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# Spatial distribution of poverty in Pakistan: an asset-based approach

Kifayat Ullah<sup>1</sup> and Muhammad Zubair Chishti<sup>1,2,3\*</sup>

## Abstract

The main objective of this study is to construct a valid and reliable asset index at household level by using NSER-BISP data in order to compute asset poverty for provinces, districts, and tehsils of the Pakistan. An asset index may be better measure than current income or expenditure for gauging household's long-term capacity for buying goods and services and its potential resilience to economic shocks. The study employs multiple correspondence analysis (MCA) to construct asset index contrary to principal component analysis (PCA), as MCA provides us weights and contributions of each dimension of binary variable separately. The average MCA score is showing the level of asset-based poverty wherein higher values of index are representing higher level of poverty. The findings indicate that incidence of asset-based poverty is differently observed across provinces and within provinces through disaggregation of the MCA score at district and tehsil levels. By and large, the poorest districts of Pakistan are belonging to Baluchistan (i.e., Sherani, Kohlu, Chaghi, and Dera Bugti) and Sindh (i.e., Badin, Umerkot, Tando Muhammad Khan, and Tharparker) provinces; however, districts of Punjab (i.e., Lahore, Rawalpindi, and Gujranwala) province are found relatively lower asset-based poverty. Further, the analysis highlights the prevalence of asset-based poverty at tehsils level as well where again the tehsils of Baluchistan and Sindh provinces are bearing the highest asset-based poverty. Furthermore, the study also contributes by visualizing the prevalence of geographical asset-based poverty at district level for all four provinces of Pakistan by GIS mapping.

**Keywords** Poverty, NSER-BISP, MCA, PCA, Pakistan

## Introduction

Poverty is generally defined as income or expenditure insufficiency, but the economic condition of a household also depends on its real and financial asset holdings. To be poor means not only to have a low income but to lack of assets, social services and voice in government [12, 17]. Poverty is normally measured using income as a welfare indicator, as it provides some indication about the capability of individuals to achieve a certain standard of living and also information about income is more readily

available information than for other variables. In fact, amongst the possible options income is not necessarily the best alternative, but it has been widely used to measure poverty mainly because of its availability [48].

In the past decade, development economists have increasingly advocate the use of assets to complement income and consumption-based measure of welfare in developing countries [11, 26]. Asset-based policy is a new kind of social policy, based on savings, investments, and wealth accumulation, encouraging personal development and providing motivation for development of one's skills and abilities in modern, post-industrial economy. This emphasizes long-term possibilities based on accumulated wealth/assets that may encourage personal financial freedom and recovery from poverty [53].

An asset index may be better measure than current income or expenditure for gauging household's long-term

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capacity for buying goods and services and its potential resilience to economic shocks [54]. The poverty analysis and social safety net team (PASSN) use an asset-based approach to poverty reduction because it focuses on assisting the poor to develop this stock and to use their wealth effectively to achieve positive changing in their lives the asset-based approach emphasizes the need to enhance the ability of poor households to participate in, and benefit from, new economic opportunities, as well as the need to reduce the risk and vulnerability face by these households (USAID). An asset-based approach to poverty focuses on assisting the poor to develop their stock of wealth and to use it effectively to achieve sustainable improvements in their lives. To ensure that the poor can create sustainable improvements in their lives, they must be able to develop and maintain their stock of wealth.

Secondly, prevalence of poverty varies within country. The spatial variations within country at province and district levels have been explored in numerous studies [4, 19, 24, 29, 38, 55]. These studies found regional and sub-regional level (district, tehsil, and even village level) disparity regarding poverty in India, Pakistan, and several African and Latin American countries. These studies found that some regions experience less poverty, whereas some regions, especially in rural areas, experience high poverty within a country.

Based on these facts, literature argues that disparities in poverty within a country are linked with differences in geographic capital-biophysical endowment, access to infrastructure and markets areas [3, 6–8, 49]. Spatial poverty has emerged as severe challenge for developing countries, which resulted in bias and unjust distribution of resources. Identification of such areas is required to avoid leakages of resources to fewer poor areas.

In case of Pakistan officially poverty is estimated from HIES/PSLM datasets which have very limited coverage at district level, and these do not have coverage of households at smaller units, i.e., tehsil, union council level. For that reason, official poverty estimates may be biased and unreliable for smaller administrative units. And this also makes evident that geographical targeting has not been under consideration by policy makers. Therefore, nationally defined poverty estimates are needed to be disaggregated into smaller units to seek out its reliability. The dream to reduce poverty would never come true until truly asset vulnerable poor areas are identified.

The main objective of the study is to compute asset-based poverty index as an alternative measure of well-being of the households. To identify spatial clustering of poverty said index are constructed at subnational level, i.e., tehsil, district of all provinces of Pakistan from NSER-BISP data set by using multiple correspondence analysis (MCA) technique. Moreover, study also develops

district-level asset-based index poverty maps for all four provinces of Pakistan by using GIS mapping technique.

Since its inception, Pakistan is bearing the brunt of poverty. To alleviate poverty, right targeting requires identification of poor areas, which have been kept ignore especially far flung areas. Various efforts are made to generate poverty estimates at subnational level in Pakistan [4, 16, 19, 27, 28, 32, 47], and these studies indicate that poverty varies across subgroups of the population with respect to income, gender, demographic characteristics of households, and occupational groups. But, numerous limitations are attached with these studies.

### Significance of the study

Since its inception, Pakistan is bearing the brunt of poverty. To alleviate poverty, exactly locational-based measurement of poverty is critically important to reduce poverty in Pakistan which is aligned to SDG-1, to reduce all forms of poverty by 2030. For this, we used Benazir Income Support Program (BISP) that has conducted a census-type household survey for the year of 2010–2011 contrary to previously done studies in case of Pakistan which use national representative data which may not produce reliable estimates at smaller units as we discussed above because of unavailability of hugely coverage of households in HIES/PSLM. National Socio-Economic Registry (NSER) data set covers huge amount of the households because this survey is the second largest household survey after population census. This survey also does not contain information of income and expenditures, but it does have information of asset possession and household roster and demographic variables. So, NSER data set provides us opportunity to construct asset-based poverty through MCA for districts and tehsils of Pakistan. The construction of index at such a smaller level, i.e., poverty at tehsil level for each district of four provinces, makes the study different from all other studies that calculate asset-based poverty only for districts of four provinces. Secondly, our study also employed multiple correspondence analysis (MCA) applied to generate index when indicators are in categorical form because contrary to already done studies which compute asset index for poverty measurement in case of Pakistan by using principal component analysis (PCA), which gets failed to provide reliable weights in the case binary or categorical variables.

The rest of the study is organized as follows: literature review is discussed in "[Literature review](#)" section; "[Theoretical grounds of asset-based poverty](#)" section encompasses the theoretical and methodological framework, data, and variable description. Results and discussion are

laid down in "Method" section, while concluding remarks are given in the last section "Results and discussion".

### Literature review

This section deals with the studies regarding spatial and geographical poverty in Pakistan. Some important studies [4, 14, 20, 25, 45] are reviewed, and these are given as follows.

Khan et al. [34] have found district-level multiple deprivations in Pakistan. The data of PSLM for the period of (2005) have been taken, and deprivation index has been constructed on the basis of education (illiteracy rate for females, illiteracy rate for male, out of school children), housing quality and congestion (percentage of homeless, percentage of home owing, inadequate material used in wall and roof, room available per member, and households having no facility of wash rooms), residential housing services (un-electrified households, households not using cooking gas, households did not have proper water facility), and employment (unemployment, employed labor force in non-manufacturing sectors). They have used PCA to generate deprivation index. The results suggested that Baluchistan province faces higher deprivation and after that KPK, Sindh, and Punjab, respectively. Moreover, district-wise analysis for least deprived suggested that Quetta was at the top of least deprived district, yielding score of 46, and Sukhar, Peshawar, Faisalabad, Gujarat, Rawalpindi, Sialkot, Gujranwala, Lahore, and Karachi were, respectively, deprived districts of Pakistan. The list of the highest deprived districts of Baluchistan Musakhel, Awaran, Kharan, Zob, Qilla Saifullah, Panjgur, Jhal Magsi, Qilla Abdullah, Khuzdar, and Kohistan were, respectively, highly deprived of the aforementioned indicators. These are indicative of the presence of the spatial and geographical poverty in Pakistan and are required to provide them government consideration.

Cheema et al. [14] have investigated spatial and geographical poverty in Punjab province, and data have been collected from Multiple Indicators Cluster Survey (MICS) for the period of 2003–2004, and it has datum which was representative at district level. The main concern was district level and sub-province-wise poverty; therefore, Punjab has been classified into four regions: Northern Punjab, South Punjab, West Punjab, and central Punjab. Central Punjab consisted of Faisalabad, Lahore, Gujranwala, Sheikhpura, Pakpatan, Sargodha, Hafizabad, Norowal, Gujrat, and Sialkot, Kasur, T.T. Singh, Jhang, Okara, and Sahiwal. North Punjab consisted of Attock, Chakwal, Rawalpindi, and Jahelum. South Punjab comprised Vehari, Lodhran, Multan, R.Y. Khan, Bahawalnagar, and Bahawalpur. Finally, West Punjab consisted of Bhakkar, Mianwali, Rajanpur, Khushab,

Layyah, Muzaffargarh, and D.G. Khan. To calculate poverty, they used deprivation indices, which were calculated by using multiple indicators education, housing quality, housing services, employment, social indicators, and poverty head counts as well. They calculated it with the help of PCA, and they also used simple poverty headcount. The results were suggestive that South and West part of the Punjab were found highly poor in terms of all poverty methods, i.e., headcount ratio and deprivation indices. The least poor part of the Punjab was central Punjab where people were enjoying much better standard of living as compared to all other provinces. There were found high poverty and deprivation differences within regions and across districts as well and poverty profile was also suggested that households which had more educated persons were less deprived. Further findings of the study suggested that poverty estimates differed regarding household characteristics as well.

