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District Level Food Insecurity in the State of Uttar Pradesh

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SUMMARY

This paper critically examines the issues related to food insecurity at district level in the state of Uttar Pradesh in India. A total of 21 indicators were used to capture the three components of food insecurity viz; *food availability, food access* and *food absorption*. The methodology adopted was an improvement over the one adopted by M.S. Swaminathan Research Foundation (MSSRF). The modified approach used geometric mean instead of arithmetic mean used by MSSRF. Principal Component Analysis (PCA) was also tried in the present study though it was found to be useful only when indicators of components of food insecurity were dealt separately. Small area estimates were used wherever required. The districts were ranked on the basis of all the indicators. After ranking the districts, a mapping index was developed. In the present study, all the 70 districts have been put into five typologies namely *'extremely insecure', 'severely insecure', 'moderately insecure', 'moderately secure'* and *'secure'* based upon composite mapping index. Class intervals of each typology have been determined by GIS software Arc View, following natural breaks in the series. All the 70 districts of the state were categorized in these typologies and a food insecurity map was developed.

Keywords: Food availability, Food access, Food absorption, Food insecurity, Principal Component Analysis, Small Area Estimates.

1.INTRODUCTION

Poverty, high levels of illiteracy, social discrimination and neglect besides other factors like poor health facilities, inadequate availability of nutritious food and poor hygiene are some of the major factors leading to food insecurity of the populace of Indian states. Failed governance has also a fair share in food insecurity. Poverty leads to poor purchasing power, lower literacy levels lead to poor awareness and social discrimination leads to denial of opportunities. All these factors combined with many other factors lead to poor levels of food security. It is therefore necessary to identify food insecure areas based on various indicators.

M.S. Swaminathan Research Foundation (MSSRF) in 2001 in its research document *'Food Insecurity Atlas of Rural India'* used nineteen indicators to capture the three components of food insecurity encompassing wide ranging factors besides many others like agriculture, sustainability, environment and ecology, health and nutrition, hygiene, living style and poverty, dietary intakes, demographic structure, etc. This was followed by two more publications viz; '*Food Insecurity Atlas of Urban India',* and '*Atlas of the Sustainability of Food Security'*. Each of these documents presents state-wise scenario on food insecurity/sustainability with the help of chosen indicators, indices and maps. Such mappings are directly useful to planners/policy makers to readily

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visualize state level disparities and identify problem states for remedial measures.

Studies by MSSRF focus on three basic components of food security/ insecurity viz., *food availability, food access* and food *absorption.* All of these components have their own importance concerning the food insecurity. Availability of food is a pre-requisite for food security and economic development. Domestic production and imports together play a significant role in food availability. For food availability, local agriculture plays a very significant role.

Food access essentially consists of a package of 'endowments' which is the acquirement of different things including food items. The problem of food access in the case of disadvantaged sections of the society is more acute and depends on food affordability.

Food absorption or ability to assimilate the food consumed is crucial to a healthy life and food security. Food absorption essentially depends upon (i) food containing all nutrients and micro-nutrients and consumed in such a manner that it is absorbed well in the body (ii) state of health of individual, pure water supply, environment and hygiene. Food absorption related problems lead to an unhealthy, under-nourished adult population having low Body Mass Index (BMI). Malnutrition leads to stunted growth of children. They are generally found to be underweight for their age. Further, food absorption problems are the root cause of many diseases.

The Institute of Applied Statistics and Development Studies (IASDS) carried out a district level study on food insecurity in rural Uttar Pradesh using 21 indicators. The study uses a slightly modified version of MSRRF methodology. Details of the indicators and modified methodology are given in Section 3.

2. LIMITATION OF STATE LEVEL ESTIMATES

A major limitation of the state level mapping as done by MSSRF is that the state level aggregation may not capture inter and intra regional variations for large states with lot of heterogeneity in the underlying indicators and sub-indicators. This may happen because of masking effects. This issue has also been highlighted by MSSRF. Quite rightly, they have pointed out that village level and block level mapping would be most useful, as it would enable us to take up speedy and location-specific action. But, attempting this exercise would be formidable in view of the enormity of the work involved and the non-availability of data on virtually all sub-indicators particularly at the village/ block level. The problem however is not that complicated at the district level and only some of the sub-indicators may not be available at this level.

The argument that the state level aggregation may not capture inter and intra regional variations for large states with lot of heterogeneity is also valid for *Uttar Pradesh (U.P.),* which has not only large variations between its four regions, terribly backward Eastern and *Bundelkhand,* moderately backward Central and rather developed Western regions, but also between districts within the same region. For instance, some of the districts in the neighborhood of Bijnor of Western region are backward.

