Social Bouquet of China Pakistan Economic Corridor: Boosting Marble Industry and Socioeconomic Prosperity of Households by Development of Mohmand Marble City

Dr. Ejaz Gul
School of Economics
Bahauddin Zakariya University, Multan, Pakistan
ejazgul@bzu.edu.pk

Abstract

Nine special economic zones (SEZs) have been planned under framework of China Pakistan Economic Corridor (CPEC) to boost trade, attract investment and increase productivity. Mohmand Marble City (MMC) is one of the nine SEZs being undertaken under CPEC. As a case study, this paper investigates benefits of Mohmand Marble City to boost marble industry, increase revenue and improve socioeconomic status of households after completion. For this purpose, primary data was collected from respondents to ascertain trend in 2015, 2016 and 2017. Mathematical framework of dynamic time variant model was used for estimation of values of socioeconomic index (S_h) for the three years. Then, values of socioeconomic index of households (S_h), marble tile production (P_m) and revenue (R_m) were estimated for 2025; the year of likely completion of development of MMC. This was done by computational software GeoGebra using differential calculus and rate of change values. Completion of MMC will have exponential effect on socioeconomic index of households, marble tile production and revenue generation. Therefore, values of 'S_h', 'P_m' and 'R_m' were estimated by GeoGebra for 2030, five years temporal gap after completion and commissioning of MMC, using mathematical framework of exponential rate model. Results indicated that after completion of MMC, it will exponentially raise socioeconomic status of households of surrounding villages, boost production of marble tiles and revenue generation.

Key words: Special, economic, zone, marble, city, trade, socioeconomic, index, households, production, revenue.

JEL Classification: D31, D63, I14, I24, I32, O18.

1. Introduction

SEZs attract investments, boost trade and enhance industrial development and technological advancement. Recent research has indicated that SEZs have dual benefits; on one hand SEZs render conventional economic benefits of increase in investment, trade and exports while on the other hand SEZs help in improvement of socioeconomic life of households living in areas surrounding these SEZs. Moreover, SEZs provide opportunities for workforce employment, better education and modern health facilities. Because of SEZs, modern energy means are extended to households living in surroundings. In short, SEZs act as catalyst for socioeconomic betterment of households as well as economic growth. Under the umbrella CPEC, nine SEZs have been planned. Socioeconomic life of households living in areas surrounding these zones will also improve as they will be the first recipients of modern facilities that these zones will bring with it. Mohmand Marble City (MMC), a planned SEZ under CPEC, is located in District Mohmand in the Khyber Pakhtunkhwa Province of Pakistan. This paper elucidates threefold effects of development of MMC. First, estimation of socioeconomic index of households (S_h) surrounding MMC. Second, estimation of marble tile production (P_m). Third, estimation of related revenue (R_m). Data on selected variables was collected for 2015, 2016 and 2017 from respondents of District Mohmand. Values of socioeconomic index of households (S_h) were estimated for 2015, 2016 and 2017 using dynamic time variant model and taking help from computational software GeoGebra. Then, using differential calculus, values of 'S_h', 'P_m' and 'R_m' were estimated by GeoGebra for 2025, the year of likely completion of MMC. Next, using exponential rate model, values of 'S_h', 'P_m' and 'R_m' were estimated by GeoGebra for 2030, five years after commissioning of MMC. Results indicated that MMC is a promising project which shall bring significant social and economic benefits. This paper is unique combination of mathematical, computational and spatial economics.

2. Contextual Appraisal

Concept of SEZs gain significance in early 60s when world realized that clustering and agglomeration of industries can attract domestic and foreigner investors. Today, SEZs in East Asia and Latin America are successful, while performance of majority of African and Asian zones is short of expected results. In essence SEZ is developed to attract investment, develop industries with modern technology, increase exports and encourage policy reforms. An industrial zone, comprising many industries of the same or different types is a form of SEZ. Impacts of industrial zone on trade, productivity and investment have been investigated by researchers around the globe but its impacts on households is a neglected area. These zones bring improved infrastructure, modern energy, excellent education and health facilities to areas where these are located and, hence, these can benefit households in surroundings.

