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Multi-criteria decision analysis for selection of vulnerable districts

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Transforming Indus Basin with climate resilient agriculture and water management

Food and Agriculture Organization of the United Nations
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Contents

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ABSTRACT

Modelling of climate change scenarios for Pakistan indicates that if agriculture and water management in the Indus River Basin continue in a 'business as usual' mode, the increase in temperatures and changes in precipitation will pose serious threats to the future livelihoods of farmers and to the Pakistani agricultural sector. In this context, FAO Pakistan has proposed a project to the Green Climate Fund (GCF) on "Transforming the Indus Basin with Climate Resilient Agriculture and Water Management". This project is designed to change that by moving away from 'business as usual' in the Basin and shifting agriculture and water management to a new paradigm in which producers are successfully adapting to climate change and are able to sustain their livelihoods. The project objective is to transform agriculture in the Basin by increasing resilience among the most vulnerable farmers and strengthening the Government's capacity to support their communities to adapt. To ensure the success of the project, an appropriate selection of districts for project interventions is a crucial factor. The technical team at FAO has employed a detailed multi-criteria decision analysis (MCDA) technique using geographic information system (GIS) for the selection of the district areas. As an outcome of the detailed MCDA analysis, a geographic information system (GIS) based vulnerability index has been developed for the districts. Based on the vulnerability index, eight districts in Punjab and Sindh are selected for the implementation of the project. The present document describes the methodology employed for the selection of the project target districts based on a series of geospatially explicit criteria and discusses the details of the datasets used. The analysis was based on independent environmental and social factors that allowed an objective selection through multiple criteria in line with the project's objective. The project has been approved by the GCF Board and signed for implementation. GCF signed the Funded Activity Agreement (FAA) to transfer USD 35 million to the FAO project in less than 24 hours after it was approved by the GCF Board. The signing represents the fastest progression from project funding approval to a funding implementation agreement during GCF's four years of operation.

INTRODUCTION

To be useful, data must be transformed into information as they are of little value in and of themselves. When data are organized, analysed, interpreted, and considered useful for the decision problem, they become information. Accordingly, geographical information can be defined as georeferenced data that has been processed into a form that is meaningful to the decision maker and is of real or perceived value in the decision-making process. Information is used by the decision maker and is derived from data (Malczewski, 1999). During the last few decades, GIS data processing and spatial analyses, together with modern decision analysis techniques, are increasingly being used to study and perform suitability evaluations for large geographic areas. From habitat suitability models, land use planning assessments to multiple types of vulnerability mapping, the GIS based multiple attribute decision-making is found effectively useful for geographical research problems. GIS is used as the platform in managing, combining and displaying the criterion data and as a tool for producing new data, especially by utilising spatial analysis functions. GIS-based (or geospatial) multicriteria decision analysis can be defined as a collection of techniques for analysing geographic events where the results of the analysis (decisions) depend on the spatial arrangement of the events (Malczewski, 1999). Multi-criteria decision analysis (MCDA) is a part of broadly defined spatial analysis. Spatial decision problems typically involve a large set of feasible alternatives and multiple, conflicting and incommensurate evaluation criteria. A number of individuals (decision-makers, managers, stakeholders, interest groups) often evaluate the alternatives. The individuals are typically characterized by unique preferences with respect to the relative importance of criteria based on which the alternatives are evaluated. Accordingly, many spatial decision problems give rise to the GIS-based multicriteria decision analysis (Malczewski, 2006). On the one hand, GIS techniques and procedures have an important role to play in analysing decision problems. Indeed, GIS is often recognized 'as a decision support system involving the integration of spatially referenced data in a problem solving environment (Cowen, 1988). On the other hand, MCDA provides a rich collection of techniques and procedures for structuring decision problems, and designing, evaluating and prioritizing alternative decisions. At the most rudimentary level, GIS-MCDA can be thought of as a process that transforms and combines geographical data and value judgments (the decision-maker's preferences) to obtain information for decision-making. It is in the context of the synergetic capabilities of GIS and MCDA that one can see the benefit for advancing theoretical and applied research on GIS-MCDA MCDM approach (Malczewski, 2006).

Any decision making process can be structured into three major phases; intelligence, design, and choice. Intelligence explores if there is a problem or an opportunity for change, Design phase is focused on the alternatives and choice investigates which alternative is best (Simon, 1960).

Background

FAO Pakistan is also extensively using GIS and spatial analyses for agriculture applications and scientific assessments. It has recently submitted a project proposal to Green Climate Fund (GCF) focussing on transforming the Indus Basin with climate resilient agriculture and evapotranspiration (ET) based water management for the benefit of small farms. During the project formulation stage, an important step to be determined was the appropriate selection of the planned/proposed areas for interventions, which will need to be decided to take into consideration the project objectives. Since the project's key objective is to promote climate-resilient agriculture and water management for the small farmers, a conceptual approach for defining vulnerable areas was developed. Based on the approach, indicators for vulnerability were defined, mapped and compared in order to come up with the most suitable districts for the project implementation.

It was agreed that the selection will be performed at the district level. The Districts of Pakistan, are the third-order administrative divisions of Pakistan, below provinces and divisions, but form the first-tier of local government. As the project focusses on climate-resilient agriculture in the wake of current global climate change, the objective of GIS based MCDA was to select such districts, which are, highly prone to natural disasters caused linked to climate change and with a higher number of small farmers at the risk. Considering this various socio-economic factor was also taken into consideration in order to map the vulnerabilities. Selection of relevant indicators was based on the objectives of the analysis and the required criteria for vulnerability assessments.