In view of the discussions above a district-wise Atlas of rural UP using small area estimates has been prepared which will be much more useful to the policy planners and implementers. Small area estimates have been derived wherever necessary to obtain district level estimates of the crucial indicator namely percentage of population with chronic energy deficiency.

An exercise at district level involving small area estimates is not only useful to the policy planners but also unfolds complexities that could arise if a similar exercise is attempted at block/village level, and enables us to understand and perceive the ways of resolving them. The findings of the study would therefore prove helpful in further research leading to preparation of Atlas at village and block levels.

3. METHODOLOGY

The study was carried out in 70 districts of Uttar Pradesh. Basic data pertaining to these districts was collected from secondary sources. As stated earlier, the study uses 21 indicators as against 19 in MSRRF study. The indicator, 'life expectancy at age one', used in MSSRF study was dropped as its reliable district level estimates are not available and it is also not considered crucial for food insecurity. In the present study two new indicators namely 'percentage distribution of households having consumption of iron below 90% RDA' and 'percentage distribution of households having

Table 1. Indicators and their data sources

Sl. No.	Indicators	Data Source
1.	Deficit in production represented by the ratio	Census, 2001Directorate of Agriculture, UP Nutritional Profile of : of consumption to production of cereals Community Uttar Pradesh, NIN- IASDS Study, 2004 District Level Population Projection in Selected States of India 2006-2016 United Nations Population Fund, 2006 http://agriculture.up.nic.in
2.	Instability in cereal production in percent	Department of Economics and Statistics, State Planning Institute, Government of Uttar Pradesh. 2008http://upgov.up.nic.in/spatrika/
3.	Sustainability index in percent U.P., 2004 http://upgov.up.nic.in/spatrika/	Directorate of Agriculture, U.P., 2008Directorate of Environment,
4.	Population affected by flood /heavy rain (in Lakh)	Flood Report, Department of Irrigation, U.P. Government, 2008http://upgov.up.nic.in/gpatrika/
5.	Percentage of total crop loss by drought upgov.up.nic.in/gpatrika/	Department of Disaster Management Report, U.P., 2004http://
6.	Calorie intake of the lowest decile (Kcal) per cu per day	Nutritional Profile of Community: Uttar Pradesh, NIN- IASDS Study, 2004Some Statistical Investigations to Assess Gender Bias and Nutritional Deficiency- IASDS Study for CSO, 2005 NFHS-3, 2005
7.	Percentage of populationconsuming less than 1890 Kcal	Nutritional Profile of Community: Uttar Pradesh, NIN- IASDS Study, 2004Some Statistical Investigations to Assess Gender Bias and Nutritional Deficiency- IASDS Study for CSO, 2005NFHS-3, 2005
8.	Percentage of households dependent on labor income	Nutritional Profile of Community: Uttar Pradesh, NIN- IASDS Study, 2004Uttaranchal and Uttar Pradesh At A Glance District wise Statistical Overview, Jagran Research Centre, 2005
9.	Rural Infrastructure index inpercent	Statistical Abstract, Uttar Pradesh, Economics & Statistics Division, State Planning Institute, Uttar Pradesh, 2008 and Uttaranchal and Uttar Pradesh At A Glance, District wise Statistical Overview, Jagran Research Centre, 2005
10.	Juvenile sex ratio female per1000 male	Census, 2001
11.	Percentage of female literacy	Census, 2001
12.	Percentage of SC & ST Population	Census, 2001
13.	Percentage of householdsbelow poverty line Uttar Pradesh , 2002	BPL Census, Department of Rural Development, Government of
14.	Maternal health Index	District Level Households and Facility Survey, (DLHS-3), Uttar Pradesh, Ministry of Health and Family Welfare, 2008
15.	Percentage of population with chronic energy deficiency	Nutritional Profile of Community: Uttar Pradesh, NIN- IASDS Study, 2004NFHS-3, 2005
16.	Percentage of severely stuntedchildren (under 5)	Nutritional Profile of Community: Uttar Pradesh, NIN- IASDS Study, 2004NFHS-3, 2005
17.	Percentage of severely wasted children (under 5)	Nutritional Profile of Community: Uttar Pradesh, NIN- IASDS Study, 2004NFHS-3, 2005
18.	Infant Mortality Rate (IMR)	Census of India, 1991 Directorate of Health & Family Welfare, U.P.NFHS-3, 2005
19.	Health infrastructure index Health & Family Welfare, UP, 2008NFHS-3, 2005	DLHS -3, 2008 District Statistical Book Data, Directorate of
20.	Percentage distribution of household according to consumption of iron below 90% RDA	Nutritional Profile of Community: Uttar Pradesh, NIN- IASDS Study, 2004
21.	Percentage distribution of household according to consumption of Vitamin-A below 90% RDA	Nutritional Profile of Community: Uttar Pradesh, NIN- IASDS Study, 2004