Socioeconomic impacts of SEZ and industrial clustering. Many researchers have investigated socioeconomic impacts of SEZs in different regions of the world. In 2012, Aggarwal carried out an incisive study to elucidated social and economic impacts of SEZs. It was concluded that these zones improve overall economic growth and social development of community. Similarly, he highlighted that SEZs are no more associated with economic benefits only; rather SEZs have huge social impacts on communities surrounding SEZs (Aggarwal, 2012). In 2014, Aharonson carried out research on innovative output that can be achieved by industrial clustering. It was highlighted in study that product innovation increases with industrial clustering that results in increased diversification with huge economic benefits (Aharonson, 2014). Beykan conducted study on Sile Shipwreck in 1988 and indicated that marble has been a great source of architectural elegance (Beykan, 1988). Similarly, Caniels has elucidated in 2005 that industrial and technological clusters in special economic zones increase innovativeness and improve quality of products and thus enhanced competitiveness is generated in firms. It was also highlighted that these clusters have huge social benefits in the form of improved facilities and job creation (Caniels, 2005). In 2004, Helsley worked on economics of agglomeration and indicated how coherent and effective agglomeration of industries can augment process of economic growth in regional context (Helsley, 2004). In an incisive study in 1998, Litwack elucidated that SEZs are catalysts for economic transition in different countries owing to socioeconomic impacts of these zones (Litwack, 1998). McCann explained in his 2011 online book that industrial clustering has been an excellent geo-economical strategy that ensured sustainable economic development and urban growth in many countries (McCann, 2011). Plummer asserted the significance of structure and dynamics of industrialization based on geographical agglomeration in 2006. It was concluded in study that geographical grouping of industries accrued socioeconomic dividends in case of many developing countries (Plummer, 2006). Likewise, Walsh has indicated that by aligning social policy with development policy of

SEZs, socioeconomic blessings of SEZs can be amplified manifold. Optimal social benefits of SEZs can be achieved with effective orientation of social policy (Walsh, 2013).

Marble industry. Marble industries have been established by many developed and developing countries that have marble deposits on their landscape. A study conducted by Hamza in 2016 highlighted that innovation in marble and granite processing can give enhanced economic benefits. He highlighted that even waste of marble and granite is not a waste as it can be re-cycled and re-used (Hamza, 2016). Similarly, Long indicated in 2016 that Roman marble quarries exhibited huge economic value and it contributed to economic growth (Long, 2016). In 1985, Max wrote a book about Connemara marble industry in Dublin. It was highlighted in the book that Connemara marble is the most distinguished marble industry in Ireland and it has significantly contributed to export of marble and earned economic benefits for the country (Max, 1985). Ratté analyzed marble industries of Vermont in 1989. He concluded that marble, granite and slate industries of Vermont have contributed to socio-economic development of the areas. These industries have attracted investment and enhanced trade (Ratté, 1989).

Marble tiles. Marble is used for making tiles of different varieties which are used in buildings. In 2014, Meyer carried research on tile industry of Italy, Spain and Brazil. It was identified in the study that clustering of industries was very beneficial and it made value chain management easy. Moreover, clustering improved the quality of tiles (Meyer, 2014). In an analytical study of 1988, Pires indicated significance of modern technology to increase value of marble tiles. It was highlighted in the study that laser cutting increases quality of marble tiles manifold compared to rough cutting. In marble industry laser cutting should be preferred (Pires, 1988). Similarly, in 1988 Röder carried out research on Numidian marble in Tunisia. It was explained in the study that yellow colour and fine texture of the marble slates made Numidian marble highly unique. This marble was used by Roman to beautify their residences (Röder, 1988). Sani presented his research about Nigerian Jakura marble in 2017. It was concluded in the study that exploration of Jakura marble for tiles production will result in significant economic growth for Nigerian economy (S. Sani, 2017).

Geology and morphology of marble reservoirs. Marble is basically a metamorphic rock having geological composition of carbonate minerals commonly known as limestone. Geology and morphology of rock deposits effect the quality of marble. In 2014, Goudie elucidated process of weathering on Namib Plains in Africa that affected the quality of marble and granite stones. The geomorphological processes added value to marble and granite reservoirs and its texture and hardness improved (Goudie, 2014). In 2004, In a study on geology of marble rocks in Greece and Turkey, Herz indicated in 1988 that Greece and Turkey have huge marble reservoirs that should be explored for production of quality marble tiles. These tiles can be exported to other countries to boost trade (Herz, 1988).

Thus, from the contemporary research it can be safely concluded that development of marble industry is profitable to economy of country. The preferred option should be to create an industrial zone with modern processing machines within manageable distance from the marble quarries to produce huge quantity of marble tiles. Such industrial zone will also bring prosperity to households in surrounding of industrial zone.

Pakistan is blessed with huge reservoirs of natural mineral resources including marble. Pakistan has an estimated 297 billion tons of marble and granite reserves in all four provinces, FATA, and Gilgit-Baltistan. Marble is the 5th largest contributor to GDP of Pakistan. Marble tiles and other products are being exported to different countries around the globe. Currently, China is the top most natural stone consumer followed by US. China accounts for 60% of Pakistan's total marble exports. China and Italy purchase raw products like slabs and blocks, process it and then re-export value-added items to other countries. Russia and the US, as well as Middle Eastern and European countries demand finished marble products, and thus constitute less than 10% of our export. Saudi Arabia alone imports marble products worth $1,500 million. This indicates the dire need for developing technology to capture value-added export markets. The current contribution of industry through export of marble and granite amounts to $134 million.