Naveed and Ali [45] have found spatial distribution of poverty where district level or clustered poverty has been detected; actually, this study is conducted under SDPI. They calculated multidimensional poverty by using Alkir and Foster approach with the help of data collected from HIES/PSLM (2007–2009). Four key dimensions were utilized to construct multidimensional poverty, i.e., education (household members attainment of primary education, child enrollment status), asset ownership (household assets, and landholding), health (access to health care facility, maternal health care), and living conditions of the households (facility of drinking water, sanitation, fuel used for cooking, quality of housing, and electrification). The main focus of the study was to disaggregate that constructed poverty index from national level to subnational level and further extended it to district level, and secondly the study identified the poorest and least poor district, and finally clustering of the geographical poverty was focused. The estimated results showed that overall one-third of the population were found below poverty line, and strong rural/urban poverty incidences could be observed within provinces. The highest poverty incidences about Baluchistan (52%) were come out and KPK (32%), Sindh (44%), and only 19% poverty were found in Punjab. It showed that Punjab province is least poor, whereas other provinces were having relatively higher poverty incidences. Moreover, the disaggregated analyses highlighted there were intra- and inter-provinces' disparities regarding poverty estimates were persistently found. South Punjab was the poorest area of Punjab, southern districts of KPK, and Southwestern part of the Sindh have been emerged as highly poor areas of the respective provinces. Additionally, this study gave the estimates of vulnerability, and it

was found rural areas were more vulnerable than that of urban, and overall vulnerability was 16 percent in Pakistan.

Arif [4] has seen through the poverty profile of Pakistan by using survey-census type data set conducted by Benazir Income Support program (BISP). The main concern of this study was to overcome the shortcoming of previous studies regarding poverty profile of Pakistan and that was small data size. BISP was helpful to calculate asset-based poverty, and the author constructed the poverty in different ways, i.e., multidimensional poverty, and proxy means test (PMT), etc., while using PMT, recommended threshold that was used by BISP to do smooth cash transfer to people who have PMT score less than or equal to 16.7. He found spatial poverty, and poverty regarding household characteristics such as age, dependency ratio, education, employment-wise, and regarding agro-climatic zones. The results were suggesting the poverty incidences that were found having high variation amongst districts, and agro-climatic zones of Pakistan. Baluchistan has appeared as highly poor provinces and even districts of this province were also found highly poor as compared to districts of other provinces. Arid and mixed zones were found highly poor areas, whereas rice-wheat and cotton-wheat areas were relatively facing lower poverty incidences. The results were indicating that there was poverty incidences varied through the household characteristics. Those households which have high or severe dependency ratio were facing high poverty incidences; moreover, high differences were found regarding sex, age, and education of the households.

Fatima [25] has analyzed the prevalence of poverty across agro-climatic regions of the Pakistan. The study has classified Pakistan into nine agro-climatic zones, which were arid zones of Punjab, mixed zones, rice-wheat zones and cotton-wheat zones of Punjab, low-intensity regions of Punjab, similarly cotton-wheat and rice-wheat Sindh, mixed zones of Sindh, and some zones with respect to KPK, and Baluchistan. The study has employed HIES/PSLM (2007–2008) data, and the study has used consumption as the indicator of welfare, and aggregate consumption was adjusted. Three poverty measures were employed, which were 1) head count ratio, average poverty gap, and squared poverty gap to estimate poverty zone wise. The findings were suggesting that Baluchistan was highly poor province because most of its regions were found extremely poor. Less poor regions were rice-wheat, cotton-wheat zones of the Punjab, whereas arid area of Punjab was also found less poor as compared to other provinces. After Baluchistan, major regions of KPK were also appeared as poor areas.

Moreover, low-intensity zones of the Punjab were facing also poverty higher than that of other provinces.

Khan et al. [35] investigate the variation of the multidimensional rural poverty across the region in case of Pakistan. In order to find out the long-run social well-being, they employed the multidirectional socioeconomic measurement of poverty. They incorporate three important dimensions, i.e., health, education, and housing facilities, for accessing rural MDP. Their analysis showed significant variations in MDP rates across region over the time periods (1998–1999, 2001–2002, 2004–2005, 2005–2006, and 2007–2008). Poverty mapping helped in identifying the poor regions, e.g., Zhob, Kalat, and D I Khan were identified as the poorest region in map. However, by visualizing the rural MDP in all time periods implies that poverty alleviation strategies may also be reshaped. Dual approach may be opted to decrease the deprivations of socioeconomic facilities, i.e., direct and indirect strategies. Direct strategies encompass for improvement of health, education, and housing facilities in rural areas. Targeted policies may be evolved with respect to highest deprivation in terms of education, health, and housing in identified poor regions. Corresponding to the type of deprivation, education, health, and housing facilities provided to extremely poor to identify regions. Increased number of health units, free schooling and stipend for students, and free health facilities for deserving rural households may be helpful to eradicate the rural poverty. Regarding indirect steps, the government may take the necessary steps to increase the income level, improve the access to health, education, health facilities, provide subsidized agriculture inputs, and create non-farm employment opportunities, easy access to farm machinery, credit facilities and necessary extension services to the rural households. The outcome of indirect strategy is more sustainable and provides freedom to rural households to decide on the weakest dimension for their spending.

Finally, the aforementioned discussion indicates that poverty varies across provinces, agro-climatic zones, and districts as well. Spatial poverty exists in Pakistan, and there is a need to trace out the asset-based poverty at subnational level in case of Pakistan.

### **Theoretical grounds of asset-based poverty**

Assets are broadly defined and multidimensional, including not only physical capital and financial assets but also the knowledge and skills of individuals, their social bounds and community relations and their ability to influence the policies and institutions that affect them. Low asset levels and the inefficient use of these assets are both causes and consequences of poverty. Financial, human, natural, physical, social, and political assets are

all important parts of the wealth of poor households, and all contribute to their well-being (World Bank). In the past, most of the economists had been increasingly vindicating the usage of asset-based well-being or poverty to complement consumption-/income-based measurement of wealth and welfare in many developing countries [26]. Notion to use income as unit of welfare has been considered and favored only because of being cardinal variable, which is very easy to use for quantitative analysis and even to interpret. Nevertheless, during the last decade the analysis of wealth or asset accumulation is rendered much attention and has been endorsed because it extends policy makers and researchers' understanding of multidimensionality of poverty, and comprehends the complexities that occurred in the process of underlying poverty reduction. The three most important reasons to use asset as indicator of well-being of the households are outlined as follows.

- (1) Assets offers much improved indication of long-term living standards than that of income/consumption approaches.
- (2) Households may have exact calculation of the possession of assets, and therefore, this approach is being used widely by researchers.

Literature regarding asset-based well-being (or inversely asset-based deprivation) has weaved up five major categories of assets which ultimately are prime indicative of determinants households' wealth and living standards, and these are financial capital, human capital, social capital, physical capital, and natural capital [11, 26, 39–43]. Each of these assets comprises some components, which are further determinant of mentioned assets, and these components are discussed in some detail as follows.

#### **Physical capital**

Physical capital is generally defined as comprising the stock of plant equipment; infrastructure and other productive resources were owned by individuals, businesses, and the public sector. In this study, however, physical capital is more limited in scope. It includes the range of consumer durables households acquire, as well as their housing.

Housing is also an important determinant of physical assets where number of rooms and facilities available in a house show condition of house, and furthermore, toilet availability (i.e., what sort of the toilet), fan, TV, fridge, and other durables are suggestive of the living standards of households. Physical assets provide the capability of households to get sustained whenever any lean period comes because it makes household in position to cope

with any shock through asset management. Physical asset contains two main categories of assets, i.e., housing related and household durables. Here, in this study households, which are lacking of durables and housing-related assets, are considered as asset-deprived household (poor).

#### **Financial capital**

The financial/productive capital asset index comprises three components, i.e., labor security, productive assets, and sources from where household receives transfer and rental income as it is apparent from flow chart. Coming to labor security which measures the extent to which an individual has security in the use of their labor potential as an asset either he is employed in public sector or private sector, and the most pathetic condition would be if households are unemployed. This is indicative of income level as well because nature of job and employment status is important to determine living standards if households are unemployed and they have meager job, they might have to still strive for taking himself out of poverty. Moreover, productive durables are significantly important because productive durable such as possession of cars, tractor, and thresher enhances the well-being of households because these are income-generating sources, and similarly, transfer/rental incomes that comprise non-earned monetary resources. Households that are deprived of these assets may face severe challenges to resist against poverty.