consumption of vitamin A below 90% RDA' have been used to capture iron and vitamin A deficiency. These indicators have helped in capturing the status of malnutrition on account of iron and vitamin A deficiency. A third indicator - 'maternal health index' was also included as it is considered crucial towards health of mother and child by health experts and nutritionists. One can easily choose scores of other indicators like rainfall, crop intensity, productivity differences etc., but such an exercise would be unmanageable as one needs to look into aspects like multi-co linearity and their relevance to food insecurity.

Table 1 gives details of the indicators used and their sources.

First 5 of these indicators relate to *food availability* and next 8 each relate to *food access* and *food absorption* respectively. It may be noted that majority of indicators pertain to the most vulnerable sections of the population within each district. More emphasis has been laid on deprivation and vulnerability and therefore the indicators chosen are not always average figures for a particular district. Average figures may be quite different from lowest decile. *Maternal health, rural infrastructure* and *rural health infrastructure* are the only parameters that represent status of a district. The rest of the 18 parameters represent deprivation and vulnerability. The food insecurity map thus highlights situations that need immediate public attention and intervention.

The MSSRF has used multiple indicators for understanding various aspects and processes of development, which is a multi-dimensional phenomenon. However, to form a judgment about the overall development status of a state/region/district, one has to combine these indicators into a single or composite development indicator of food security or insecurity at a sectoral and/or aggregate level. This raises issues regarding the weights assigned to different indicators and the technique used for their aggregation. The most commonly used methods for preparing a composite index are the ranking method, indexing method and multivariate data analysis techniques, i.e. principal component analysis and cluster analysis.

MSSRF has used the Ranking Method which is the simplest and the most commonly used method for preparing composite index of food security/ development. This method consists of assigning ranks for each indicator separately and simply totaling the ranks for each state/region/district to arrive at the aggregate rank. In this method all indicators are implicitly assigned equal weights, which may not always be appropriate. This method also fails to take into account the extent of variations in the magnitude of differences between units. The MSSRF has discussed the problem of aggregation of indicators in the section on methodology, stating that the simple adding up of the ranks of indicators in skewed distribution influences the interpretation of the relative position of the various states.

The methodology used by MSSRF was modified before adoption. The modified approach used geometric mean instead of arithmetic mean used by the MSSRF. Geometric mean (GM) was preferred over arithmetic mean (AM) as AM is greatly influenced by large values in the data. In fact a single large value can influence the AM and thus may lead to erroneous conclusion; on the other hand GM is preferred when data is not homogeneous. Principal Component Analysis (PCA) technique was also tried in the present study. The principal component method is statistically a more sophisticated method of analysis than the ranking of the index method. Under this method weights are assigned to each variable on the basis of the correlation matrix. The PCA analysis was not fruitful as seen from the following.

Principal Component Analysis using extraction method was done on all the 21 variables. In PCA, the **eigenvectors** correspond to principal components and the **Eigen values** to the variance explained by the principal components. Generally, all Eigen values greater than 1 and explained total variations exceeding 50 percent for all such Eigen values indicate the corresponding vectors (components) being significant contributors. For details please see Jollife (2002).

The variables were standardized for PCA. This was done by dividing the deviation of the value of a variable from the mean by standard deviation. Eight Eigen values were greater than 1, explaining over 74 percent of total variation. However, the first two components explained only 31.3 (18.9 and 12.4 respectively) percent of this variation. The third component was also close enough with a value of 10.2. Possible reasons for low levels of explained variation by first two components may be the non-normality, inadequate sample size, inappropriate and/or improper

choice of indicators, as also revealed by low values in correlation matrix; or else, non-linear relationship among variables. There are 70 districts against 21 indicators. Thus, we have sample size of 70 districts which is over 3 times the number of indicators (21), whereas the recommended sample size is 5 times the number of variables (here indicators), a little over 3 times. The non-normality test based upon Shapiro-Wilk's statistic revealed that all group 1 (availability) variables are non-normal, in group 2, out of 8 variables 3 are non-normal and in group 3 (absorption) out of 7, 3 are non-normal.

It may, therefore, not be a sound idea to pursue further analysis with PCA. Yet, we proceeded with PCA to gain insight. A further effort was made for carrying out PCA separately for each of different groups – indicators of each of food availability, food access, and food absorption. Quite surprisingly, the results showed marked improvements.