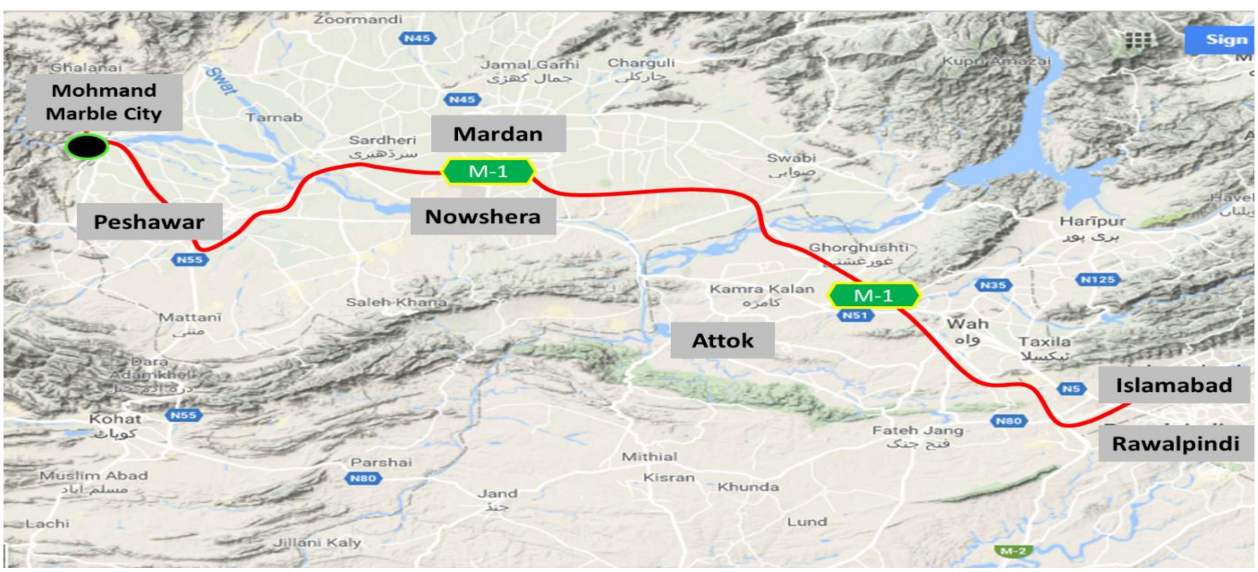
Pakistan Stones Development Company (PASDEC) is the leading body of marble and natural stone industry. In case of Pakistan, most of processing units in country are prepared with local man-made crude cutting machines consuming high electricity expenditure. Over 2,000 processing units are operational in the country and more than 1200 quarries are operational. Besides, industry has provided jobs to around 200,000 individuals. Pakistan's annual quarry production is 3.82 million tons. Country's annual production of marble tiles is around 2.5 million tones, which contributes merely 2% to global market. Despite many constraints faced by industry, sharp increase in its exports during last decade shows its high potential for trade.

3. Research Area

Mohmand is a district of Khyber Pakhtunkhwa Province of Pakistan. It has mountainous topography with few plain spots. Its current population is 4,66,984 with a growth rate of 1.77. Male population is 2,38,003 while female population is 2,28,981. Total area of Mohmand district is 2296 square kilometers.

Mohmand Marble City is located at Michni in Mohmand District roughly at a half an hour distance from Peshawar, the capital of Khyber Pakhtunkhwa Province. Location of marble city is shown in figure 1. There are many marble reservoirs in District Mohmand. Tiles from Mohmand marble have many varieties of colour and texture and composition. About 7,000 million tons of good quality marble exist in complete Mohmand district. Currently, more than thousand million tons of marble stone are excavated annually from different mines of Mohmand Agency that means only meager utilization of huge reservoir present in the area.

Figure 1. Location of Mohmand Marble City



Present capacity of marble industry in Mohmand is production of 800 million tons of marble tiles. This indicates that presently marble industry in Mohmand is operating at below the optimum potential. Main reasons for this are; lack of capacity to handle huge marble reservoir, vintage and out dated machines and processes, lack of infrastructure, energy break downs, lack of innovation, lack of skilled labour and professionals, and lack of interest by investors. However, presence of huge marble reservoir attracted planners and, now, a marble city is being developed in District Mohmand.

Mohmand Marble City is spread over 353 acres. This modern state of the art city is being established at the cost of PKR 2.6 billion. Marble city is comprised of 295 modern, well equipped industrial processing and production units. Marble city offers many investment and employment opportunities. It will bring energy, infrastructure, education and health facilities with it that will benefit producers, labour and households in surrounding. In district Mohmand, unemployment is extensive which shall be reduced to some extent as construction of marble city offers 18000 direct jobs. Marble city is well connected with road, air and railway network as shown in table 1. This connectivity will help in transforming MMC as hub of marble industry.