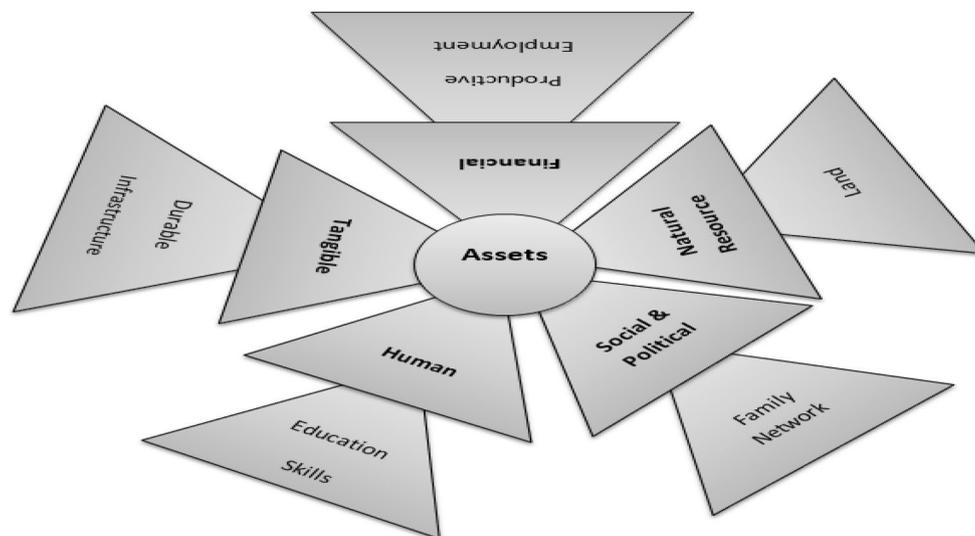
#### **Human capital**

Human capital assets contain investment in human health, education, and nutrition, which affect the human ability to work. Defining human capital in exact way is not easy but commonly education is taken its proxy. Actually human capital is more related to individuals, but, if household is subject, then aggregation is required to observe household-level human capital. Unusually, household surveys comprise information regarding human capital that is completed years of education. So, this proxy is widely used in survey data. Clearly, Fig. 1 presents the flow chart of conceptual synergies of assets.

#### **Method**

##### **Asset-Based Poverty Index**

The existing literature (i.e., [1, 5, 21, 37] suggests multiple techniques to calculate multidimensional and asset-based poverty indices, and those approaches are Alkire and Foster [2] counting approach, principal component analysis (PCA), stochastic dominance (SD), and multiple correspondence analysis (MCA). Specially to calculate asset-based poverty, equal weighting approaches are not considered as appropriate because every asset is



**Fig. 1** Categories of assets

differentiated on the basis of economic value and its significance. Therefore, unequal weighting approaches are thought to be appropriate to construct asset-based poverty index. PCA and MCA are two approaches which are overwhelmingly applied to this sort of poverty as Filmer and Pritchett [26] and Rutstein and Johnson [51] have employed PCA to generate asset-based poverty index. But their studies do not take notice of the limitations of the PCA, which is applicable only in the case of continuous variables, and it fails to provide reliable weights when variables are not continuous [10, 12, 13, 15, 17, 18, 23, 56, 57]. It is usually witnessed that asset variables are found in binary and categorical form. Therefore, alternative to this approach some studies [5, 9] employed MCA to construct asset-based poverty index.

This study also wants to construct asset-based poverty index, whereas all variables are in binary and categorical form, which are discussed in the next section. Above discussion suggests us to use MCA, which is appropriate technique to generate index by using multiple categories of household asset variables. The obtained composite poverty index would be decomposed with respect to different administrative units such as provinces, districts, and tehsils. The detailed discussion and specification of the MCA are given as follows.

MCA is applied to generate index when indicators are in categorical form because PCA gets failed to provide reliable weights in the case of binary or categorical variables. Index of asset poverty is generated by combining 23 indicators which cover housing-related indicators (i.e., flush washroom, no washroom, pit latrine), household durable assets (i.e., freezer, TV, air cooler, air-conditioner, washing machine, and geyser, etc.), capital assets (i.e.,

tractor, car, and scooter, etc.), livestock species, human assets, or capital (i.e., levels of education of household head).

The beauty of MCA is that it provides us weights and contributions of each dimension of variable; for example, the case of binary variable MCA computes weights for both 1 and 0 separately. Index is constructed on the basis of no holding of assets and it gives value which ranges between zero and 1. A higher value of the asset-based poverty index is suggestive of higher level of asset-based poverty and vice versa. The study computes asset poverty for provinces, districts, and tehsils of the Pakistan, and an erudite discussion is hatched for all these administrative units in following sections [22, 25, 30, 31, 33, 36, 39, 40, 44, 46, 50, 52, 59].

#### **Multiple correspondence analysis (MCA)**

MCA is an extension of simple correspondence analysis (CA), and it allows estimating the pattern of the several categorical variables and it also provides the generalization of the principal component analysis (PCA) when the variables are not continuous. Actually, MCA has been designed to bring improvement in procedure of PCA because in the case of binary or multivariate categorical variables PCA fails to generate reliable weights. Contrary to PCA, it is applied to the multivariate categorical data through CA algorithm in the form of Burt matrix, which is the indicator matrix, and this matrix is transposed and multiplied by itself. Furthermore, it concedes eigenvalues, which give a better approximation of the inertia explained by the factors. The procedure of this approach comprises exploration of the internal structure of a covariance matrix. MCA helps to

produce an additive decreasing disaggregation of total variance of Burt or indicator matrix. MCA employs Chi-square metric, whereas PCA uses Euclidean metric to estimate the distance between columns of matrix under concern ([21], 5, Wambugu 2010). Furthermore, MCA comprises some additional properties outlined as follows.

*I-Distributional equivalence property* this property is also termed as the marginalization preference, and it ensures the MCA overweighs the smaller categories within each primary indicator. For the purpose of this study, the assets of the poorest households are receiving higher weights in the construction of composite index for asset-based poverty.

*II-Duality or reciprocal bi-additivity property* composite asset-based poverty score is the simple average of standardize factorial weights. Similarly, the weight of the given asset-based poverty category is also the simple average of standardize composite asset poverty scores of the population units belonging to the corresponding poverty gaps.

Asseline [5] also discusses two more properties that must be fulfilled. MCA-based asset poverty index should be monotonically increasing in each of its primary indicators, and secondly, it should satisfy the composite poverty ordering consistency. Hence, all these properties are imperative to be satisfied while applying MCA.

The specification of the MCA is presented in the following equation.

$$C_i = \frac{1}{K} \left[ \sum_{k=1}^K \sum_{j=1}^n W_{jk}^K I_{jk}^K \right] \tag{1}$$

The above equation shows the specification of MCA where  $J_k$  is the number of categories of the indicator  $k$  and  $W_{jk}^K$  is the score of category  $J$  and  $I_{jk}^K$  are the binary variables.

The main features of the MCA show that one can attain the contribution and weights of each category of the variables. For example, in the case of binary variables, it provides contribution and weight of both 0 and 1 separately. The obtained scoring coefficients or weights are applied to each household, and then, composite index is generated. The estimated values of composite asset-based poverty index revolve between 0 and 1. The higher the values of index would reflect the higher poverty status (or i.e. approaches to 1) and index would show lower poverty if values of index range closer to zero.

**Table 1** Percentage NSER sample for provinces. *Source:* BISP, Islamabad

Province name	Sample size	Percent	Comparison with actual NSER distribution
Punjab	509,773	53.45	1.04
Sindh	232,440	24.37	1.00
KPK	127,974	13.42	0.96
Baluchistan	34,948	3.66	0.80
Islamabad	6,951	0.73	1.04
Gilgit-Baltistan	5,365	0.56	0.80
FATA	15,891	1.67	0.88
Azad Jammu Kashmir	20,310	2.13	0.93

**Data and variable construction**

The limitation of this NSER-BISP census-type survey data is that it does not contain the information of income and expenditures of the households, but it holds data of assets of households, i.e., human capital, household assets, land, and employment status (private/public job, and unemployed). Therefore, this study will calculate asset-based poverty from this data set to find out spatial distribution of asset poverty in Pakistan.

**National Socioeconomic Registry (NSER, 2010–2011)**

The Benazir Income Support Program (BISP) has made effort to identify poor households through a multidimensional measure and conduct a door-to-door census to calculate (proxy means test) PMT score and this survey named as National Socioeconomic Registry (NSER).

The total coverage of the survey is over 27 million households (HH) that constitutes more than 150 million people across the country. The estimated population during 2010 was 177.94 million which implies the coverage of this survey was around 85 percent. Province coverage shows that 14.88 million households were covered in Punjab, 6.6 million in Sindh, 3.6 million in KPK, and 1.1 million in Baluchistan. The coverage of Azad Jammu Kashmir (AJK) is around 0.588 million, and Gilgit-Baltistan contains 0.15 million, whereas Federally Administrative Tribal Area (FATA) covers 0.40 million.