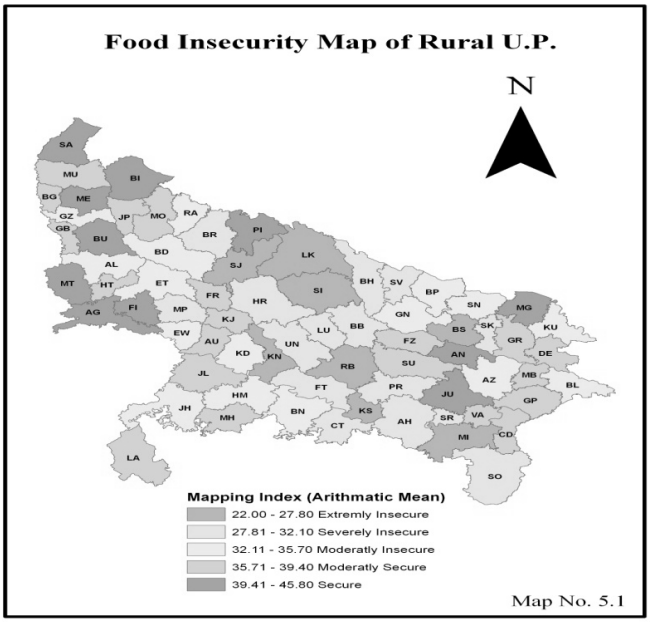
Out of 5 indicators of food availability, all related to agriculture, three Eigen values were greater than 1, and first two principal components accounted for 54 percent, while the third contributed another 20 percent. The fourth one with an Eigen value of 0.88 also contributed 18 percent of total variation. Out of 8 indicators of food access, four Eigen values were either greater than 1 or close to 1; first two principal components accounted for 53 percent, while the third and fourth one, together, also contributed over 25 percent of total variation. Out of 8 indicators of food absorption, infant mortality was dropped as it contained several missing values. Out of remaining 7, three Eigen values were greater than 1, the fourth one had the value 0.95; first two principal components accounted for 41 percent, while the next two contributed another 31 percent.

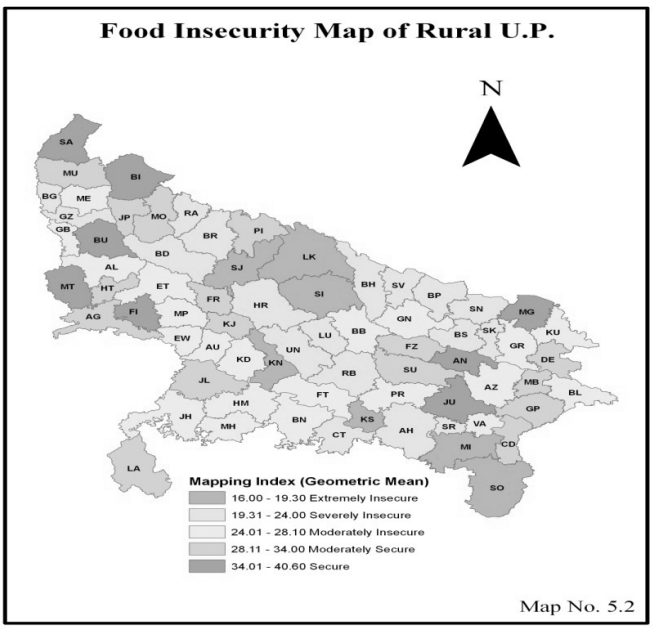
It is observed from the analyses of separate groups that PCA does perform reasonably well. However, this is not the case when all groups are combined to perform an overall PCA. A possible reason for this could be the non-linearity among variables of different groups. The PCA results, besides non-normality, also suggest presence of non-linearity among variables of three different groups indicating inappropriateness of PCA.

The above discussion clearly cautions against using PCA without validating underlying assumptions. PCA is likely to be useful for within group analysis and may be inappropriate for between group analyses.

4. FOOD INSECURITY MAP OF RURAL UTTAR PRADESH

In the present study, all the 70 districts have been put into five typologies namely *'extremely insecure', 'severely insecure', 'moderately insecure', moderately secure'* and *'secure'* based upon composite mapping index. Details of these districts along with their abbreviations are given in the Appendix. Class intervals of each typology have been determined by GIS software Arc View, following natural breaks in the series. Two types of mapping indices and typologies of food





insecurity situation based upon arithmetic and geometric means have been computed. For clarity, AM and GM mapping index of different districts are also reported in Table A1 in the Appendix. Before we proceed further it may be desirable to compare the two approaches – AM and GM. The insecurity ranks matched for 50 out of 70 districts. For the remaining 20 districts (see, Table A2 in Appendix), in all but one case the two results differ by one level on either side depending upon the type of skewness in mapping indices.