Table 1
Description of Mohmand Marble City

Project	**Province**	**Area (Acres)**	**Type**	**Connectivity (Kilometers)**					
				Motorway / Highway	Airport	Railway Station	Dry Port	Sea Port	City Centre
Mohmand Marble City	Khyber Pakhtunkhwa	353	Marble industry	33	40	40	40	-	38

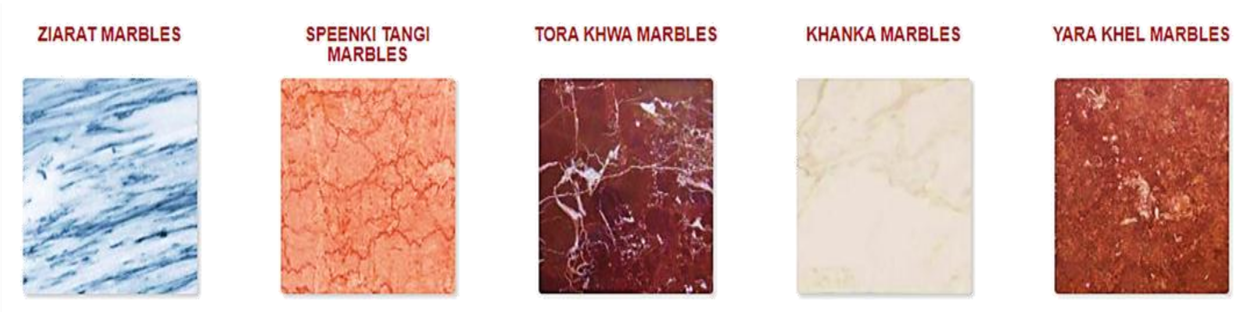
(Source: http://cpec.gov.pk/special-economic-zones-projects)

Geology of Mohmand marble reservoir indicated that it contains chromite, silica sand, dolomite, manganese, quarts, feldspar at different locations of district. After quarrying, raw pieces of rocks are transported to respective marble factories where these raw junks are converted into fine marble tiles through a manufacturing process as shown in figure 2.

Figure 2. Process of Marble Processing

Quarrying from marble reservoir at different sites produce different types of fascinating quality marble tiles as shown in figure 3.

Figure 3. Marble Products in Mohmand District



(Source: http://mohmandmarble.com)

4. Theoretical Building Blocks of Study

Socioeconomic status of households 'S_h' living in the villages surrounding MMC, annual production of marble tiles 'P_m' and revenue generated 'R_m' were taken as dependent variables. To find out value of socioeconomic status of households 'S_h', six explanatory or independent variables were selected. Description of variables is shown in table 2.

Table 2

Description of dependent and independent variables

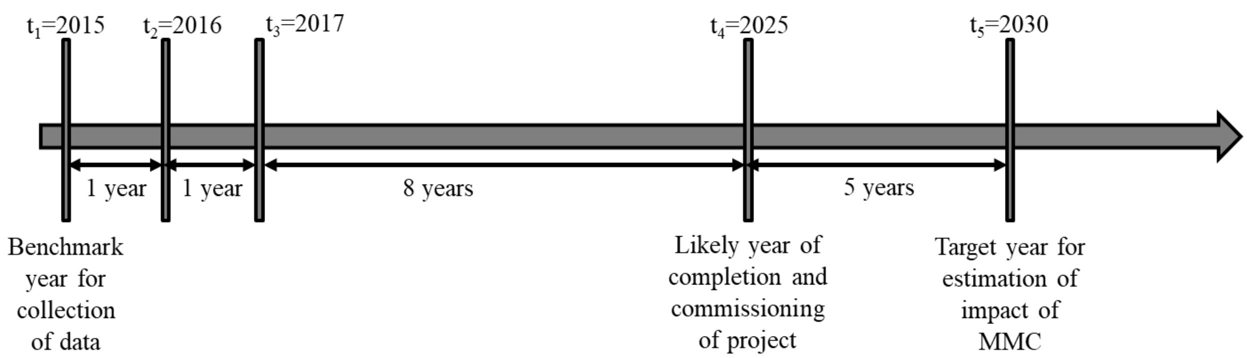
Variables	Symbol	Description
Dependent variables		
Socioeconomic Index	S_h	Index showing socioeconomic status of households living in areas surrounding MMC.
Marble tile production	P_m	Quantity of marble tiles produced (million tons per year).
Revenue generated	R_m	Revenue generated by selling of marble tiles (million PKR per year).
Independent variables for estimation of socioeconomic index (S_h)		
Per capita income	I	Average per capita income of households (PKR per year).
Employment	W	Average annual number of workers in in marble industry in District Mohmand.
Male education	E_m	Average annual enrolments of male students in educational institutes (public and private schools, colleges and above).
Female education	E_f	Average annual enrolments of female students in educational institutes (public and private schools, colleges and above).
Health	H	Average annual number of patients in public and private hospitals, basic health units, treatment centres.
Energy	E	Average annual per capita electricity consumption (kilowatt hours) of households

Using Leonhard Euler functional notation, socioeconomic status was taken as function of five selected explanatory variables as shown in equation (1).

$$\text{Socioeconomic status of households } (S_h) = f(I, W, E_m, E_f, H, E) \ldots \ldots \ldots (1)$$

Five temporal nodes were used to find out values of socioeconomic status of households, marble tiles production and revenue generated from marble tiles trade. These five nodes included: 2015 as t_1, the bench mark year for collection of data; 2016 as t_2, 2017 as t_3, 2025 as t_4, the year of likely completion and commissioning of MMC and 2030 as t_5, year for which impact assessment of MMC was required to be estimated. Temporal nodes are indicated in figure 4.