After cleaning the data and dropping missing information, we have exactly 953,652 households. The percentage frequency distribution of selected sample size is suggestive of the larger sample from Punjab (53.45%) and 24% of selected sample belong to Sindh, and 13.42% of sample is covered by KPK, whereas 3.66% sample consists of 34,948 households from Baluchistan province. Table 1 makes it evident that these four provinces of Pakistan cover 94.91 percent of whole selected sample size. Rests of the coverage of households are made by Islamabad (0.73%) which

**Table 2** Description of the indicators used in asset-based poverty index calculated by MCA

Indicators	Description of the asset-based indicators	Unit
Flush Washroom	It takes value 1 if HHs have flush washroom and otherwise zero	Dummy
Pit Latrine	1 if HHs have pit latrine and otherwise zero	Dummy
No Toilet	1 if HHs have no latrine and otherwise zero	Dummy
Freezer/Fridge	1 if HHs have freezer/fridge and otherwise zero	Dummy
Washing machine	1 if HHs have washing machine and otherwise zero	Dummy
Motorcycle	1 if HHs have motorcycle and otherwise zero	Dummy
Car	1 if HHs have car and otherwise zero	Dummy
TV	1 if HHs have TV and otherwise zero	Dummy
Tractor	1 if HHs have tractor and otherwise zero	Dummy
Air Cooler	1 if HHs have air cooler and otherwise zero	Dummy
Air Conditioner	1 if HHs have air conditioner and otherwise zero	Dummy
Geyser	1 if HHs have geyser and otherwise zero	Dummy
Heater	1 if HHs have heater and otherwise zero	Dummy
No Education	1 if HH has no education and otherwise zero	Dummy
Primary Education	1 if HH has primary education and otherwise zero	Dummy
Middle Education	1 if HH has middle education and otherwise zero	Dummy
Metric Education	1 if HH has metric education and otherwise zero	Dummy
Intermediate	1 if HH has intermediate education and otherwise zero	Dummy
Above Intermediate	1 if HH has above inter education and otherwise zero	Dummy
Sheep	1 if HHs have any sheep and otherwise zero	Dummy
Goat	1 if HHs have any goat and otherwise zero	Dummy
Cow	1 if HHs have any cow and otherwise zero	Dummy
Buffalo	1 if HHs have any buffalo and otherwise zero	Dummy

HHs stands for households, whereas HH stands for household head

is capital of Pakistan, and Gilgit Baltistan (0.56%), FATA (1.67%), and AJK (2.13%). It is important to mention that the limitation of NSER is that it fails to identify rural and urban households.

And a detailed distribution of data collected for this study is presented in Table 1 where province-wise sample size is given.

#### **Variables construction**

This section comprises the detailed discussion on construction of the variables which are being used in construction of asset-based poverty index.

#### **Variables used in asset-based poverty index**

The asset-based poverty index is constructed by application of MCA on the basis of household assets which are valuable assets, household durable assets, livestock assets, and housing-related variables and education level which is indicative of human capital. All those variables are given in Table 2.

Above-mentioned indicators are used to generate asset-based poverty by using MCA, which would give us contribution and relative weights of each dimension of every indicator. The beauty of this approach is this we can

understand which asset is more contributing in poverty of concerned geographical unit. All these indicators of asset variables are widely used by literature, and they are constructed by same definition more or less.

## **Results and discussion**

### **Asset-based poverty estimated by multiple correspondence analysis (MCA)**

The study also aims at estimating the asset-based poverty from NSER dataset by using MCA. Before analyzing the asset-based poverty, the study discusses percentage distribution of all indicators which are employed to compute asset-based poverty.

### **Percentage distribution of indicators of household assets**

Percentage distribution of the indicators of household assets is given in Table 3, and it covers both dimensions of households that respective asset is owned by households and not ownership of physical assets. The results are indicating that education attainment is not found amongst highly owned asset. The term asset for education is used because it is the indicator of human capital. Hence, the deprivation of education is observed higher amongst the employed assets in poverty index.

**Table 3** Percentage distribution of household assets in Pakistan. *Source:* Author's calculation

Asset	Not own (%age)	Own (%age)	Asset	Not own (%age)	Own (%age)
Bike	81.98	18.02	Cooking Stove	40	60
Freezer Refreg	84.37	15.63	Washing Machine	76.42	23.58
Buffalo-Cow	78.4	21.6	Pit latrine	80.98	19.02
Goat Sheep	80.92	19.08	Toilet	34.81	65.19
Above Inter Education	96.67	3.33	Toilet Flush	53.83	46.17
Intermediate Education	96.66	3.34	Car	98.73	1.27
Metric Education	88.75	11.25	Heater	96.61	3.39
Middle Education	90.75	9.25	TV	60.43	39.57
Primary Education	54.86	45.14	Geezer	98.04	1.96
Air conditioner	98.44	1.56	Air cooler	98.15	1.85
Tractor	99.19	0.81	Microwave oven	98.6	1.4

**Table 4** Provincial asset-based poverty by decomposition of MCA score. *Source:* Author's own calculation

Province	Overall mean MCA score	% Distribution of four groups HH by MCA score			
		1st Group (0.0 ≤ MCA < 0.25)	2nd Group (0.26 ≤ MCA < 0.50)	3rd Group (0.51 ≤ MCA < 0.75)	4th Group (0.74 ≤ MCA < 1)
Punjab	0.68	0.10	2.68	79.84	17.37
Sindh	0.71	0.03	0.93	64.46	34.59
KPK	0.70	0.02	1.02	67.02	31.94
Baluchistan	0.72	0.07	1.12	53.04	45.77
Islamabad	0.61	8.77	13.30	70.99	6.94
Gilgit	0.70	0.00	1.73	69.67	28.61
Fata	0.73	0.05	0.83	63.43	35.70
AJK	0.69	0.06	2.59	67.03	30.32

Above table is suggesting that households are highly deprived in terms of physical assets such as households having bike or not, freezer, livestock ownership, wash-room-related indicator, air cooler, air conditioner, and other assets. Evidently, it can be observed from Table 3 that households are facing higher poverty in terms of each asset items.

#### Analysis of asset poverty by provinces

The decomposition of the index for province of the Pakistan is suggesting that Baluchistan province is yielding the highest score of 0.72, whereas KPK (0.70), Sindh (0.71), and Punjab are retaining the lowest score of 0.68. These scores are indicating that asset-based poverty higher in Baluchistan province and Punjab is the least poor in terms of asset-based poverty. By and large, the mean score of all provinces is very high which makes it evident that people of Pakistan are facing severe poverty in terms of assets (Table 4).

The results for other larger administrative units of the Pakistan are making evident that FATA is retaining the

score of 0.73 which is the highest score. The estimated score is suggesting that FATA is the poorest area of Pakistan in terms of asset-based poverty. Gilgit-Baltistan and AJK are conceding 0.70 and 0.69 MCA score, respectively. And Islamabad is found to be the least poor area of the Pakistan which contained 0.61 score.<sup>1</sup>

The study further decomposes the MCA score in four groups which are: (1) MCA score is less than 0.25, (2) MCA score ranges between 0.25 and 0.50, and (3) MCA ranges between 0.51 and 0.75, and (4) lastly MCA ranges between 0.76 and 1.00. The objective of this decomposition is to learn the severity of the asset-based poverty. The estimated results are highlighting that most of the households are laying in the higher score groups for all provinces.

Above table is showing that 79% households of the Punjab province are found lying in third group where score of the MCA ranges between 0.51 and 0.75, whereas 17.37% households are facing the severest asset-based

<sup>1</sup> See Table 4.

poverty. Further findings are indicating that 46% households of the Baluchistan Province are observed as the severest poor who are found amongst the fourth group ( $0.74 \leq MCA \leq 1.00$ ), while her 53% households are prevailing in the range of third group ( $0.51 \leq MCA \leq 0.75$ ). The results for Sindh province are showing that 64% of the households are found in third group, whereas 35% households of the Sindh are lying in fourth group which is showing severe asset-based poverty. Similarly, 67% households of the KPK are observed as asset-based poverty found in third group, whereas 32% households are presented in the severest poor group. The rest of the information are presented in table given above.

#### **Asset-based poverty index by districts and tehsils of Punjab**

An index constructed by MCA is further decomposed for districts of Punjab. The results indicate that highest asset poverty is prevailing in district Rajanpur of South Punjab wherein MCA score has been observed 0.75, and second highest score of index is 0.73 for district Muzaffargarh, whereas third highest MCA score is observed for district Rahim Yar Khan (0.72). Decomposition of the asset score is highlighting that overall mean score of all districts of Punjab province is ranging between 0.6 and 0.75, which is evidently obvious from Table 4.

Lahore district is found conceding the 0.61 score which is the lowest score of index which indicates that Lahore is the least asset-based poor district of Punjab. Similarly, the MCA score is showing that Rawalpindi district is conceding second least score, whereas Gujranwala district is found taking third lower score of the MCA index.

The rest of the detail of the districts is presented in Table 5, which shows that asset-based poverty is highly prevalent in all districts of the Punjab, whereas previous section also suggests that predicted consumption-based poverty has been found almost 35%. But MCA-based index of household asset poverty is showing that households of Punjab province are not well off in terms of assets which determines the well-being of households in society.