4.1 Food Insecurity Pattern

There are three typologies in the food insecure viz., *extremely insecure, severely insecure* and *moderately insecure.*

(i) Extremely Insecure Districts: *Kanpur Nagar, Kaushambi, Lakhimpur Kheri, Mirzapur, Shahjahanpur, Sitapur* and *Sonbhadra* are extremely food insecure districts of Uttar Pradesh. These are shown in red color in the map. These are the districts with lowest mapping indices (see Appendix). It may be observed from the map that these districts form small clusters, showing thereby that the problems are common inside the clusters. It can be seen that the districts of *Lakhimpur Kheri, Shahjahanpur* and *Sitapur* constitute one cluster followed by another cluster of *Mirzapur* and *Sonbhadra.* In these districts major factors responsible for poor *food availability* are floods, instability in cereal production. For poor *food access* factors like poor rural infrastructure, low female literacy, and large population of SC/ST are responsible. As for poor *food absorption* poor maternal health, low CED, wasted children and high rate of infant mortality are some of the responsible factors.

(ii) Severely Insecure Districts: *Allahabad, Baghpat, Bahraich, Balrampur, Bareilly, Basti, Budaun, Chitrakoot, Ghaziabad, Hardoi, Lucknow, Raebareli, Rampur, Sant Kabir Nagar, Sant Ravidas Nagar, Shravasti, Siddharth Nagar* and *Unnao* are severely food insecure districts of Uttar Pradesh. Mapping indices of these districts are low in values and therefore justify their inclusion in this category. These are depicted in mustard color in the map. In this typology also one can observe 'neighbor affinity' in the form of clusters. The factors responsible are more or less the same as for 'extremely insecure' category.

(iii) Moderately Food Insecure Districts: *Aligarh, Auraiya, Azamgarh, Ballia, Banda, Barabanki, Etah, Etawah, Fatehpur, Gautam Buddha Nagar, Gonda, Gorakhpur, Hamirpur, Jhansi, Kanpur Dehat, Kushi Nagar, Mahoba, Mainpuri, Meerut, Pratapgarh* and *Varanasi* are moderately food insecure districts of Uttar Pradesh. These are shown in light green color in the map. Here also formation of clusters can be seen. As expected mapping indices of these districts are moderate in values justifying their inclusion in this category.

Sitapur with lowest mapping index *has* emerged as the most food insecure district. The indicators that appear to contribute significantly to food insecurity are *instability in cereal production, floods, and rural infrastructure*. In *Sitapur* about 35 percent of the population belongs to SC/ST segment and more than 60 percent population suffers from CED. The district with highest mapping index is *Mathura* and is therefore most secure district. Even this district suffers from problems. Total crop loss due to drought is more than 73 percent and juvenile sex ratio is only 867 per thousand in *Mathura* district. Thus, each district has its own problems and should be addressed very carefully.

5. MAJOR RECOMMENDATIONS

General

As stated earlier food insecurity has three basic components viz; *food availability*, *food access* and *food absorption*. Agriculture plays a very significant role both for *food availability* and *food access,* as good crop production leads to good *food availability* while earnings from the agriculture and related activities provide livelihood and better purchasing power leading to *food access.* The present study indicates that major contributors to inadequate food availability are instability in food production, deficit in cereal production, poor sustainability and loss of crops due to natural calamities like floods etc. Cropping and irrigation intensities play significant roles in *food availability*. In Uttar Pradesh irrigation intensity is much higher than cropping intensity warranting efforts to enhance the cropping intensity. This can possibly be achieved by providing better supply and efficient use of seeds, fertilizers and pesticides.

Besides improved performance in agriculture and related sectors, efficient public distribution of food grains is the key to food availability and access. The welfare schemes like NREGA and public distribution system (PDS) are intended to ensure access. However, there have also been problems with efficient implementation of these two schemes. Out of 47 percent households which were issued job cards under NREGA only 17.7 percent of the registered people were provided jobs under the scheme, while only a little over one percent completed 100 days at work. The performance of the PDS as a delivery mechanism varies considerably across districts and there have been widespread reports of malfunctioning in distribution of quantity and quality of food grains.

Yet another project ICDS, which aims to ensure food and nutrition security to children below 6 years, adolescent girls and pregnant and lactating women has not made any significant inroads because of malpractices and inefficiency.