Figure 4. Temporal Nodes for Study



Socioeconomic status of households was calculated for 2015, 2016 and 2017 by using mathematical framework of dynamic time variant model (DTVM) as given in equation (2), (3) and (4).

$$\text{Socioeconomic Index, } S_h(2015) = \left[\omega \frac{\sum_1^n[v_{t_1}]}{\sum_1^n[(v_{at_3} - v_{at_1})]} + \frac{\sum_1^n[v_{t_3}] - \sum_1^n[v_{t_1}]}{T \sum_1^n[(v_{at_2} - v_{at_1})]} + \text{Tx} \frac{\sum_1^n[v_{t_1}] + \sum_1^n[v_{t_2}] + \sum_1^n[v_{t_3}]}{\omega[\sum_1^n(v_{t_3}) - \sum_1^n(v_{t_1})]}\right] \ldots \ldots \ldots (2)$$

$$\text{Socioeconomic Index, } S_h(2016) = \left[\omega \frac{\sum_1^n[v_{t_2}]}{\sum_1^n[(v_{at_2} - v_{at_1})]} + \frac{\sum_1^n[v_{t_3}] - \sum_1^n[v_{t_2}]}{T \sum_1^n[(v_{at_3} - v_{at_2})]} + \text{Tx} \frac{\sum_1^n[v_{t_1}] + \sum_1^n[v_{t_2}] + \sum_1^n[v_{t_3}]}{\omega[\sum_1^n(v_{t_2}) - \sum_1^n(v_{t_{11}})]}\right] \ldots \ldots \ldots (3)$$

$$\text{Socioeconomic Index, } S_h(2017) = \left[\omega \frac{\sum_1^n[v_{t_3}]}{\sum_1^n[(v_{at_3} - v_{at_2})]} + \frac{\sum_1^n[v_{t_2}] - \sum_1^n[v_{t_1}]}{T \sum_1^n[(v_{at_3} - v_{at_1})]} + \text{Tx} \frac{\sum_1^n[v_{t_1}] + \sum_1^n[v_{t_2}] + \sum_1^n[v_{t_3}]}{\omega[\sum_1^n(v_{t_3}) - \sum_1^n(v_{t_2})]}\right] \ldots \ldots \ldots (4)$$

Description of different symbols used in equation (2) is as under.

- 'ω' was dynamic constant that was dependent on prevailing socioeconomic conditions. It could take value from 0 to 0.99. Since, work on MMC is still in progress, its value was taken as 0.25 representing initial conditions.
- 'v' was numerical value of explanatory variable in particular year.
- 'v_a' was annual average numerical value of explanatory variable.
- 'n' indicated number of explanatory variables for estimation of socioeconomic index.
- 'T' was the temporal span in years.

To explain dynamic time variant model, just glance equation (2) that indicates that it was a unique mathematical framework owing to its constituents. It contained three distinct parts. First part, $\omega \frac{\sum_1^n[v_{t_1}]}{\sum_1^n[(v_{at_3} - v_{at_1})]}$ was kinetic component. Second part, $\frac{\sum_1^n[v_{t_3}]-\sum_1^n[v_{t_1}]}{T\ \sum_1^n[(v_{at_2} - v_{at_1})]}$ was distributive component. Third part, $\frac{\sum_1^n[v_{t_1}]+\sum_1^n[v_{t_2}]+\sum_1^n[v_{t_3}]}{\omega \text{ x } T[\sum_1^n(v_{t_3})-\sum_1^n(v_{t_1})]}$ was temporal component. Similar is the case with equation (3) and (4). Thus, it was a wholesome and comprehensive mathematical model covering essential dynamic and temporal variations in values of explanatory variables for socioeconomic index.

We had to estimate value of socioeconomic index of households for 2025. This was done by using computational software, GeoGebra applying mathematical technique of rate of change values. These rate of change values were determined by applying mathematical framework of differential calculus.

However, after completion and operationalization of MMC, it is expected that socioeconomic index of households 'S_h', production of marble tiles 'P_m' and revenue 'R_m' will increase exponentially. These values were estimated for 2030 by computational software, GeoGebra using newly designed mathematical framework of exponential rate model as shown in equation (3). The formula may look different compared to traditional exponential function's formula because in this case we were interested in effects of MMC after likely completion of construction in 2025 and not from the bench mark year 2015.

$$S_h, P_m, R_m \text{ values in } 2030 = v_{2025} + \left[\frac{(1+\mu)^t - 1}{\mu}\right] \ldots \ldots \ldots (3)$$

Where 'μ' rate of annual increase in the values of 'S_h', 'P_m' and 'R_m' from 2015 to 2025, 't' is the temporal span after completion and commissioning of MMC and 'v' is values in 2025.