VULNERABILITY INDICATORS

Considering the project's objectives, most up to date and relevant data about the vulnerability indicators was gathered from the available national data sources and other freely available sources to help in the selection of the most vulnerable districts. The key datasets/criterion layers acquired at the district level are listed as below:

Table 1: Datasets used in multi-criteria decision analysis (number of layers)

VULNERABILITY CRITERIA	INDICATOR
Agriculture	Cropped area per district
Percentage of small farms per district	
Percentage of agricultural households per district	
Natural hazards	Drought hazard Index
Flood hazard index	
Poverty	Multi-dimensional poverty index (MPI)
Food security	Food consumption score (FCS)

I) AGRICULTURE RELATED INDICATORS

The information about the cropped area per district was initially retrieved from the Agricultural Census 2010 published by Pakistan Bureau of Statistics. However, it was found out that in some districts the figures showed some variations with respect to the extent of the district as the census was done in 2010 and some of the districts were merged/formed after that. In addition to this, the data from agriculture census was older and therefore, the crop data developed by FAO and Pakistan Space and Upper Atmosphere Research Commission (SUPARCO) developed under the project of "Agricultural Information System-Building provincial Capacity in Pakistan for Crop Estimation, Forecasting, and Reporting based on the integral use of Remotely Sensed Data; GCP/PAK/125/USA" was used. The project focused on enhancing and improving existing systems based on the integral use of remotely sensed data into the existing data collection, analysis, and dissemination systems; as well as the development of complementary systems to validate the use of satellite remotely-sensed data for area estimation and yield forecasting. This data was also adopted due to their much higher detail of information and better spatial resolution. Land cover data produced under the same project was also used to map the extent of agriculture land classes.

1. Rabi and kharif crop masks; FAO and SUPARCO

The FAO/ Pakistan Space and Upper Atmosphere Research Commission (SUPARCO) rabi and kharif crop masks depict the extent of five major crops (rice, wheat, sugarcane, cotton, and potato for Punjab and Sindh with the spatial resolution of 5 m. The main seasonal crops in Pakistan are divided into two categories i.e. rabi and kharif. The crops which are cultivated in the start of rainy season (monsoon), are known as kharif crops. They are harvested at the end of the monsoon season. Rice, maize, bajra, sugarcane, and cotton are all kharif crops. Rabi crops, also known as win-ter crops, are sown at the beginning of winter season (October or November) and are harvested in the spring season. Wheat, barley, and mustard are some of the major rabi crops. The layers were produced through a semi-automated pattern recognition procedure with SPOT-5 satellite image and eventual visual interpretation. The basic guidelines considered for mapping the crop masks were to relate to the data storage hierarchy scheme, satellite data nomenclature, processing levels, crops colour coding and other parameters. For rabi crop masks, two satellite image acquisitions were made for rabi crops 2013/14. The first acquisition was made during December–January 2013/14, covering the period of early crop growth. The second acquisition was carried out during February–March 2014 at peak crop growth.

For kharif crop masks, two satellite image acquisitions were made for kharif crops 2014/15. The first acquisition was made during May–June 2014 covering the period of early crop growth. The second acquisition was carried out during August–September 2014 at peak crop growth. An appropriate record of satellite acquisitions was maintained.

All images were spatially enhanced with a single approach. They were rectified with baseline Ortho-rectified SPOT5 image data. Their subsets were prepared according to the administrative district boundary. A standard operating procedure (SOP) was documented to develop standard and harmonized procedures for quality control and to arrange homogeneous adoption of procedures for quality control. The stratified random sampling technique was used for ground validation of image classification results. Sampling sites and a number of points were based on crop density and heterogeneity. District wise ground truth points were collected for the whole project area in Punjab and Sindh (Food and Agriculture Organization of the United Nations, SUPARCO, 2017).

2. Land cover data – FAO and SUPARCO

FAO and SUPARCO produced the land cover atlases for Punjab and Sindh under the same project on "Agricultural Information System – Building Provincial Capacity in Pakistan for Crop Estimation, Forecasting, and Reporting based on the integral use of Remotely Sensed Data; GCP/ PAK/125/USA". Due to the importance of land cover mapping for agriculture purposes, a harmonized land cover database and land cover atlas of each of the two provinces of Punjab and Sindh were developed (Food and Agriculture Organization of the United Nations, SUPARCO, 2014). The Provincial land cover database of Punjab is created using a number of data sources ranging from remote sensing satellite imagery (at 5 meters resolution or better), available historical digital datasets and in-situ data. The FAO Land Cover Classification System (LCCS was used for the creation of the national legend in consultation and inputs from the national experts (Gregorio, 2005). The FAO methodology for land cover change mapping was implemented using the FAO land cover change mapping toolbox. FAO provided substantive technical assistance to the national experts to undertake a consistent assessment of the land cover in Pakistan.

It was determined that the land cover database would assist not only the development of a robust statistical area frame methodology but would also be the basis for the development of improved capacity for natural resources monitoring and management in Pakistan.

The legend of the land cover atlas has 13 main land cover classes, which have been further subdivided into 36 classes, mapped based on the analysis, interpretation, and validation of SPOT-5 very high-resolution satellite data (5 metre). The SPOT-5 satellite images were segmented into homogeneous polygons and labelled using the LCCS classification system and adopting the FAO methodology and its land cover toolbox (Food and Agriculture Organization of the United Nations and SUPARCO, 2017)

The classification was available at full level with 36 different classes and at an aggregated level with 13 classes:

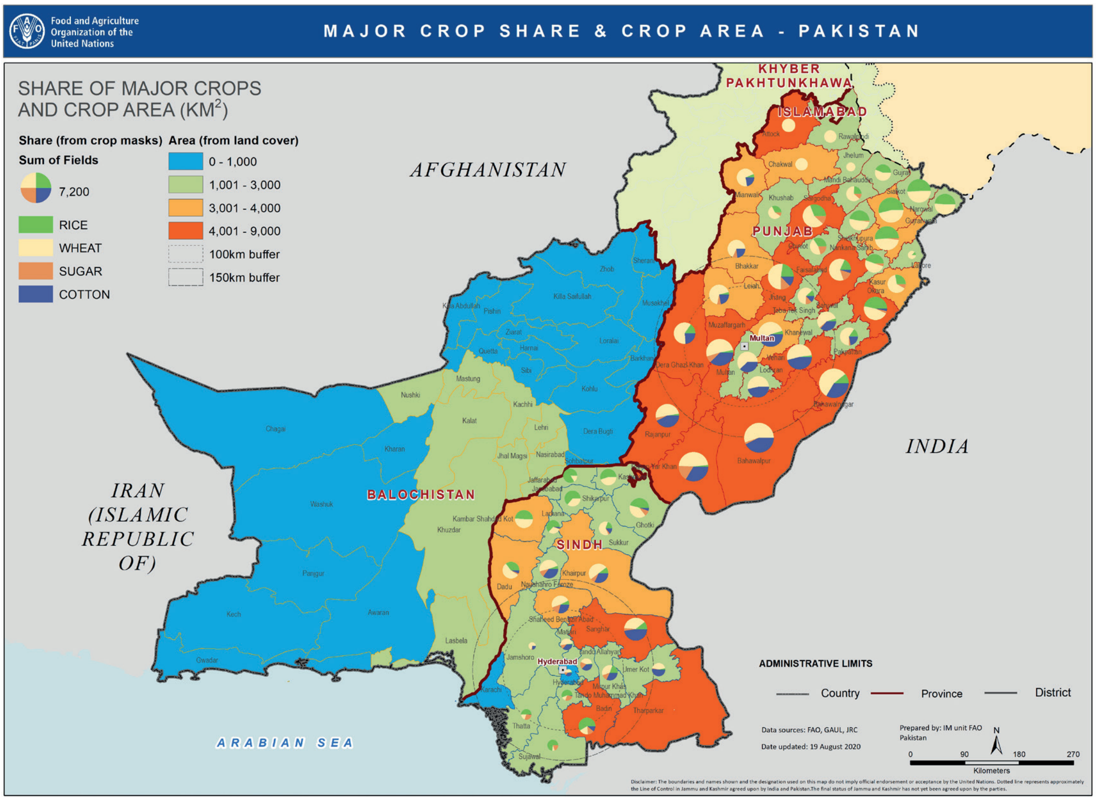
Table 2: Legend of land cover classification data