Banking and credit facilities is another area of concern. Banking facilities are available to only 21.3 percent villages at state level. At district level availability of banking facility is highly skewed. This varies from zero to 90 percent. As for loaning facilities for agriculture, at state level this is 46.6 percent of the total loan provided. At district level this varies from one percent to 92 percent, once again indicating highly skewed distribution.

In India agriculture that comprises of crops, animal husbandry, fisheries and agro-forestry etc. form the backbone of rural economy. In India farming is still farmers' oriented and not industry oriented. As most of the rural employment is dependent on agriculture, it is desirable to create better opportunities in agriculture by converting unskilled labors to skilled labors. This can be achieved by bringing new technologies in agriculture through proper and effective coordination between agricultural universities and extension agencies. Agencies like Krishi Vigyan Kendras need strengthening. The promotion of Village Food Banks, Seed Banks and Forage and Feed Banks is highly desirable for food and feed security during distress times. Farmers should be provided with a single card which should fetch them different facilities like credits/ loans/ seeds/fertilizers etc. Panchayats can play effective roles in this direction. It is also necessary to invent special packages for marginal and landless farmers. This group must be given extra fillip to make them competitive with medium and large farmers. Marginal farmers must be given credit at reduced interest rates and flexible repayment schedule.

Food instability and deficit crop production needs to be tackled vigorously. Rural infrastructure needs immediate pushup. Maternal health, CED, consumption of less than 1890 cals/day, consumption of less quantity of iron and Vitamin A lead to poor food absorption. In Uttar Pradesh 35 districts have lower calories consumption than the state average. Similarly, iron and vitamin A consumption is at very low levels across all districts of the state. Very low calorie consumption among the poorest is a matter of concern. The situation pertaining to calorie intake by landless households and marginal cultivators is grim. All these issues and those related to caste, gender and female literacy need to be addressed. In addition to these, better disaster management is required to meet the challenges due to natural calamities like floods etc.

Specific

The implementations of suggestions as above are likely to make improvements in food and nutrition security across all districts. However, there has to be special focus on extremely and severely insecure districts. Out of 70 districts of Uttar Pradesh, 46 districts were found to food insecure at different levels (7 extremely insecure, 18 severely insecure and 21 moderately insecure). Reasons for their being food insecure varies from district to district.

Kanpur Nagar, Kaushambi, Lakhimpur Kheri, Mirzapur, Shahjahanpur, Sitapur and Sonbhadra are extremely food insecure districts, while *Allahabad, Baghpat, Bahraich, Balrampur, Bareilly, Basti, Budaun, Chitrakoot, Ghaziabad, Hardoi, Lucknow, Raebareli, Rampur, Sant Kabir Nagar, Sant Ravidas Nagar, Shravasti, Siddharth Nagar* and *Unnao* are severely food insecure districts of Uttar Pradesh. All these districts lack in varying extent in each of food availability, access and absorption. We address each of these aspects separately.

Food Availability: Among the extremely insecure districts, *Kanpur Nagar, Kaushambi, Mirzapur, Sitapur* and *Sonbhadra* have deficit in production over cereal consumption, *Sitapur* has low sustainability, and

Lakhimpur Kheri, Shahjahanpur, Sitapur, Mirzapur, Sonbhadra and *Kaushambi* suffer recurrent crop losses due to floods and draught.

Similarly, amongst severely insecure districts, *Lucknow* has very high level of deficit in production over cereal consumption. Other districts having deficit are *Allahbad, Bahraich, Chitrakoot, Ghaziabad, Raebareli and Siddharthnagar. Baghpat, Ghaziabad, Chitrakoot, Sant Ravidas Nagar, Budaun, Lucknow* and *Raebareli* have either low Sustainability or instability in crop production. *Ghaziabad, Bareilly, Lucknow, Unnao, Basti, Sant Kabir Nagar, Siddharth Nagar Allahabad, Chitrakoot* and *Sant Ravidas Nagar* have the recurrent problem of crop loss due to floods and Draught.

In view of the above it is necessary to enhance the production in sustainable manner through innovative technologies and sustained efforts towards strengthening extension of lab to land. Further, it is essential to effectively manage natural disasters like floods and draughts.

Food Access: Among the extremely insecure districts, *Mirzapur* and *Sonbhadra have* dependence on labor income for livelihood resulting in poor purchasing power, while *Rampur, Hardoi, Bahraich, Shravasti* and *Siddharth Nagar* of severely insecure category have this problem.

Mirzapur, Sonbhadra and *Kanpur Nagar* among the first category and *Hardoi, Lucknow, Raebareli, Unnao, Bahraich, Basti, Shravasti* and *Chitrakoot* of the second category have a sizable population in BPL/ SC, ST category.