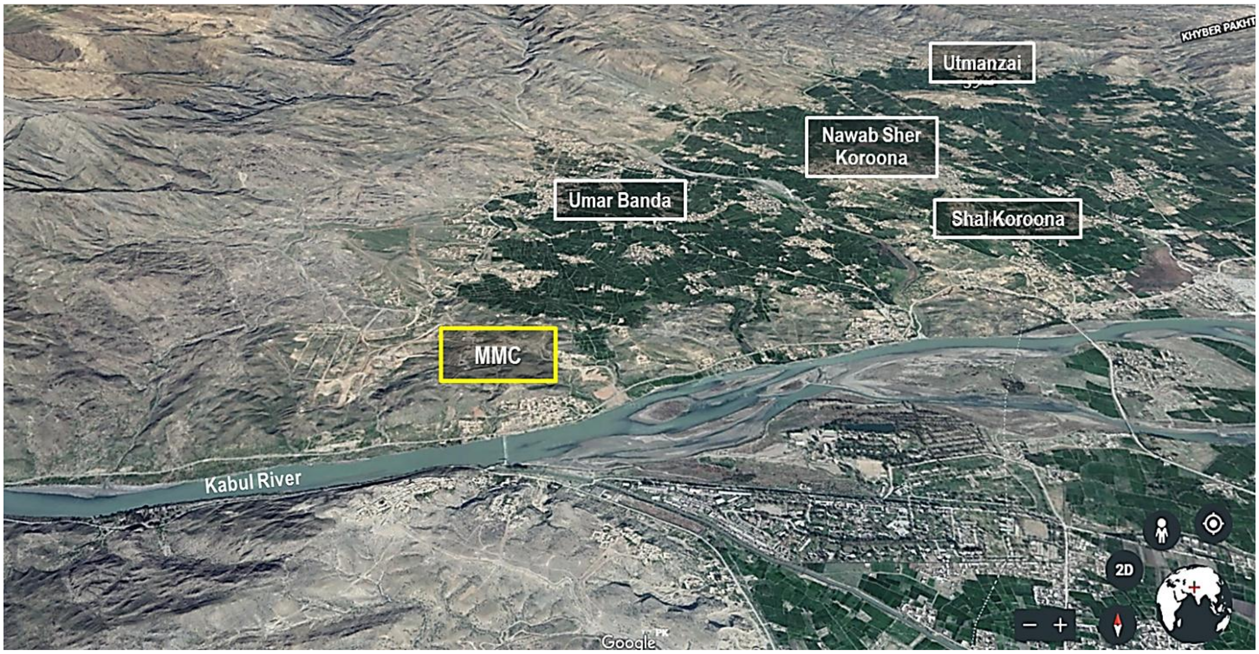
Using this mathematical and computational software, data was analyzed and results were obtained that have been discussed in the ensuing sections.

5. Research Design and Data Collection

A very comprehensive research design was chalked out for data collection. Data was required to be collected on three variables; socioeconomic index 'S_h', marble tile production 'P_m' and revenue generated 'R_m'. Data on these variables was required to be collected for 2015, 2016 and 2017. Primary data was collected through questionnaires, interviews and field visits. Secondary data was collected from available documents on relevant websites, records available with district administration and relevant ministries. Data collection methodology is explained below.

Data Collection for socioeconomic index of households. Socioeconomic index of households 'S_h' was a subjective dependent variable. Therefore, data on its constituent explanatory or independent variables such as per capita income, employment, education, health and energy was required to be collected to estimate its value. For this purpose, primary data was collected from the households of surrounding villages; Umar Banda, Nawab Sher Koroona, Utmanzai and Shal Koroona as shown in figure 5. Four teams collected data from households of four villages (one team per village). Total sample size was 200 respondents (50 respondents from each village). Questionnaire was translated in native 'Pashto' language for easy comprehension of households. Sample composition is shown table 3.

Figure 5. Data Collection for Socioeconomic Index of Households



Data Collection for quantity of marble tiles and revenue generated. As marble tile production 'P_m' and revenue generated 'R_m' are quantitative variables, therefore, data for these variables was collected directly from factory owners (producers), workers, investors, retailers, wholesalers, consumers and technical experts. For this purpose, one team was formulated with a distinct questionnaire specially designed for respondents from marble industry. Respondents were knowing values of annual quantity of marble tiles produced and revenue generated in 2015, 2016 and 2017. Total sample size was 200 respondents. Sample composition is shown in table 3.

Data Composition. Sample composition was diverse. Respondents were selected randomly without any bias or affiliation. Respondents were helped to comprehend the questions being asked in the questionnaire. Sample composition is shown in table 3.

