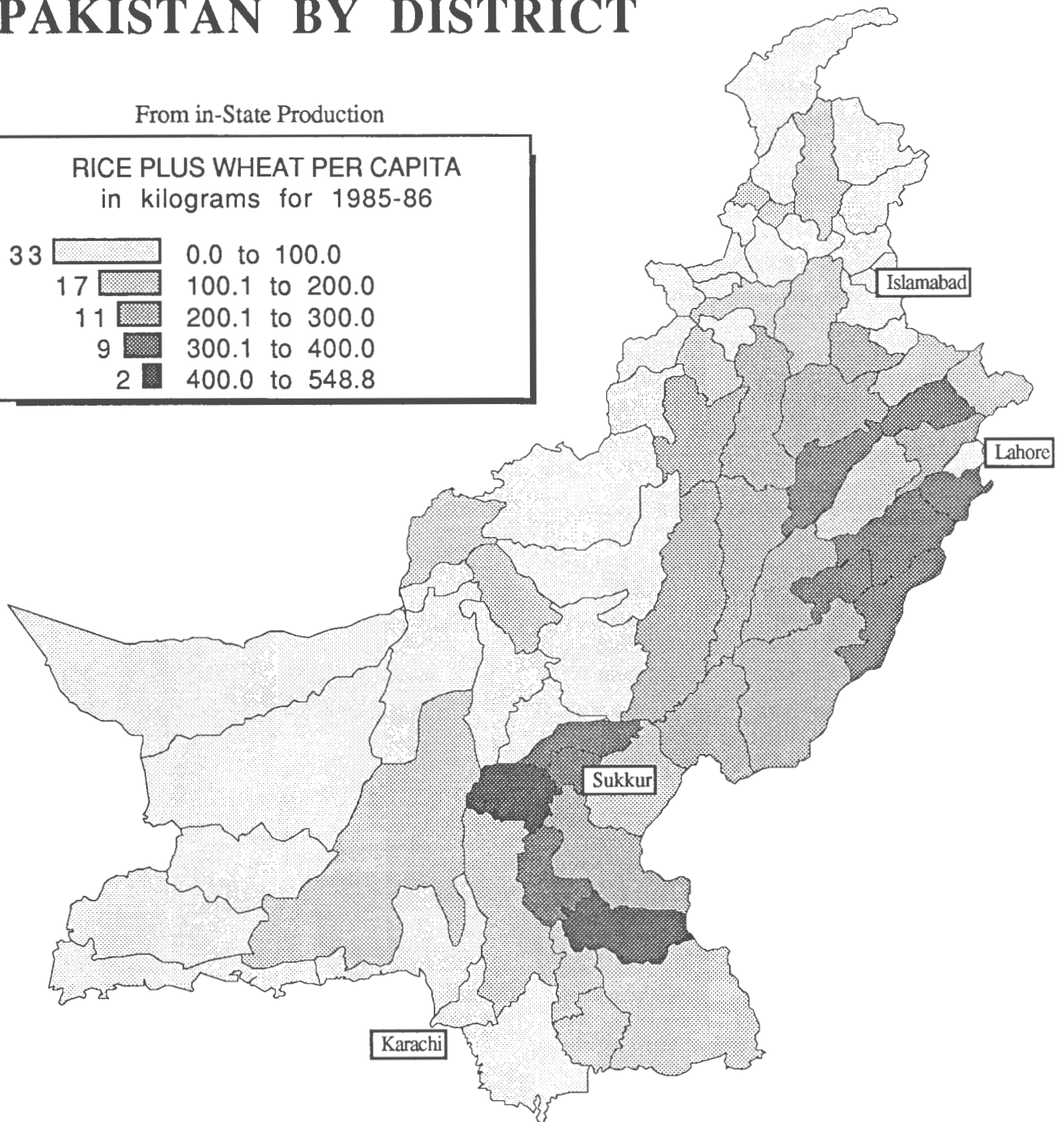
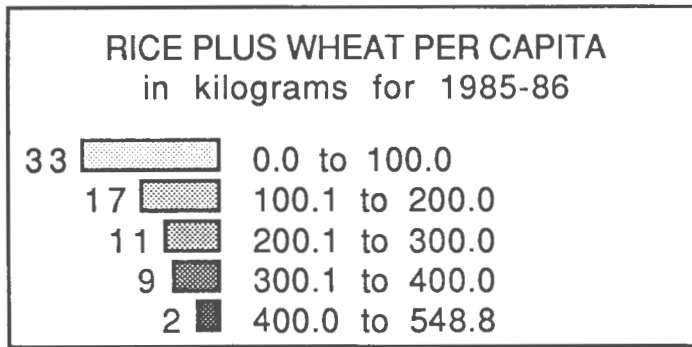