Orchard	Rangelands – natural shrubs and herbs rangelands
Crop irrigated	Built-up area
Crop marginal and irrigated saline	Bare areas with sparse natural vegetation
Crop in flood plain	Water bodies
Crop rainfed	Bare areas
Forest	Snow and glaciers
Natural vegetation in wet areas	

Among the 13 classes in the land cover atlas, four are crop-related: crop Irrigated; crop marginal and irrigated saline; crop in flood plain; and crop rainfed. The crop-related classes were separated and extracted to produce an agricultural mask of the land cover for each district.

FAO/SUPARCO crop masks and FAO land cover data were aggregated at the district level and visualized together to show the districts with a larger agricultural extent and the relative occupancy of the four major crops. Figure 1, depicts the share of the four major crops from the FAO/SUPARCO crop masks in Punjab and Sindh (bigger pie charts indicate a higher sum of the four crops area per district, with a maximum of 7 200 km^2). The background colours of the map show the sum of the area of the four crop-related classes from the aggregated land cover classification, displayed as choropleth (thematic map where each area is shaded according to the values of a variable).

Figure 1: Share of major crops from FAO/SUPARCO crop masks and crop area from FAO land cover



Source: Adapted from Map No. 4181 Rev. 1 UNITED NATIONS January 2004.

3. Agriculture households and small sarms

The data on the number of agricultural households and small farms in each district was also derived from the Pakistan Agriculture census. This was later converted into a percentage to reflect percentages of agricultural households and small farms in each district.

II) NATURAL HAZARDS

Two major Natural Hazards faced by the country include droughts and floods. Both of these are important to analyse the areas under agriculture vulnerable to damages caused by them.

1. Drought hazard

Drought is one of the complex meteorological disasters affecting water resources, agriculture, livestock, and socio-economic patterns of a region. Although drought prediction is difficult, it can be monitored based on climatological information. In a research by Pakistan Meteorological Department (PMD), high spatiotemporal resolution drought climatology, using observational, gridded precipitation data (0.5*×0.5*) from the Global Precipitation Climatological Centre and soil moisture data from the Climate Prediction Centre for the 60-year period 1951–2010 were studied to map the standardized precipitation index (SPI). The results showed strong temporal correlations among anomalies of precipitation, soil moisture, and SPI. Analysis of long-term precipitation was used to develop a drought hazard map of Sindh in which ten districts are recognized as highly vulnerable to drought. Similar approach was adopted by PMD to develop a district wise vulnerability to droughts (Shahzada Adnan, 2015).

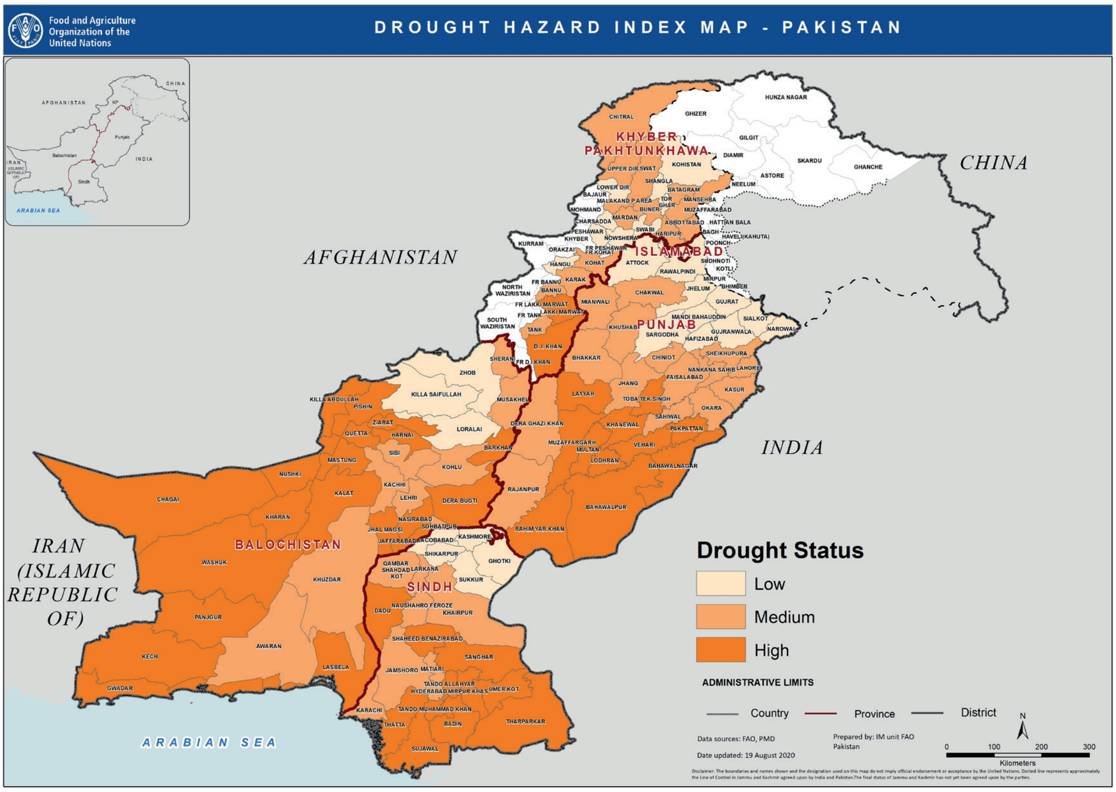
Drought hazard index data for the current analysis was derived from PMD's drought index and it is based on soil moisture and precipitation data, available from 1951 to 2010, which are used to calculate three parameters: 1) dependency on seasonal (winter/monsoon) rainfall; 2) drought frequency (using the Standardized Precipitation Index or SPI); and 3) soil moisture. The original dataset was a -5point scale of hazard level that is reclassified into a 3-point scale of Low, Medium, and High (NDMA, World Food Programme, 2017).