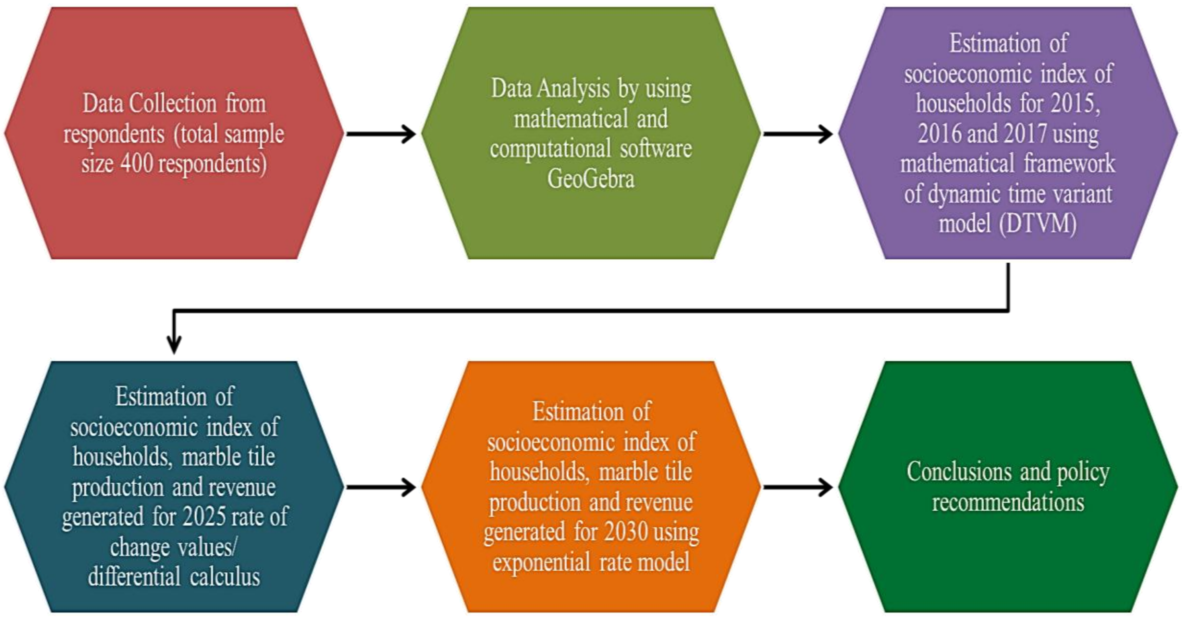
Table 3
Sample composition

Respondents	Education	Gender	Age (years)	Size (numbers)
Households	May be educated or uneducated. For uneducated questionnaire was translated into native language 'Pashto'	No gender discrimination	18-50	200
Marble factory owners (producers)				50
Workers				50
Investors				20
Retailers (sellers)				20
Wholesalers				20
Consumers (purchasers)				20
Technical experts				20
Total sample size				400

Use of mathematical and computational software. After collection, data was sifted, tabulated and fed into computational software, GeoGebra for analysis. GeoGebra is a dynamic mathematical package that contains solution packages for problems related to geometry, algebra and calculus. It has user friendly facilities to create spreadsheets, plots and graphs with relevant details including trend equations. Data was processed by software after numerous iterations and attenuations. Results obtained from data processing have been discussed in ensuing section.

Research Design. Study was completed using a systematic research scheme comprising distinct steps. At each stage of research, errors were avoided by careful handling of data and efficient use of computational software. Overall research design that was adopted for study is shown in figure 6.

Figure 6. Research Design



6. Data Analysis

Socioeconomic Index of households 'S$_h$'. Data was summarized and tabulated on excel sheets. These excel sheets also indicated major descriptive statistics for the data. Computational software GeoGebra has the ability to import excel sheets into its system. Summarized data sheets of explanatory variables for socioeconomic index are shown in appendix 1 attached at the end of paper. Data was imported in the software to estimate socioeconomic index of households for 2015, 2016 and 2017. Summary of calculation is shown in table 4. Equations (2), (3) and (4) were used for estimation of socioeconomic index of households. Values of socioeconomic index for 2015, 2016 and 2017 were 145.16, 438.84 and 1024. 88 respectively. It is worth mentioning here that work on MMC started in 2015 under CPEC. As a first step, marble industries in District Mohmand were facilitated in quarrying, production, transportation and manufacturing processes. Similarly, transportation of manufactured marble tiles to markets and related taxes and duties were relaxed. Investors were invited to invest in the fast-growing marble industry. Available record indicated that many investors invested in marble industries that boosted marble industry. In 2015 alone, public and private sector investment of more than 2050 million PKR was recorded in the marble industry. Positive business environment was shaped up when government gave many relaxations to marble tiles producers. All these steps had effect on socioeconomic status of households as well. Consequently, just after a year by 2016, socioeconomic index of households raised by 202% to its value in 2015. Similarly, its value in 2017 further increased by 133.5%