The study also endeavors to decompose the MCA index at tehsils of Punjab province. Table given in Appendix-A1 comprises detailed information of asset-based poverty computed from MCA for tehsils by districts. The results are indicating variation in the score of asset-based poverty for all tehsils across and within districts of the Punjab. Results obtained from MCA are demonstrating that across districts, tehsil of Rajanpur such as Rojhan (0.76), Jampur (0.74), and tehsils of districts Chiniot, Faisalabad, Rahim Yar Khan, and Muzaffargarh are found having highest score of the asset-based poverty, whereas tehsils of Lahore such as Samanabad (0.57) and Shalimar town (0.58), Gujranwala, and Rawalpindi are conceding

**Table 5** Asset-based poverty index for districts of Punjab. *Source:* Author's calculations

District name	MCA score	S.E	District name	MCA score	S.E
Attock	0.662	0.00092	Leiah	0.72	0.00054
Toba tek singh	0.666	0.0007	Chiniot	0.714	0.0007
Sialkot	0.626	0.00066	Jhang	0.717	0.00043
Sheikhupura	0.65	0.00059	Faisalabad	0.675	0.0004
Sargodha	0.694	0.00051	Lahore	0.616	0.00049
Sahiwal	0.691	0.00055	Gujranwala	0.64	0.00057
Rawalpindi	0.639	0.00057	Kasur	0.699	0.00057
Rajanpur	0.75	0.00049	Khushab	0.693	0.00069
R.Y. Khan	0.721	0.00035	Khanewal	0.702	0.00047
Pakpattan	0.71	0.00058	Gujrat	0.639	0.00083
Okara	0.702	0.00043	Bahawalnagar	0.696	0.00055
Narowal	0.68	0.00073	Bahawalpur	0.706	0.00052
Nankana sahib	0.692	0.00084	Bhakkar	0.709	0.00066
Muzaffargarh	0.734	0.00031	Chakwal	0.686	0.00089
Multan	0.702	0.00049	Jhelum	0.646	0.0011
Mianwali	0.691	0.00082	D.G. Khan	0.718	0.00052
Mandi B.Din	0.67	0.00099	Hafizabad	0.695	0.00092
Lodhran	0.718	0.0005	Vehari	0.702	0.00048

relatively lower score of the MCA index of asset-based poverty.

Further the findings are indicative of the variation in the incidence of the asset-based poverty within district as well. The score for Rajanpur is showing that tehsil Rajanpur is relatively least poor, whereas tehsil Rojhan is the poorest of this district. Similarly, tehsil Bhowana is appeared as highly poor tehsil of district Chiniot, and tehsil Fateh Jang is the poorest tehsil of the Attock district, whereas tehsil Kot Radha Kishen of district Kasur is highly conceding MCA score. Similarly, all tehsils of all districts are also showing the different scores of asset-based poverty computed by MCA.

Conclusion of the whole discussion is that asset-based poverty has been estimated for the districts and their tehsils of the Punjab province. Especially districts of the South Punjab are appeared as having higher index of asset-based poverty.

#### **Asset-based poverty index by districts and tehsils of Sindh province**

The estimated results for the districts of the province Sindh are showing that Badin (0.77), Umerkot (0.764), Thatta (0.754), Tanddo Muhammad Khan (0.754),

**Table 6** Asset-based poverty index for districts of Sindh province. Source: Author's own calculation

District name	MCA score	S.E	District name	MCA score	S.E
Badin	0.77565	0.00042	Khairpur	0.72862	0.00052
Dadu	0.72547	0.00051	Larkana	0.7355	0.00064
Ghotki	0.73344	0.00058	Naushahro feroze	0.73523	0.00056
Hyderabad	0.68415	0.00077	Sanghar	0.72739	0.00044
Jacobabad	0.73316	0.00067	Nawab Shah	0.7448	0.00062
Jamshoro	0.72353	0.00079	Shikarpur	0.73457	0.00054
Kambar Shahdad kot	0.72991	0.00046	Sukkur	0.69755	0.00083
Karachi Central	0.62701	0.00062	Tando Allahyar	0.74807	0.00102
Karachi East	0.63919	0.0005	Tando Muhammad Khan	0.75486	0.00095
Karachi Malir	0.6650	0.0006	Tharparkar	0.74713	0.00025
Karachi South	0.64776	0.00061	Thatta	0.75442	0.0004
Karachi West	0.66743	0.0004	Umer kot	0.76447	0.00056
Kashmore	0.73257	0.00058			

Tanddo Allah Yar (0.744), and Tharparker (0.743) are containing, respectively, a higher score of asset-based poverty. The most of districts of Sindh province are conceding the score above 0.70 on average, whereas Karachi is the least district of Sindh. Further results of the Karachi are highlighting that Karachi West is the poorest area, whereas Central Karachi is the least poor district where MCA score is observed 0.62. And Karachi Malir is also conceding higher score, which is the second highly poor district of Karachi Division. The detailed demonstration of the MCA score for asset-based poverty is presented in Table 6.

The decomposed asset-based poverty index is showing that tehsils of the Badin district such as tehsil Golarachi (0.78), Tandobago (0.76), and tehsil Malti (0.75) are appeared as the poorest asset-based poverty, whereas the tehsils of districts of Tando Allah Yar, Tharparker, Thatta, and Shikarpur are also showing high asset-based poverty. Similar to the asset-based poverty for districts of the Sindh, tehsils of the respective districts are found higher score obtained from MCA, and the detailed description of these scores is given in Appendix-A2.

In sum, the findings are suggestive of the higher score of poverty for districts and tehsils of the asset-based poverty as compared to Punjab province.

#### **Asset-based poverty index by districts and tehsils of KPK province**

Asset-based poverty index is suggestive of higher poverty in KPK as compared to Punjab but lower than Sindh. The poorest districts of KPK are Upper Dir (0.743), Lakki Marwat (0.74), Sawabi (0.739), Charsada (0.738), and Lower Dir (0.731), respectively, in terms of asset-based poverty. Virtually all districts are conceding higher poverty score, which makes it evident that asset-based

poverty is prevailing very high. The least poor district of KPK is Shangla which appeared as taking 0.67 MCA score.

After discussing the district-level mean score of the asset-based poverty, the study also decomposes the MCA score for tehsils of KPK. MCA score indicates that asset-based poverty is found prevailing in tehsils, and their scores are observed higher as compared to district level. The poorest tehsil Kala Dhaka of district Mansehra is found containing 0.76, whereas tehsil Oghi of same district is also found conceding score (0.759), which is the second poorest tehsil of KPK. The least poor tehsil of KPK is Peshawar where 0.67 score is observed. Majority of the tehsils are facing severe asset-based poverty as MCA scores given in Appendix-A3.

By and large, asset-based poverty is highly prevalent in all districts of the KPK. And further the poverty index is also decomposed at tehsils level where the results demonstrated high levels of MCA score (Table 7).

#### **Asset-based poverty index by districts and tehsils of Baluchistan**

Mean score of MCA is indicating that Sherani (0.78), Washuk (0.766), Kohlu (0.76), Chaghi (0.761), and Barkhan (0.757) are found, respectively, the poorest districts of Baluchistan. Only Quetta district is appeared as the least poor district of the Baluchistan.

Table 8 indicates that MCA score is found very high in all districts of the Baluchistan province, which highlight that households of the districts of Baluchistan are facing severe asset-based poverty. Results further demonstrate that almost all districts are found containing MCA score higher than 0.70, which suggests the severity of poverty in province.

**Table 7** Mean score of asset-based poverty index for districts of KPK. *Source:* Author's own calculation

District name	MCA score	S.E	District name	MCA score	S.E
Upper dir	0.740	0.0007	Kohistan	0.702	0.0011
Abotabad	0.708	0.0018	Kohat	0.715	0.0011
Tank	0.718	0.0006	Karak	0.682	0.0012
Swat	0.730	0.0007	Haripur	0.699	0.0012
Swabi	0.739	0.0006	Hangu	0.709	0.0008
Shangla	0.676	0.0007	D. I. Khan	0.707	0.0017
Peshawar	0.686	0.0009	Chitral	0.706	0.0008
Nowshera	0.707	0.0007	Charsadda	0.736	0.0009
Mardan	0.723	0.0007	Buner	0.718	0.0007
Mansehra	0.706	0.0013	Batagram	0.694	0.0011
Malakand	0.720	0.0008	Bannu	0.672	0.0010
Lower Dir	0.734	0.0007	Lakki Marwat	0.742	0.0007

**Table 8** Mean score of asset-based poverty index for districts of Baluchistan. *Source:* Author's own calculation

District name	MCA score	S.E	District name	MCA score	S.E
Ziarat	0.73321	0.0024	Killa saiful-lah	0.6878	0.00209
Zhob	0.74697	0.00212	Killa abdullah	0.71543	0.00172
Washuk	0.7668	0.00242	Khuzdar	0.74183	0.00104
Sibbi	0.7354	0.00269	Kharan	0.73465	0.00237
Sherani	0.7876	0.00165	Kech	0.73067	0.00092
Quetta	0.66765	0.00137	Kalat	0.73023	0.00199
Pishin	0.70594	0.00139	Kachhi	0.74806	0.00125
Panjgur	0.74145	0.00155	Jhal magsi	0.7404	0.00206
Nushki	0.75015	0.00259	Jaffarabad	0.74409	0.00131
Nasirabad	0.7574	0.00147	Harnai	0.7422	0.00261
Musakhel	0.74571	0.00084	Gwadar	0.75061	0.00167
Mastung	0.70753	0.0012	Dera bugti	0.75767	0.00285
Loralai	0.73842	0.0017	Chagai	0.76185	0.00187
Lasbela	0.75284	0.00107	Barkhan	0.75744	0.0022
Kohlu	0.76248	0.00326	Awaran	0.75157	0.00152

Table given in Appendix-A4 also demonstrates that tehsils of Baluchistan province are also experiencing higher asset-based poverty because MCA scores are found relatively higher as compared to district-level mean scores. The variation of asset-based deprivation is prevailing within districts as well, and it indicates that Phelawagh is the poorest tehsil in district Dera Bugti, similarly Sui tehsil is standing at second poorest tehsil, whereas tehsil Dera Bugti is the least poor tehsils of the district. Tehsils of Quetta are facing relatively lower

poverty, while tehsils rests of the districts are not suggesting encouraging spectrum, wherein average MCA score is estimated very high as compared to the tehsils of all other provinces.