2. Flood hazard

The Joint Research Centre (JRC) of the European Commission prepares the flood hazard map of the world, a ten-year return period. Flood hazard data were obtained from the Joint Research Centre Data Catalogue of the European Commission (Dottori, *et al.*, 2016). This collection contains a set of flood hazard maps and the map depicts flood-prone areas at a global scale for flood events with a ten-year return period. Resolution is 30 arc seconds (about 1 km).

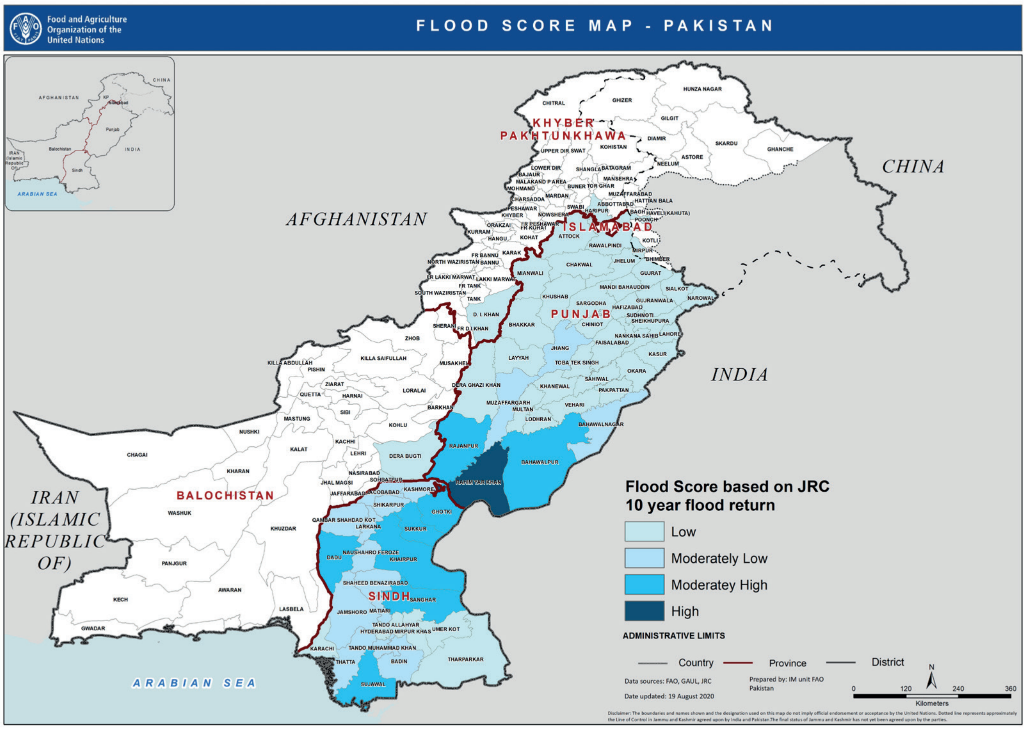
To provide information at district level the JRC data were aggregated per district calculating the sum of the values per district and eventually grouping the districts with a 1 standard deviation classification to achieve four scores (Figure 3:). The map can be used to assess flood exposure and the risk of population and assets. The ten-year return period data were chosen among the other existing datasets (20-, 50-, 100-, 200- and 500- year return period) as being more appropriate for the project lifespan (Dottori, *et al.*, 2016).

Figure 2: Map for district-wise drought hazard index sourced from PMD



Source: *Adapted from Map No. 4181 Rev. 1 UNITED NATIONS January 2004*

Figure 3: Map for district-wise flood hazard data using JRC data



Source: *Adapted from Map No. 4181 Rev. 1 UNITED NATIONS January 2004*

III) POVERTY

Poverty is a complex and multidimensional phenomenon. It is often thought of as an indefinable concept whereby it is hard to decide if it is an output of some endowments and choices or it is input to metrics of better well-being.