Shahjahanpur, Sitapur, Mirzapur and *Sonbhadra* among extremely insecure districts and *Unnao, Balrampur, Basti, Sant Kabir Nagar, Shravasti, Siddharth Nagar* and *Sant Ravidas Nagar* of the other category have very poor rural infrastructure.

Kaushambi, Budaun, Bareilly, Rampur, Bahraich, Balrampur, Shravasti and *Siddharth Nagar have* very low female literacy rate, while *Kanpur Nagar, Baghpat, Ghaziabad, Budaun, Bareilly, Rampur, Unnao, Balrampur, Basti , Sant Kabir Nagar* and *Chitrakoot*, have low calorie intake.

Poor purchasing power is the greatest road block towards food access. It is therefore necessary to enhance the employment opportunities for the population. Agriculture that comprises of crop and animal husbandry, fisheries, forestry, agro-forestry, agro processing and agribusiness forms backbone of the livelihood security system in our country across the states and districts. As indicated in MSSRF report our agriculture is 'farmers farming' and not 'factory farming'. Health hazards of plants and animals are on account of 'factory farming'. Thus, in our country the solution lies in creating jobs/livelihoods through agriculture. Since the share of agricultural workers is declining in workforce, it is necessary to enhance the productivity. As most of families engaged in rural areas are unskilled, their income levels are low. Thus, there is a need to convert unskilled workers into skilled workers. This can be achieved by providing proper training facilities through Agricultural universities, KVK's etc. Besides this, rural infrastructure can be improved by providing seed centers and pesticides/ insecticides stores and improved banking facilities etc. Proper schooling facilities are also essential for development.

Food Absorption: Poor Health infrastructure and maternal health, high infant mortality, CED and low consumption of iron and vitamin-A contribute to poor food absorption. *Mirzapur* and *Sonbhadra among extremely insecure* and *Budaun, Bareilly, Rampur, Allahabad, Chitrakoot and Sant Ravidas Nagar* among severely insecure districts have poor maternal health. *Bareilly, Budaun, Rarbareli, Unnao, Balrampur, Basti, Sant Kabir Nagar, Allahabad* and *Chitrakoot* of the latter category have high infant mortality rates, whereas *Ghaziabad, Budaun, Bareilly, Rampur, Bahraich, Sant Kabir Nagar, Shravasti* and *Siddharth Nagar* of the same category have high prevalence of CED. Among the extremely insecure category, *Lakhimpur Kheri, Shahjahanpur, Sitapur* and *Kanpur Nagar* have high prevalence of CED.

Majority of population in *Mirzapur, Sonbhadra* and *Kanpur Nagar* among extremely insecure districts and *Baghpat, Ghaziabad, Bahraich, Balrampur* and *Siddharth Nagar* among severely insecure districts have very low consumption of iron. Similarly, those with very low consumption of Vitamin A are *Lakhimpur Kheri* and *Kaushambi* of the first category and *Baghpat, Ghaziabad, Bahraich, Balrampur, Basti* and *Sant Ravidas Nagar* of the second category. *Bareilly, Lucknow and Basti* among this category also have poor health infrastructure**.**

Health facilities need revamping with effective implementation of food, health and nutrition security schemes like ICDS, mid-day meals and PDS. Programs like food fortification need to be implemented rigorously. Health infrastructure needs to be improved.

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REFERENCES

Institute of Applied Statistics and Development Studies (2013). *Food Insecurity Atlas of Rural Uttar Pradesh using Small Area Estimates.*

Jolliffe, I.T. (2002). *Principal Component Analysis.* 2nd Edition, Springer Series in Statistics.

MS Swaminathan Research Foundation (2001). *Food Insecurity Atlas of Rural India.*

MS Swaminathan Research Foundation (2002). *Food Insecurity Atlas of Urban India*.

MS Swaminathan Research Foundation (2004). *Atlas of the Sustainability of Food Security in India.*