### Geographic information system (GIS) mapping

In recent years, however, there is an increasing recognition of the role of geography in understanding and analyzing poverty. The development of geographic information systems (GIS) together with advances in remote sensing has taken the leap to incorporate spatial data and satellite imageries suitable for poverty analysis. GIS was also found to be useful in highlighting geographic variations of poverty and simultaneously displaying different dimensions and understanding its determinants at disaggregated level.

District-level asset-based poverty score is mapped by GIS. These maps are given in Appendix-B1 for districts of Punjab, Appendix-B2 for districts of Sindh, Appendix-B3 for districts of KP, and Appendix-B4 for districts of Baluchistan. Nonetheless, districts of Baluchistan province are found highly poor in terms of household asset ownership. Again, district of Punjab is facing relatively lower poverty.

### Conclusion

The findings indicate that incidence of asset-based poverty is differently observed across provinces and within provinces through disaggregation of the MCA score at district and tehsil level. FATA and Baluchistan are the poorest larger administrative units of the Pakistan, whereas Islamabad is appeared as the least poor administrative unit.

By and large, the poorest districts of Pakistan are belonging to Baluchistan (i.e., Sherani, Kohlu, Chaghi, and Dera Bugti) and Sindh (i.e., Badin, Umerkot, Tando Muhammad Khan, and Tharparker) provinces; however, districts of Punjab (i.e., Lahore, Rawalpindi, and Gujranwala) province are found relatively lower asset-based poverty. Further the analysis highlights the prevalence of asset-based poverty at tehsils level as well where again the tehsils of Baluchistan and Sindh provinces are bearing the highest asset-based poverty.

The estimated findings of the study may help policymakers in achieving the sub-targets of SDG-1 for Pakistan. Few important policy implications are recommended for poverty at districts and tehsils levels of Pakistan. Financial assistance schemes are one such policy that targets the poor and can reduce poverty at sub-regional level. Therefore, governments should create suitable social, legal, and political environments to combat the issue of regional poverty. Hence, in terms of the policy, this study suggests that policies designed at reducing

regional poverty should first consider asset holdings of deprived households at the sub-regional level in Pakistan as a pre-requisite for poverty eradication.

**Limitation of the study**

We have tried our best to weave up ongoing study and have tried to cover all aspects as much as possible which

could be helpful to complete the study. Nonetheless, there are some limitations of the study that we are failed to incorporate rural–urban differences because NSER dataset does not contain rural urban distinction. If we have this identification, results can be better and much improved.

**Appendix-A1: Asset-based MCA score of Punjab at tehsil level**

District	Tehsil name	MCA	S.E	District	Tehsil Name	MCA	S.E	District	Tehsil name	MCA	S.E				
Attock	Attock	0.644	0.0023	Hafizabad	Hafizabad	0.679	0.0013	Muzaffargarh	Alipur	0.725	0.0007				
	Fateh jang	0.68	0.0022		Hafizabad	Pindi bhattian	0.713		0.0011	Jatoi	0.751	0.0007			
	Hasan abdal	0.658	0.0025		Jhang	18-hazari	0.738		0.0081	Kot addu	0.728	0.0006			
	Hazro	0.653	0.002		Jhang	Ahmadpur sial	0.732		0.0008	Muzaffargarh	0.737	0.0005			
	Jand	0.676	0.0018		Jhang	Jhang	0.713		0.0006	Nankana sahib	Nankana sahib	0.702	0.001		
Bahawal-nagar	Pindi gheb	0.659	0.0026	Jhelum	Shorkot	0.714	0.001	Narowal	Sangla hill	0.656	0.0019				
	Bahawalnagar	0.706	0.0011		Dina	Dina	0.632		0.0026	Shah kot	0.684	0.0018			
	Chishtian	0.691	0.0011		Jhelum	Jhelum	0.628		0.0021	Narowal	Narowal	0.682	0.001		
	Fortabbas	0.687	0.0014		Pind dadan khan	Pind dadan khan	0.671		0.0019	Shakargarh	Shakargarh	0.675	0.0012		
	Haroonabad	0.678	0.0014		Kasur	Sohawa	0.656		0.0028	Okara	Zafarwal	0.69	0.0023		
	Minchinabad	0.716	0.0011			Chunian	Chunian		0.708		0.0011	Depalpur	0.708	0.0006	
	Ahmadpur east	0.729	0.0007			Kasur	Kasur		0.704		0.0009	Okara	Okara	0.696	0.0007
	Bahawalpur	0.674	0.0011			Kot radha kishen	Kot radha kishen		0.714		0.002	Renala khurd	Renala khurd	0.697	0.0012
	Hasilpur	0.695	0.0014			Khanewal	Pattoki		0.678		0.0011	Pakpattan	Arif wala	0.716	0.0008
	Khairpur tamewali	0.722	0.0014		Jahanian		Jahanian		0.7	0.0012	Pakpattan		Pakpattan	0.704	0.0008
Yazman	0.72	0.0012	Kabirwala	Kabirwala	0.717		0.0008	Rahim yar khan	Liaquat pur	0.734	0.0006				
Bhakkar	Bhakkar	0.696	0.0011	Khanewal	Khanewal	0.694	0.0009	Rahim yar khan	Rahim yar khan	0.71	0.0006				
	Darya khan	0.714	0.0013		Khushab	Mian channu	0.695		0.0009	Rajanpur	Sadiqabad	0.722	0.0008		
	Kalur kot	0.715	0.0013			Khushab	Khushab		0.685		0.0008	Jampur	0.745	0.0007	
	Mankera	0.729	0.0014			Noorpur	Noorpur		0.717		0.0011	Rajanpur	0.735	0.001	
Chakwal	Chakwal	0.677	0.0014	Lahore		Qaidabad	0.694	0.0051	Rawalpindi		Rojhan	0.764	0.0007		
	Choa saidan shah	0.677	0.0026		Allam iqbal town	Allam iqbal town	0.605	0.0018		Gujar khan	0.671	0.0013			
	Kallar kahar	0.692	0.0024		Aziz bhatti town	Aziz bhatti town	0.609	0.0022		Kahuta	0.672	0.002			
	Tala gang	0.7	0.0014		Data gb town	Data gb town	0.596	0.0019		Kallar say-addan	0.66	0.0023			
Chiniot	Bhawana	0.731	0.0009	Lahore	Gulberg town	0.614	0.0025	Rawalpindi	Kotli sattian	0.712	0.002				
	Chiniot	0.702	0.0011		Lahore	Lahore	0.635		0.0012	Murree	0.688	0.0019			
	Lalian	0.714	0.0014		Lahore city	Lahore city	0.611		0.0008	Rawalpindi	0.625	0.0007			
Dera ghazi khan	D.g khan (tribal area)	0.732	0.0012	Lahore	Nashter town	0.653	0.0013	Sahiwal	Taxila	0.614	0.002				
	Dera ghazi khan	0.714	0.0006		Ravi town	Ravi town	0.636		0.0014	Chichawatni	0.69	0.0007			
	Taunsa	0.725	0.001		Samanabad town	Samanabad town	0.575		0.0021	Sahiwal	0.694	0.0007			

District	Tehsil name	MCA	S.E	District	Tehsil Name	MCA	S.E	District	Tehsil name	MCA	S.E
Faisalabad	Chak jhumra	0.687	0.0017	Leiah	Shalimar town	0.586	0.0022	Sargodha	Bhalwal	0.691	0.0012
	Faisalabad	0.644	0.0007		Wahga town	0.658	0.0019		Kot momin	0.715	0.0011
	Faisalabad sadar	0.682	0.0008		Choubara	0.743	0.0007		Sargodha	0.68	0.001
	Jaranwala	0.7	0.0007	Lodhran	Karor lal esan	0.72	0.0008	Shahpur	0.705	0.0011	
	Summundri	0.668	0.0011		Leiah	0.719	0.0009	Sillanwali	0.692	0.0017	
	Tandlian wala	0.736	0.0009		Dunyapur	0.715	0.001	Ferozewala	0.661	0.0016	
Gujranwala	Aroop town	0.628	0.0058	Mandi bahauddin	Kahrroo pacca	0.716	0.0009	Sheikhpura	Muridke	0.651	0.0012
	Gujranwala	0.625	0.0008		Lodhran	0.722	0.0007		Safdarabad	0.657	0.0016
	Kamoke	0.662	0.0014		Malakwal	0.685	0.0018		Sharak pur	0.657	0.0027
	Khiali shah pur town	0.652	0.004	Mianwali	Mandi bahauddin	0.651	0.0017	Sheikhpura	0.665	0.0009	
	Nandi pur town	0.608	0.0071		Phalia	0.681	0.0016	Sialkot	Daska	0.633	0.0012
	Nowshera virkan	0.676	0.0013		Isakhel	0.706	0.0014	Pasrur	0.66	0.0011	
	Qila dedar singh town	0.627	0.0047	Mianwali	Mianwali	0.688	0.0012	Sambrial	0.63	0.0018	
	Wazirabad	0.649	0.0014		Piplan	0.683	0.0016	Sialkot	0.603	0.0011	