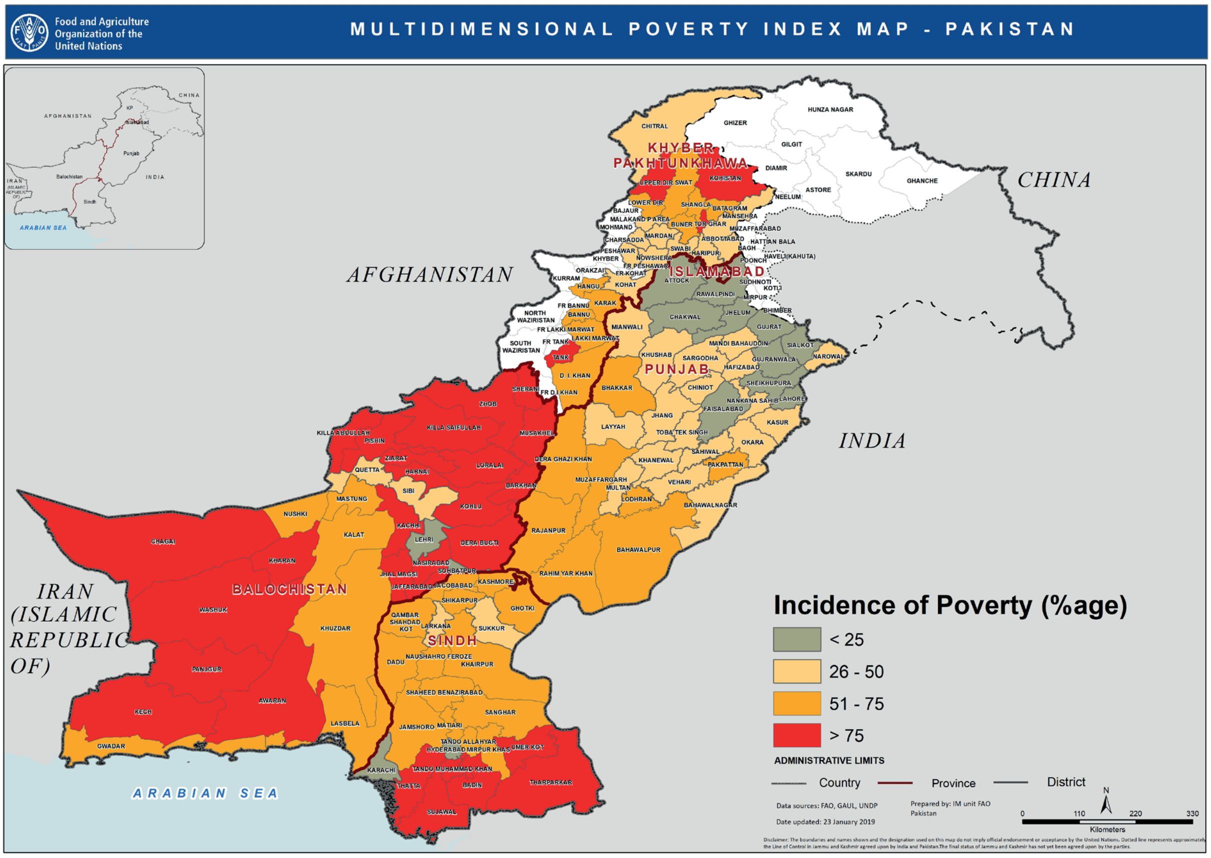
1. Multi-dimensional poverty index

Multidimensional poverty index (MPI) is based on several deprivations such as the inability to attain a good education, a lack of access to healthcare facilities, poor housing and an unsafe environment in which to live. The index computed by aggregating these deprivations has profound usefulness for policies and plans as this index can be disaggregated on the basis of deprivations and geography. Multidimensional poverty is also helpful for balanced social policies. The government of Pakistan uses the MPI tool to assess poverty with multiple facets. The MPI reports by the Ministry of Planning, Development and Reform with the support of UNDP present the national Multidimensional Poverty Index based on the Alkire-Foster methodology. It has three dimensions: education, health and living standards.

MPI is a product of two essential components: the poverty "headcount" and the "intensity" of deprivation. Applying the data from the Pakistan Social and Living Standards Measurement (PSLM) survey for the 2014/15 period, it was found out that the Multidimensional Poverty Index stands at 0.197. This indicates that poor people in Pakistan experience 19.7 percent of the deprivations that would be experienced if all people were deprived in all indicators using the same data from the 2014/15 PSLM survey, the country's multidimensional poverty "headcount ratio" was estimated at 38.8 percent of the population. This means that 38.8 percent of the population of Pakistan is poor according to the MPI. (The Ministry of Planning, Development & Reform and UNDP, 2015).

The headcount or incidence of poverty, as a key component of the MPI, is an excellent measure by which to determine the number of individuals who may be categorized as poor in any geographical region. Using the MP published report of the GoP, MPI data at the district level was acquired for the MCDA analysis. The district level incidence of poverty in percentage was reclassified into four classes with 1 for the least poor and 4 for the poorest districts.

Figure 4: Map for multi-dimensional poverty index (MPI) (five years average 2010-2015)



***Source:** Adapted from Map No. 4181 Rev. 1 UNITED NATIONS January 2004*

IV) FOOD SECURITY

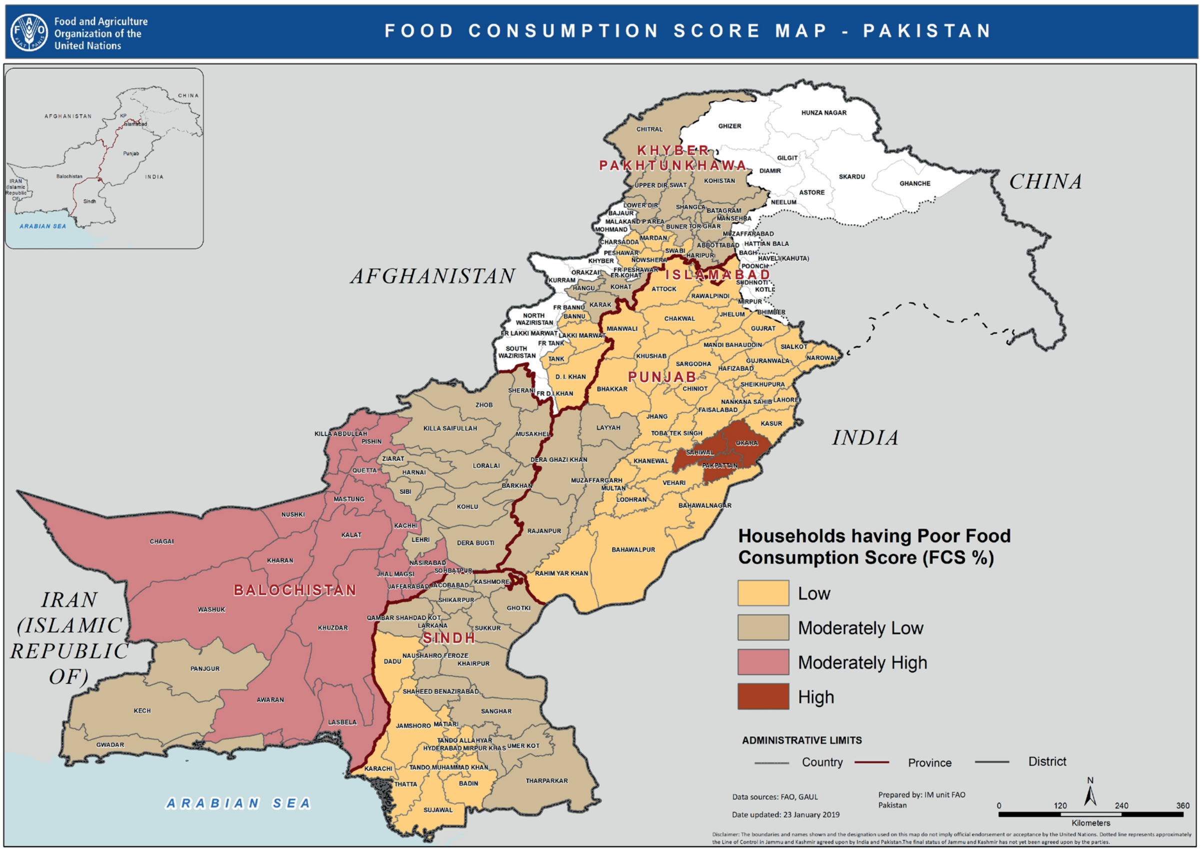
The data on the food security indicators are sourced from the Food Security Assessment (FSA) carried out by the Ministry of National Food Security and Research in 2016. Data to compile food security and nutrition indicators were collected via a door-to-door survey of 13 994 households, designed to be statistically representative at administrative divisions, provincial and national levels. The field survey was conducted from November 2015 to March 2016. This report relied on indicators compiled following internationally accepted definitions and standards to measure the food security and nutrition status of the households reached by the survey. These indicators cover a range of dimensions of food security outcomes. Food security indicators can be divided into two groups: the first one based on the analysis of food consumption data, the second one based on self-reported experiences and conditions associated with food insecurity.