Appendix

Table A1. Districts*, their Abbreviations and Mapping Indices

Sl. No.	Districts	Abbreviations	Mapping Index		Sl. No.	Abbreviations	Districts	Mapping Index	
			Arithmetic Mean	Geometric Mean				Arithmetic Mean	Geometric Mean
1	Agra	**AG**	39.8	32.5	**36**	**JU**	Jaunpur	41.8	38.1
2	Aligarh	**AL**	34.7	26.6	**37**	**JH**	Jhansi	33.4	27.1
3	Allahabad	**AH**	30.5	24.0	**38**	**JP**	J.P. Nagar (Jyotiba Phoole Nagar)	39.0	33.3
4	Ambedkar Nagar	**AN**	41.4	35.2	**39**	**KJ**	Kannauj	39.4	31.9
5	Auraiya	**AU**	36.1	25.7	**40**	**KD**	Kanpur Dehat	33.6	26.8
6	Azamgarh	**AZ**	34.0	28.1	**41**	**KN**	Kanpur Nagar	26.5	18.6
7	Baghpat	**BG**	38.3	21.1	**42**	**KS**	Kaushambi	26.3	16.9
8	Bahraich	**BH**	31.5	22.4	**43**	**KU**	Kushi Nagar	35.5	27.8
9	Ballia	**BL**	33.8	25.9	**44**	**LK**	Lakhimpur Kheri	26.0	16.5
10	Balrampur	**BP**	33.5	21.4	**45**	**LA**	Lalitpur	37.6	32.1
11	Banda	**BN**	33.1	26.2	**46**	**LU**	Lucknow	31.8	21.1
12	Barabanki	**BB**	31.2	26.2	**47**	**MG**	Maharajganj	42.9	37.6
13	Bareilly	**BR**	30.8	20.7	**48**	**MH**	Mahoba	38.2	26.3
14	Basti	**BS**	27.8	22.5	**49**	**MP**	Mainpuri	32.1	25.8
15	Bijnor	**BI**	43.4	38.7	**50**	**MT**	Mathura	45.8	40.6
16	Budaun	**BD**	32.7	20.3	**51**	**MB**	Mau (Maunathbhanjan)	37.4	31.3
17	Bulandshahar	**BU**	40.3	35.0	**52**	**ME**	Meerut	40.0	24.5
18	Chandauli	**CD**	37.9	32.6	**53**	**MI**	Mirzapur	26.7	19.3
19	Chitrakoot	**CT**	29.2	22.7	**54**	**MO**	Moradabad	36.2	29.6
20	Deoria	**DE**	37.3	31.1	**55**	**MU**	Muzaffar Nagar	38.9	32.0
21	Etah	**ET**	34.0	26.5	**56**	**PI**	Pilibhit	42.3	31.3
22	Etawah	**EW**	35.1	27.3	**57**	**PR**	Pratapgarh	31.2	26.5
23	Faizabad	**FZ**	37.9	33.5	**58**	**RB**	Raebareli	27.5	23.2
24	Farukkhabad	**FR**	36.6	33.2	**59**	**RA**	Rampur	32.6	21.1
25	Fatehpur	**FT**	30.7	26.3	**60**	**SA**	Saharanpur	40.1	36.6
26	Firozabad	**FI**	42.9	38.7	**61**	**SK**	Sant Kabir Nagar	28.8	23.5
27	G. B. Nagar (Gautam Buddha Nagar)	**GB**	36.8	27.8	**62**	**SR**	Sant Ravidas Nagar	30.4	21.0
28	Ghaziabad	**GZ**	33.5	21.0	**63**	**SJ**	Shahjahanpur	27.5	17.9
29	Ghazipur	**GP**	36.6	31.8	**64**	**SV**	Shravasti	31.7	20.8
30	Gonda	**GN**	35.7	25.4	**65**	**SN**	Siddharth Nagar	34.2	21.1
31	Gorakhpur	**GR**	36.3	26.2	**66**	**SI**	Sitapur	22.0	16.0
32	Hamirpur	**HM**	35.5	24.4	**67**	**SO**	Sonbhadra	29.9	16.2
33	Hardoi	**HR**	30.2	22.7	**68**	**SU**	Sultanpur	36.0	30.6
34	Hathras (Mahamaya Nagar)	**HT**	37.9	34.0	**69**	**UN**	Unnao	28.9	21.7
35	Jalaun	**JL**	37.8	30.0	**70**	**VA**	Varanasi	37.4	27.2

*Currently, there are 75 districts in Uttar Pradesh though during the study period there were only 70 districts

Table A2. Mapping Typologies of Districts

Sl. No.	Districts	Mapping Typology (Arithmetic Mean)	Mapping Typology (Geometric Mean)
1	Agra	5	4
2	Auraiya	4	3
7	Baghpat	4	2
3	Balrampur	3	2
4	Barabanki	2	3
5	Basti	1	2
6	Budaun	3	2
7	Fatehpur	2	3
8	G. B. Nagar	4	3
9	Ghaziabad	3	2
10	Gorakhpur	4	3
11	Mahoba	4	3
12	Mainpuri	2	3
13	Meerut	5	3
14	Pilibhit	5	4
15	Pratapgarh	2	3
16	Raebareli	1	2
17	Rampur	3	2
18	Siddharth Nagar	3	2
19	Sonbhadra	2	1
20	Varanasi	4	3