#### Appendix-A2: Asset-based MCA score of Sindh at tehsil level

District name	Tehsil name	MCA	S.E	District name	Tehsil name	MCA	S.E	District name	Tehsil name	MCA	S.E	
Badin	Badin	0.7642	0.00078	Kashmore	Kandh kot	0.7269	0.0011	Shaheed benazir abad	Sakrand	0.7487	0.0012	
	Golarchi	0.7775	0.0007		Kashmore	0.7322	0.0011		Shikarpur	Garhi yasin	0.7442	0.0009
	Matli	0.7577	0.00103		Tangwani	0.7394	0.0007		Khanpur	0.7503	0.0008	
	Talhar	0.7625	0.00143		Khairpur	Faiz ganj	0.7364		0.0013	Lakhi	0.7303	0.0011
	Tando bago	0.7674	0.00082		Gambat	0.7271	0.0013		Shikarpur	0.7141	0.0012	
Dadu	Dadu	0.7114	0.00105	Khairpur	Khairpur	0.7024	0.0016	Sukkur	New sukkur	0.7044	0.0017	
	Johi	0.7558	0.0009		Kingri	0.7216	0.0016		Rohri	0.7117	0.0016	
	Khairpur nathan shah	0.7215	0.00086		Kot diji	0.7414	0.001		Salehpat	0.7348	0.0017	
Ghotki	Mehar	0.721	0.00092	Larkana	Nara	0.7563	0.001	Tando allahyar	Sukkur	0.6356	0.002	
	Daharki	0.731	0.00141		Sobho dero	0.7288	0.0014		Chamber	0.7649	0.0013	
	Ghotki	0.726	0.00107		Thari meer wah	0.7343	0.0011		Jhando mari	0.7619	0.0012	
	Khanganrh	0.7454	0.00159		Baqrani	0.7506	0.0013		Tando allahyar	0.7282	0.0019	
	Mirpur math-elo	0.7336	0.0014		Dokri	0.7506	0.0011		Tando muhammad khan	Bulri shah karim	0.7624	0.0012
	Ubauro	0.7422	0.00104		Larkana	0.7231	0.0011		Tando ghulam hyder	0.7694	0.0012	
Hyderabad	Hyderabad	0.7447	0.0012	Matitari	Rato dero	0.7382	0.0013	Tharparkar	Tando muhammad khan	0.7376	0.002	
	Hyderabad city	0.652	0.00103		Hala	0.7298	0.0018		Chachro	0.7503	0.0003	
	Latifabad	0.6683	0.00117		Matitari	0.7519	0.0012		Diplo	0.7488	0.0005	

District name	Tehsil name	MCA	S.E	District name	Tehsil name	MCA	S.E	District name	Tehsil name	MCA	S.E	
Jacobabad	Qasimabad	0.6824	0.00293	Mirpur khas	Saeedabad	0.7424	0.0017		Mithi	0.7411	0.0006	
	Garhi khairo	0.7454	0.00129		Digri	0.7331	0.0009		Nagar parkar	0.7487	0.0005	
Jamshoro	Jacobabad	0.7111	0.00128		Hussain bux marri	0.7057	0.0421	Thatta	Ghorabari	0.7656	0.0008	
	Thul	0.7467	0.00078		Jhudo	0.6873	0.0345	Jati	0.762	0.0008		
	Kotri	0.7136	0.00123		Kot ghulam muhammad	0.7412	0.001	Keti bunder	0.7656	0.0016		
	Manjhand	0.7419	0.00184		Mirpur khas	0.6967	0.0015	Kharo chan	0.7737	0.0018		
Kambar shahdad kot	Sehwan sharif	0.7237	0.00131	Naushahro feroze	Sindhri	0.7237	0.0195		Mirpur bathoro	0.7525	0.0011	
	Thano bula khan	0.7522	0.00167		Bhiria	0.727	0.0012		Mirpur sakro	0.7507	0.001	
	Meero khan	0.7367	0.00132		Kandiaro	0.7434	0.0011		Shah bunder	0.761	0.001	
	Nasir abad	0.7299	0.00118		Mehrab pur	0.733	0.0016		Sujawal	0.7465	0.0014	
	Qambar ali khan	0.7316	0.00093		Moro	0.7385	0.0012		Thatta	0.7456	0.001	
	Qubo saeed khan	0.7372	0.00117		Naushahro feroze	0.7313	0.0012		Umer kot	Kunri	0.7595	0.0014
	Shahdad kot	0.7127	0.00134		Sanghar	Jam nawaz ali	0.7294		0.0013	Pithoro	0.7704	0.0012
	Sijawal junejo	0.7342	0.00151		Khipro	0.742	0.0008		Samaro	0.7735	0.001	
Karachi central	Warah	0.7322	0.00089	Sanghar	0.7349	0.0008	Umer kot	0.7615	0.0008			
	Karachi central	0.627	0.00062	Shahdad-pur	0.7212	0.001						
Karachi east	Karachi east	0.6392	0.0005	Sinjghoro	0.729	0.001						
Karachi malir	Karachi malir	0.6786	0.01201	Shaheed benazir abad	Tando adam	0.706	0.0013					
	Malir	0.666	0.0006		Daulat pur	0.7532	0.0011					
Karachi south	Karachi south	0.6478	0.00061	Daur	0.7588	0.0008						
Karachi west	Karachi west	0.6674	0.0004	Nawabshah	0.7133	0.0017						

### Appendix-A3: Asset-based MCA score of KPK at tehsil level

District name	Tehsil name	MCA	S.E	District name	Tehsil name	MCA	S.E
Abbottabad	Abbottabad	0.67193	0.00099	Malakand p area	Bat khela	0.70587	0.00164
	Havelian	0.67638	0.0097		Dargai	0.70655	0.002
Bannu	Bannu	0.69431	0.00105	Mansehra	Bala kot	0.71296	0.00123
	T a adj bannu	0.625			F.r kala dhaka	0.76052	0.00083
Batagram	Allai	0.72245	0.00078		Mansehra	0.71102	0.00103
	Batagram	0.71566	0.00095		Oghi	0.75866	0.00115
Buner	Daggar	0.73617	0.00091	Mardan	Katlang	0.698	
Charsadda	Charsadda	0.69694	0.00112	Nowshera	Mardan	0.70492	0.00089
	Shabqadar	0.70564	0.00143		Takht bhai	0.71249	0.00122
	Tangi	0.72443	0.00144		Nowshera	0.68571	0.00088
Chitral	Chitral sub-	0.70601	0.00231	Peshawar	Pabbi	0.68771	0.00556
	Mastuj sub-	0.70814	0.00227		Peshawar	0.67554	0.00068
D. I. Khan	D.i.khan	0.67913	0.00128	Shangla	Alpuri	0.74065	0.00091
	Draban	0.74976	0.00164		Bisham	0.72497	0.00161
	Kulachi	0.74191	0.00183		Chakisar	0.73321	0.00171

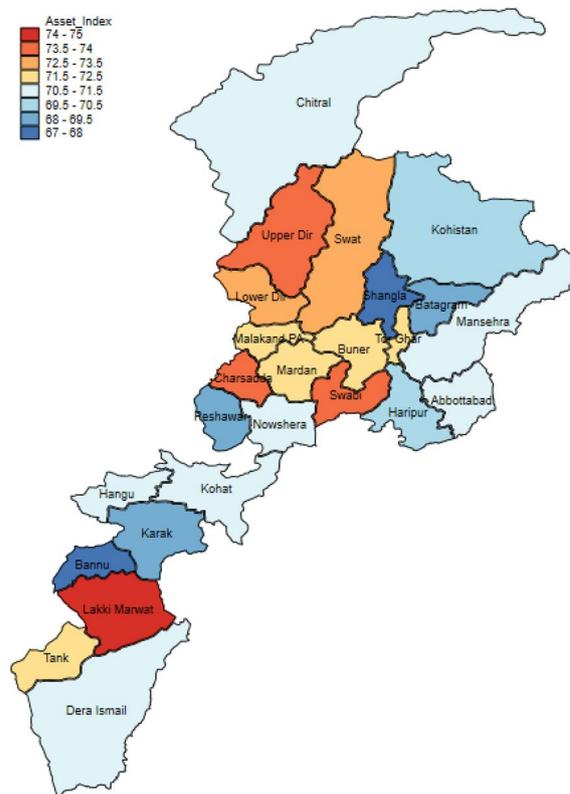
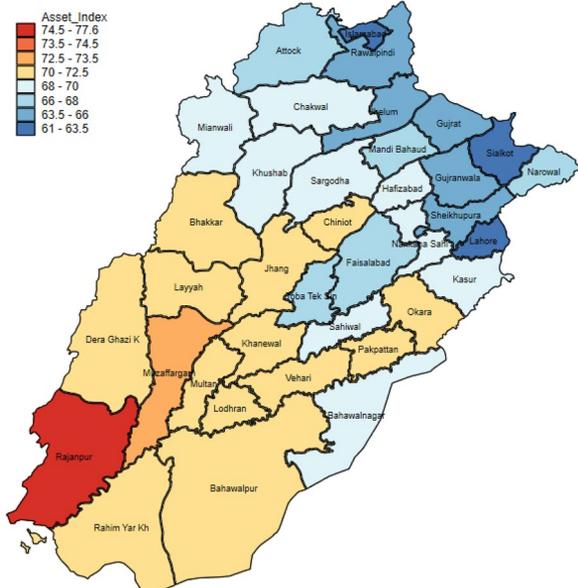
District name	Tehsil name	MCA	S.E	District name	Tehsil name	MCA	S.E
	Paharpur	0.72149	0.00133		Martoong	0.75554	0.00137
	Paroa	0.73554	0.00133		Puran	0.74154	0.00117
Hangu	Hangu	0.71866	0.00135	Swabi	Lahor	0.73293	0.00128
	Tall	0.67627	0.00198		Swabi	0.72869	0.00089
Haripur	Ghazi	0.69754	0.0032		Topi	0.73233	0.00408
	Haripur	0.67891	0.00123	Swat	Bahrain	0.75833	0.01933
Karak	Banda daud shah	0.70273	0.00209		Matta	0.73182	0.00116
	Karak	0.71659	0.0017		Swat	0.71437	0.00074
	Takhat nasrati	0.72024	0.00176	Tank	Tank	0.70659	0.00191
Kohat	Kohat	0.69504	0.00126	Upper dir	Barawal	0.74342	0.00205
	Lachi	0.73232	0.00204		Dir sub-	0.73736	0.00102
Kohistan	Dassu sub-	0.75231	6 0.0011363		Kal koat (kohistan)	0.74636	0.00194
	Palas sub-	0.73663	0.00109		Khall	0.671	
	Pattan sub-	0.7332	0.00121		Wari sub-	0.74092	0.00139
Lakki marwat	Lakki marwat	0.73325	0.00068				
	Sarai naurang	0.7475	0.0085				
	T.a.adj.lakki marwat	0.74391	0.00468				
Lower dir	Adenzai	0.71829	0.00173				
	Balambat	0.70451	0.00213				
	Jandool	0.72445	0.00463				
	Lalqila	0.72668	0.0018				
	Munda	0.74023	0.00216				
	Samarbagh	0.7365	0.00172				
	Timergara	0.70983	0.00227				