1. Food consumption score

For the Food consumption score (FSC), the data on the percentage of households reporting average food consumption that provides less than the daily-recommended dietary energy intake level was taken from the food security assessment. The households provided information on the total amount of food consumed in the household over

the reference period (14 or 30 days, depending on the type of food item). This information was used to compute an estimate of the average daily consumption of food, expressed in dietary energy per adult equivalent, for each household. Traditionally, the percentage of households reporting an average daily dietary energy consumption below the recommended intake level in the population (which equals 2 350 Kcal per adult equivalent, as per the guidelines published by the Ministry of Planning, Development, and Reform) had been considered an indicator of the adequacy of dietary energy consumption in the population.

Figure 5: Map for households having poor food consumption score



Source: *Adapted from Map No. 4181 Rev. 1 UNITED NATIONS January 2004*

It is nevertheless a useful indicator of the adequacy of local food supplies, which can be used to identify areas in the country where total food supply is low and guide the planning of food-related intervention. Considering the food con-sumption score- a proxy for food security- for the food consumed within the seven day period prior to the survey, 39 percent of the population has acceptable food consumption, whilst 9 percent has poor food consumption, and more than half (52 percent) is on the borderline (Ministry of National Food Security and Research, 2017).

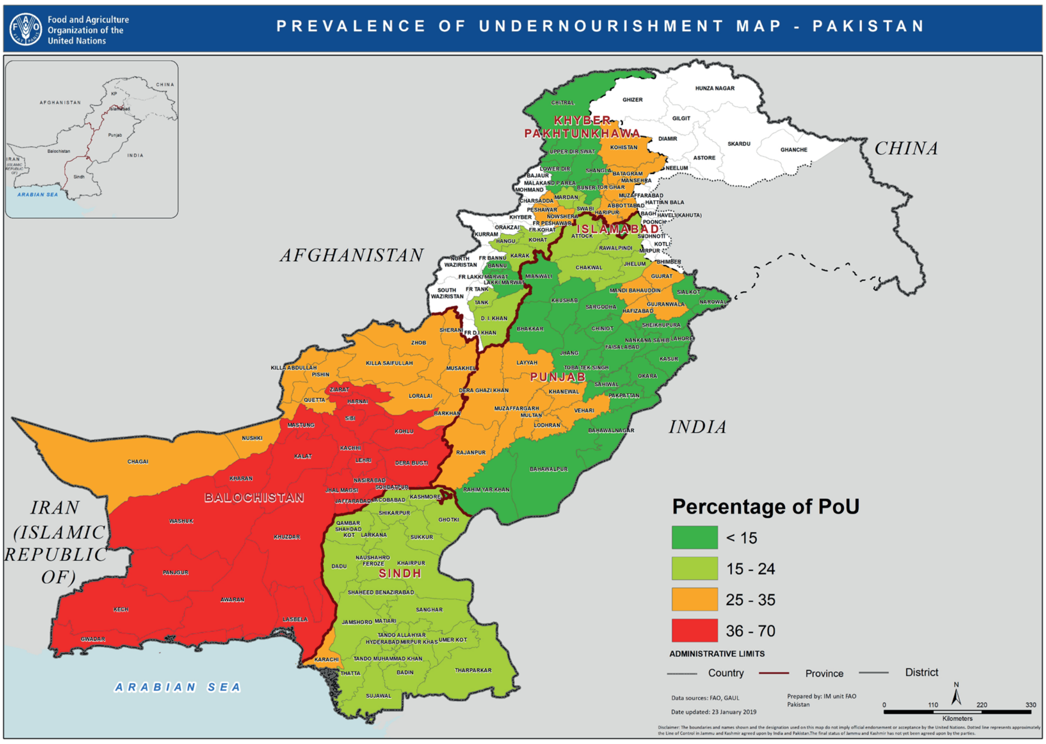
2. Prevalence of undernourishment

As the Food consumption score does not take into consideration differences in energy requirements due to differences in body masses and physical activity levels within each sex and age category, therefore, it cannot be considered as an indicator of the percentage of individuals in the population with inadequate dietary energy consumption (for which the appropriate indicator is the prevalence of undernourishment computed following the methodology proposed by FAO).

The prevalence of undernourishment is an estimate of the percentage of individuals in a population that consume, on a regular basis, amounts of food that are insufficient to provide the amount of dietary energy that is necessary to conduct an active and healthy life. FAO has long devised a statistical method that allows estimating the PoU in a population using data from household surveys that report the overall food consumption, and the composition of the household by sex, age and – possibly – height and prevailing physical activity levels. A statistical model of the daily dietary energy consumption level for the average individual in the population is used to estimate the probability that daily dietary energy consumption is below the level that would guarantee the maintenance of an active and healthy life. The model is estimated on the data collected with household food consumption surveys and is applied to each sub-national population for which the survey is representative (Ministry of National Food Security and Research, 2017).

The information on division wise PoU was used to assign ranks to the districts on a scale from 1-4, whereby 1 being districts with a low prevalence of undernourishment and 4 for the very high prevalence of undernourishment.