PAKISTAN BY DISTRICT



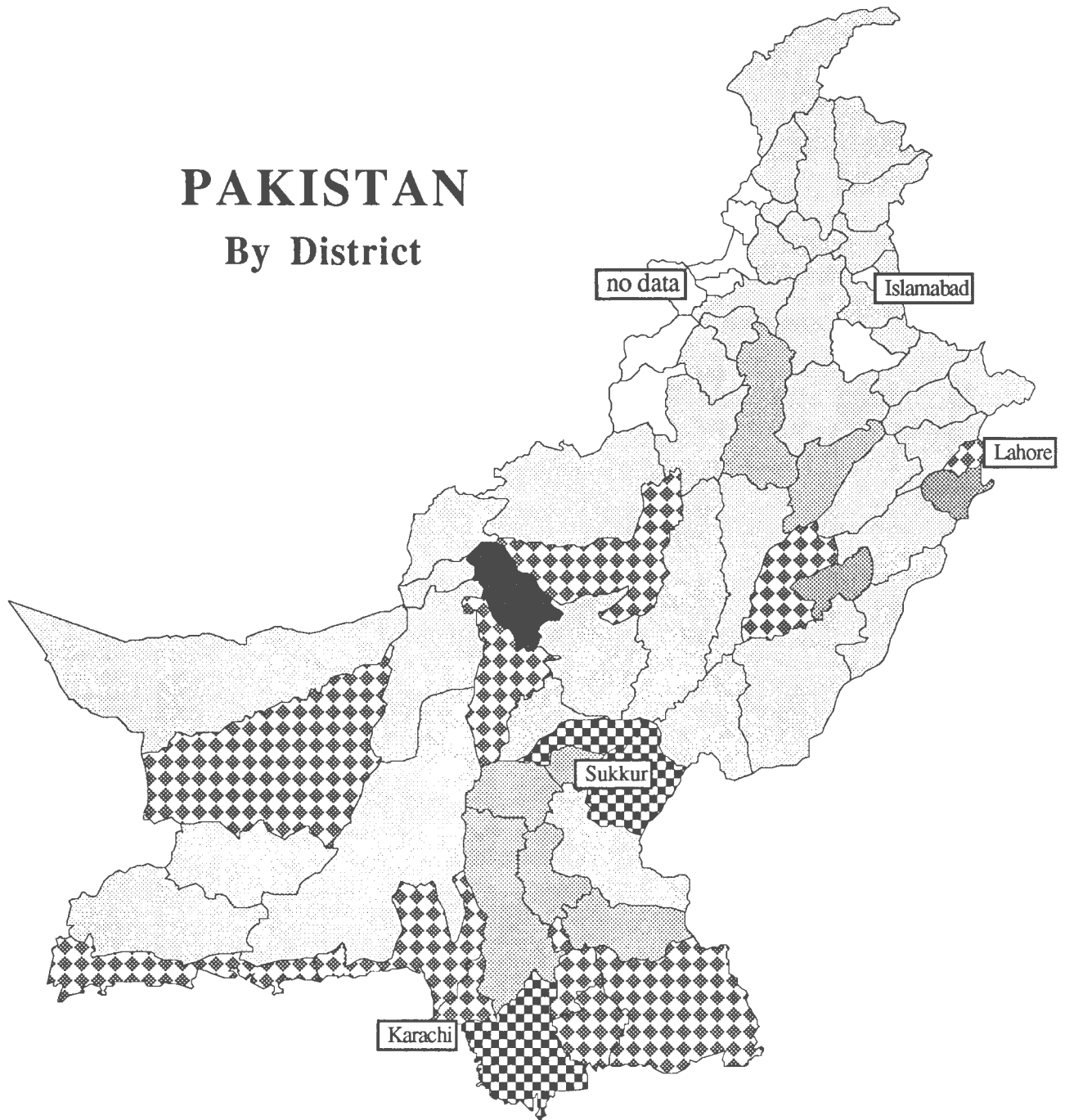
PAKISTAN BY DISTRICT

From in-State Production

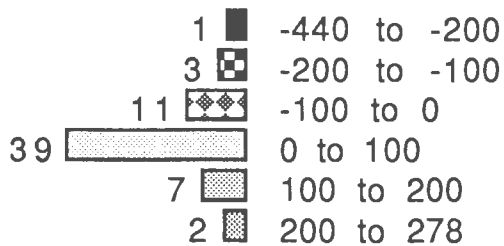


PAKISTAN

By District



Changes in Rice-Wheat Availability
in kg/capita/year ('70-'88)



Availability in 1972 = 130 kg/cap
 Availability in 1988 = **151 kg/cap**
Up 21 kg/capita

IRRI, CIMMYT, NARS '92 R&EH

PAKISTAN

RICE-WHEAT SYSTEM AREA
Changes 1970-1988 (ha)

Each Dot ● = 5000

Solid dots = area gain
Hollow dots = area loss