#### Appendix-A4: Asset-based MCA score of Baluchistan at tehsil level

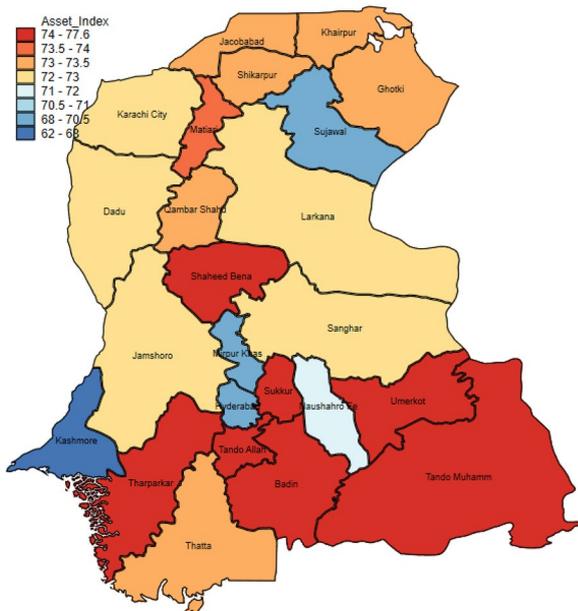
District name	Tehsil name	MCA	S.E	District name	Tehsil name	MCA	S.E	District name	Tehsil name	MCA	S.E
Awaran	Awaran sub-	0.75559	0.00302	Kachhi	Sanni sub-	0.752159	0.001249	Loralai	Duki	0.741528	0.002415
	Jhal jhao	0.74462	0.00194	Kalat	Kalat sub-	0.727498	0.003409	Loralai		0.721956	0.003211
	Korak jhao	0.76135	0.00279		Man-gochar	0.727787	0.003939	Mekhtar		0.773928	0.002762
	Mashkai sub-	0.74279	0.0041	Kech	Buleda sub-	0.73743	0.003129	Mastung	Dasht sub-	0.73324	0.001705
Barkhan	Barkhan sub-	0.75736	0.0022		Kech (turbat) sub-	0.730352	0.001088		Mastung sub-	0.704893	0.001326
Chagai	Dalbandin sub-	0.76685	0.0017		Mand sub-	0.715849	0.007353	Musakhel	Musakhel sub-	0.744997	0.000973
	Nokkundi	0.75903	0.005		Tump sub-	0.724668	0.002457	Nasirabad	Chhattar sub-	0.75929	0.002212
	Taftan sub-	0.69581	0.01567	Kharan	Kharan sub-	0.734295	0.00239		Dera murad jamali sub-	0.746013	0.002894
Dera bugti	Dera bugti sub-	0.74818	0.00496	Khuzdar	Khuzdar sub-	0.726732	0.001799		Tamboo	0.765232	0.002437
	Phela-wagh sub-	0.77499	0.0036		Naal sub-	0.767477	0.00146	Nushki	Nushki sub-	0.7499	0.002604
	Sui sub-	0.75502	0.00465		Wadh sub-	0.749287	0.001863	Panjgur	Gawargo	0.744839	0.003257

District name	Tehsil name	MCA	S.E	District name	Tehsil name	MCA	S.E	District name	Tehsil name	MCA	S.E
Gwadar	Gwadar sub-	0.7413	0.00258		Zehri	0.724103	0.004506		Jaheen proom	0.756813	0.008196
	Jiwani	0.74755	0.00505	Killa abdul-lah	Chaman sub-	0.728229	0.002716		Panjgur sub-	0.74095	0.001844
	Ormara	0.76626	0.00397		Gulistan sub-	0.692329	0.003455	Pishin	Barshore sub-	0.750228	0.002118
	Pasni sub-	0.75956	0.00276		Killa abduallah	0.703972	0.003174		Karezat sub-	0.696383	0.003133
Harnai	Harnai	0.74175	0.00282	Killa saiful-lah	Killa saiful-lah sub-	0.694996	0.002519		Pishin sub-	0.694072	0.001844
	Shahrig	0.74603	0.00635		Muslim bagh	0.685029	0.005314	Quetta	Quetta	0.666037	0.001414
Jaffar-abad	Gandakha	0.75876	0.00225		Upper zhob sub-	0.675996	0.004325		Quetta saddar	0.685041	0.005407
	Jhat pat sub-	0.73092	0.0026	Kohlu	Kohlu	0.75662	0.00424	Sibbi	Lehri sub-	0.752012	0.00382
	Sohbatpur	0.75367	0.00252		Mawand sub-	0.772808	0.004934		Sibi sub-	0.725721	0.003551
	Usta moham-mad sub-	0.7402	0.00252	Lasbela	Bela sub-	0.750977	0.002086	Sukkur	Pano aqil	0.76	
Jhal magsi	Bhag sub-	0.75387	0.00233		Dureji sub-	0.772579	0.003365	Washuk	Mashkhel	0.778865	0.002327
	Dhadar sub-	0.7354	0.00331		Gaddani	0.757812	0.003338		Washuk	0.758347	0.003795
	Gandawa sub-	0.74422	0.00355		Hub sub-	0.726234	0.002926	Zhob	Kakar khurasan sub-	0.790805	0.001843
	Jhal magsi sub-	0.73692	0.00262		Kanraj sub-	0.772052	0.002336		Sherani sub-	0.778767	0.00186
	Lakhara	0.765199	0.002012		Zhob sub-	0.741772	0.0023				
	Othal	0.760227	0.00289	Ziarat	Sinjawi sub-	0.763772	0.005565				
	Son maini	0.754343	0.002983		Ziarat sub-	0.728693	0.002576				

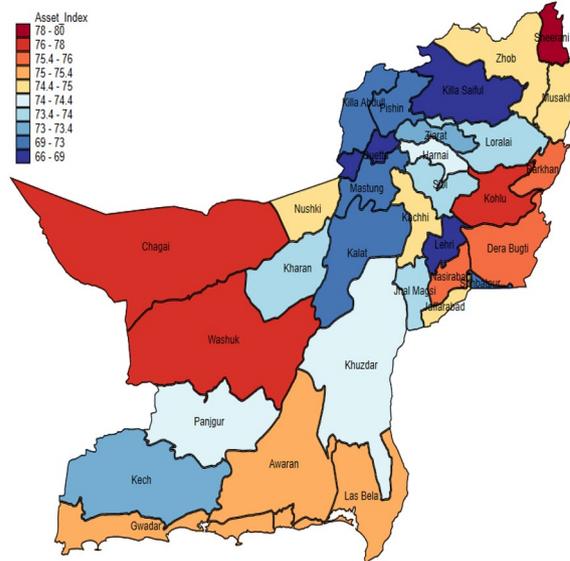
**Appendix: B1: Asset-based poverty map of Punjab at district level by GIS mapping**



**Appendix: B2: Asset-based poverty map of Sindh at district level by GIS mapping**



**Appendix: B4: Asset-based poverty map of Baluchistan at district level by GIS mapping**



**Appendix: B3: Asset base poverty map of KPK at district level by GIS mapping**

**Abbreviations**

MCA	Multiple correspondence analysis
PCA	Principal component analysis
PASSN	Poverty analysis and social safety net team
NSER	National Socio-Economic Registry

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KU conceptualized the paper, did the analysis, and interpreted the results. MZC wrote the introduction, literature review, improved and supervised the article.

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**Availability of data and materials**

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**Declarations****Ethics approval and consent to participate**

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**Consent for publication**

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**Competing interests**

The authors declare that they have no competing interests.

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