Figure 6: Map for prevalence of undernourishment (PoU)



Source: *Adapted from Map No. 4181 Rev. 1 UNITED NATIONS January 2004*

III) METHODOLOGICAL FRAMEWORK

To select the most vulnerable districts with the multi-criteria decision analysis, a number of phases were implemented. Spatial Analyst tool box of ArcGIS software was used to run the analysis.

Table 3: Main phases of the GIS based multi-criteria decision analysis

PHASE	STEPS
Data preparation	• Acquisition of data from multiple sources • Conversion of data into GIS friendly formats • Data harmonization/reclassification • Preparation of criterion map layers
Data standardization	• Map standardization i.e. classifying each layer with an equal distribution in four classes from 1 to 4 (where 1 stood for the lowest priority and 4 for the highest priority)
Weighted sum	• Assigning weights to each criterion layer • Preparation of weighted standardized maps • Performing weighted Sum analysis by preparing an overall ranking map using overlaying weighted standardized criterion maps
Results & discussions	• Identifying the districts with the highest scores of weighted criteria • Discussion with relevant stakeholders, cross-validation and government • Final selection of districts

Before performing the MCDA, a number of relevant criteria were defined. Multiple criteria layers were assigned different weights according to their vulnerability. The datasets were processed, harmonized and classified in scores for the eventual integration. The weights assigning carried out keeping in view the need for identifying the agricultural areas with a higher number of small farms more prone to drought and climate change, which are considered more vulnerable to climate change. The key steps of the analysis are summarized below.
Higher weights were assigned to two datasets due to their relevance in the context of the project objective: (i) the percentage of crop areas against the total district areas; and (ii) the drought hazard index. This allowed us to address areas more dedicated to agriculture and more susceptible to climate change, specifically with respect to drought occurrence, which has become more frequent. The other parameters received an equal weight of 10, all of which make a total of 100.

Two main cities, Multan and Hyderabad, were considered and displayed in the spatial representation of the data for eventual discussion on the practical aspects of project implementation. FAO is currently implementing projects related to climate change and disaster risk management in those regions. Effective implementation of the proposed

project was considered in selecting two cities, as it can utilize the experiences gained in the projects, and FAO can mobilize the trained personnel, as well as the infrastructure and network developed in the projects. Two radiuses of 100 km and 150 km around the cities were considered for a display to show the distance from the cities.

The datasets above were aggregated at the district level to produce one layer per attribute were with one value per district, i.e. one value per each attribute at the district level in each single dataset.

The data were eventually classified in scores from 1 to 4 from the lowest to the highest priority. In this way, it was eventually straightforward to display them and to run the multi-criteria decision analysis.

Through a GIS application, the values per each district per each attribute were summed at the district level according to the assigned weight to achieve a final score per district. The assigned weights were in accordance with the importance/relevance of the datasets for the desired objectives as shown in Table 4.

Table 4: Selection of criteria per district for the multi-criteria decision analysis

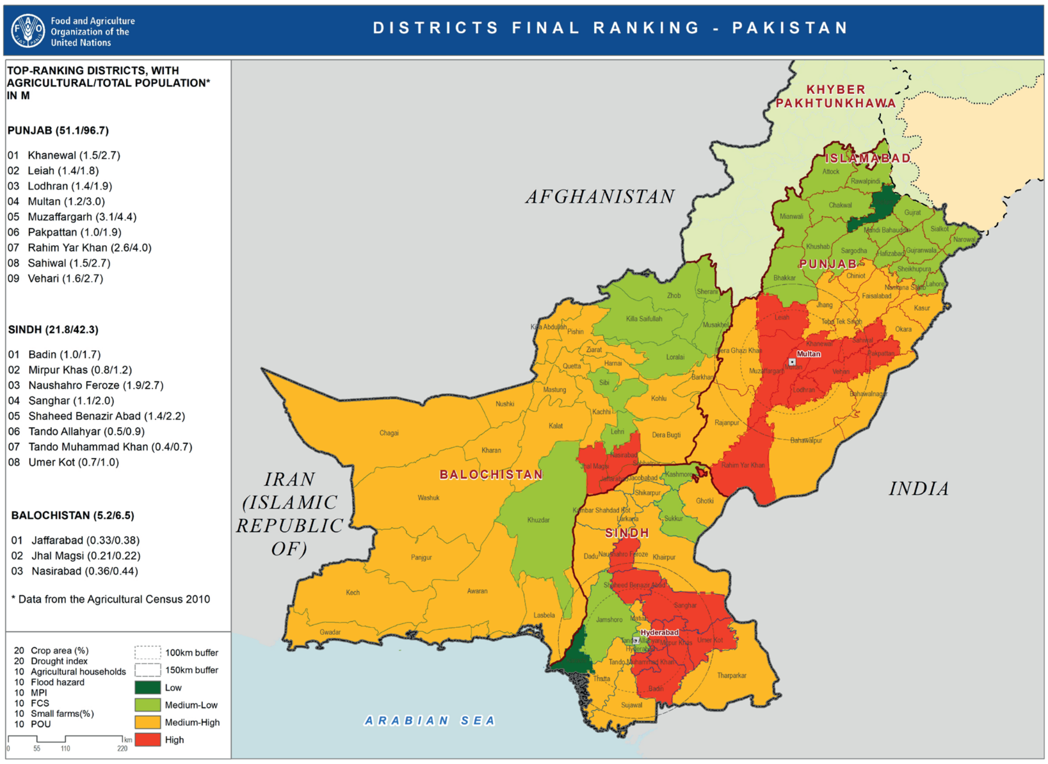
N	CRITERIA/DATASETS	SOURCE	ATTRIBUTE	WEIGHT
1	Crop area	FAO and SUPARCO land cover data 2013	Percentage of four crops classes in FAO land cover	20
2	Drought hazard index	National drought monitoring centre, Pakistan Meteorology Department	Drought hazard index	20
3	Flood hazard	Flood hazard map of the world, ten-year return period, from the Joint Research Centre of the European Commission	Percentage of flooded area in crop area	10
4	Multidimensional Poverty Index (MPI)	UNDP and Government of Pakistan	Multidimensional poverty index	10
5	Food consumption Score (FCS)	Food Security Assessment (FSA),	Food consumption score	10
6	Agricultural households	Pakistan Bureau of Statistics, Agricultural Census 2010	Number of agricultural households	10
7	Percentage of small farms	Pakistan Bureau of Statistics, Agriculture Census 2010	Number of farms smaller than 5 acres for Punjab and smaller than 12 acres for Sindh	10
8	Prevalence of undernourishment (PoU)	Food Security Assessment (FSA), Ministry of National Food security and research	PoU at divisional level	10

OUTPUT

Districts with higher scores have been ranked accordingly and displayed in Figure 8 and Table 5, which also shows the total and agricultural population, as well as the selection criteria and the weights adopted in the selection.

The result of the analysis were presented to the government, in particular to the provincial governments, to make the final decision of the project districts.

Figure 7: Final ranking of districts in Baluchistan, Punjab, and Sindh



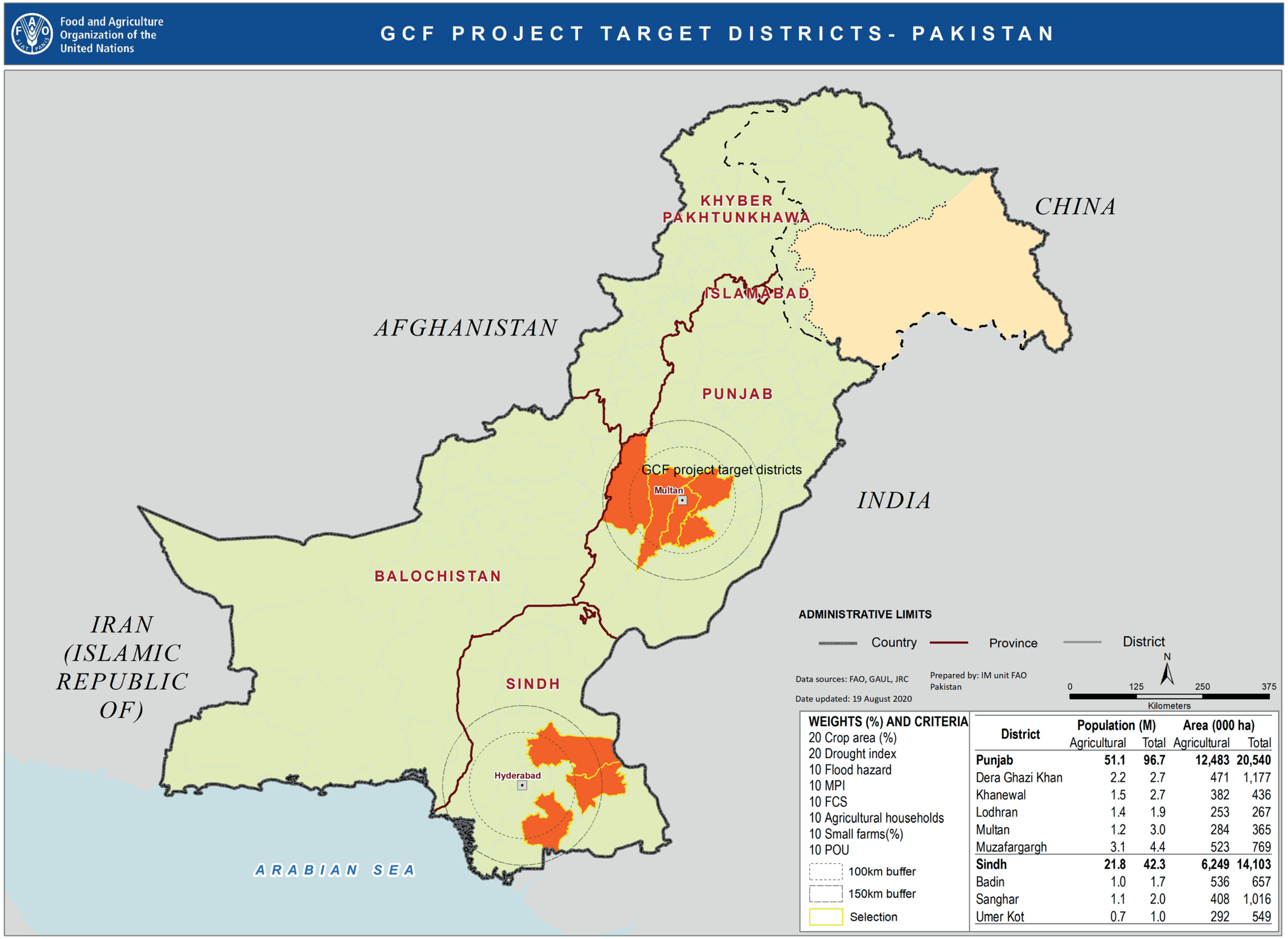
***Source:** Adapted from Map No. 4181 Rev. 1 UNITED NATIONS January 2004*

The selected districts include Dera Ghazi khan, Khanewal, Lodhran, Multan, Muzaffargarh, Badin, Sanghar and Umerkot. Initially, four districts were selected by the government in Punjab, and three districts were selected by the government in Sindh; however, upon request from the Punjab government, Dera Ghazi Khan district was included as the fifth district for Punjab, as its agriculture areas are predominantly rainfed.

Table 5: Final selection of districts in the provinces of Punjab and Sindh

PROVINCES AND DISTRICTS	AGRICULTURAL POPULATION (MILLIONS)	TOTAL POPULATION (MILLIONS)	TOTAL DISTRICT AREA (KM²)
PUNJAB TOTAL	51.1	96.7	205 403
Dera Ghazi Khan	2.2	2.7	11 766
Khanewal	1.5	2.7	4 356
Lodhran	1.4	1.9	2 666
Multan	1.2	3.0	3 648
Muzaffargarh	3.1	4.4	7 688
SINDH TOTAL	21.8	42.3	141 029
Badin	1.0	1.7	6 575
Sanghar	1.1	2.0	10 158
Umer Kot	0.7	1.0	5 490

***Figure 8:** Final selection of districts in the provinces of Punjab and Sindh*



***Source:** Adapted from Map No. 4181 Rev. 1 UNITED NATIONS January 2004*

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Food and Agriculture Organization of the United Nations
National Agriculture Research center (NARC) Premises
Park Road, Chak Shahzad, Islamabad
Website: www.fao.org/Pakistan
: @FAOPakistan

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