Table 4

Summary of calculations for socioeconomic index

Years	Dynamic Constant ‘ω’	Duration ‘T’	$\sum_{1}^{n}[v_{t_1}]$	$\sum_{1}^{n}[v_{t_2}]$	$\sum_{1}^{n}[v_{t_3}]$	$\sum_{1}^{n}[(v_{at_3} - v_{at_1})]$	$\sum_{1}^{n}[(v_{at_3} - v_{at_2})]$	$\sum_{1}^{n}[(v_{at_2} - v_{at_1})]$	$\left[\sum_{1}^{n}(v_{t_3}) - \sum_{1}^{n}(v_{t_1})\right]$
2015	0.25	3	495803	-	-	12191	-	-	48765
2016	0.25	3	-	525685	-	-	4721	-	-
2017	0.25	3	-	-	544568	-	-	7471	-

$\left[\sum_{1}^{n}(v_{t_3}) - \sum_{1}^{n}(v_{t_2})\right]$	$\left[\sum_{1}^{n}(v_{t_2}) - \sum_{1}^{n}(v_{t_1})\right]$	S_h Value (as per equation 2, 3 & 4)
-	-	$S_h(2015) = \left[\omega \frac{\sum_1^n[v_{t_1}]}{\sum_1^n[(v_{at_3} - v_{at_1})]} + \frac{\sum_1^n[v_{t_3}] - \sum_1^n[v_{t_1}]}{T \sum_1^n[(v_{at_2} - v_{at_1})]} + Tx \frac{\sum_1^n[v_{t_1}] + \sum_1^n[v_{t_2}] + \sum_1^n[v_{t_3}]}{\omega[\sum_1^n(v_{t_3}) - \sum_1^n(v_{t_1})]}\right]$ $S_h(2015) = \frac{0.25 \text{ x } 495803}{12191} + \frac{48765}{1 \text{ x } 7471} + \frac{1\text{x } (495803 + 525685 + 544568)}{0.25 \text{ x } 48765} = 145.16$
18883	-	$S_h(2016) = \left[\omega \frac{\sum_1^n[v_{t_2}]}{\sum_1^n[(v_{at_2} - v_{at_1})]} + \frac{\sum_1^n[v_{t_3}] - \sum_1^n[v_{t_2}]}{T \sum_1^n[(v_{at_3} - v_{at_2})]} + Tx \frac{\sum_1^n[v_{t_1}] + \sum_1^n[v_{t_2}] + \sum_1^n[v_{t_3}]}{\omega\,[\sum_1^n(v_{t_2}) - \sum_1^n(v_{t_{11}})]}\right]$ $S_h(2016) = \frac{0.25 \text{ x } 525685}{7471} + \frac{18883}{2 \text{ x } 4721} + \frac{2 \text{ x } (495803 + 525685 + 544568)}{0.25 \text{ x } 29882} = 438.84$
-	29882	$S_h(2017) = \left[\omega \frac{\sum_1^n[v_{t_3}]}{\sum_1^n[(v_{at_3} - v_{at_2})]} + \frac{\sum_1^n[v_{t_2}] - \sum_1^n[v_{t_1}]}{T \sum_1^n[(v_{at_3} - v_{at_1})]} + Tx \frac{\sum_1^n[v_{t_1}] + \sum_1^n[v_{t_2}] + \sum_1^n[v_{t_3}]}{\omega\,[\sum_1^n(v_{t_3}) - \sum_1^n(v_{t_2})]}\right]$ $S_h(2017) = \frac{0.25 \text{ x } 544568}{4721} + \frac{29882}{3 \text{ x } 12191} + \frac{3 \text{ x } (495803 + 525685 + 544568)}{0.25 \text{ x } 18883} = 1024.88$

(Source: Author’s own calculations)

compared to its value in 2016. So, three aspects were very evident from this estimation; one, confidence of investors, producers, wholesalers, consumers improved as a result of start of work on MMC and related government actions. Second, growing and progressive marble industry environment was shaped up by establishment of MMC and clustering of marble industries around it. Third, socioeconomic status of households improved due to start of work on MMC and government's facilitative actions.

Marble tile production 'P_m'. The finished products from marble industry are fine quality marble tiles. Data values of quantity of marble tiles produced in District Mohmand in million tons per year were directly obtained from marble industries through meetings and interviews of producers and industrialists. Data values obtained from respondents is shown in table 5.

Table 5
Annual marble tile production 'P_m'

Year	Marble Stone Quarry (million tons per year)	Quantity of Marble Tiles (million tons per year)	Increase (%) Quantity of Marble Tiles
2015	2000	436	-
2016	6000	503	15.36%
2017	14000	813	61.63%

Start of work on construction of MMC and friendly steps of government for marble industries resulted in boosting marble tile production by 15.3% in 2016 and by 61.6% in 2017. Government's will to establish of MMC under CPEC has motivated producers, workers and consumers of marble industry manifold.

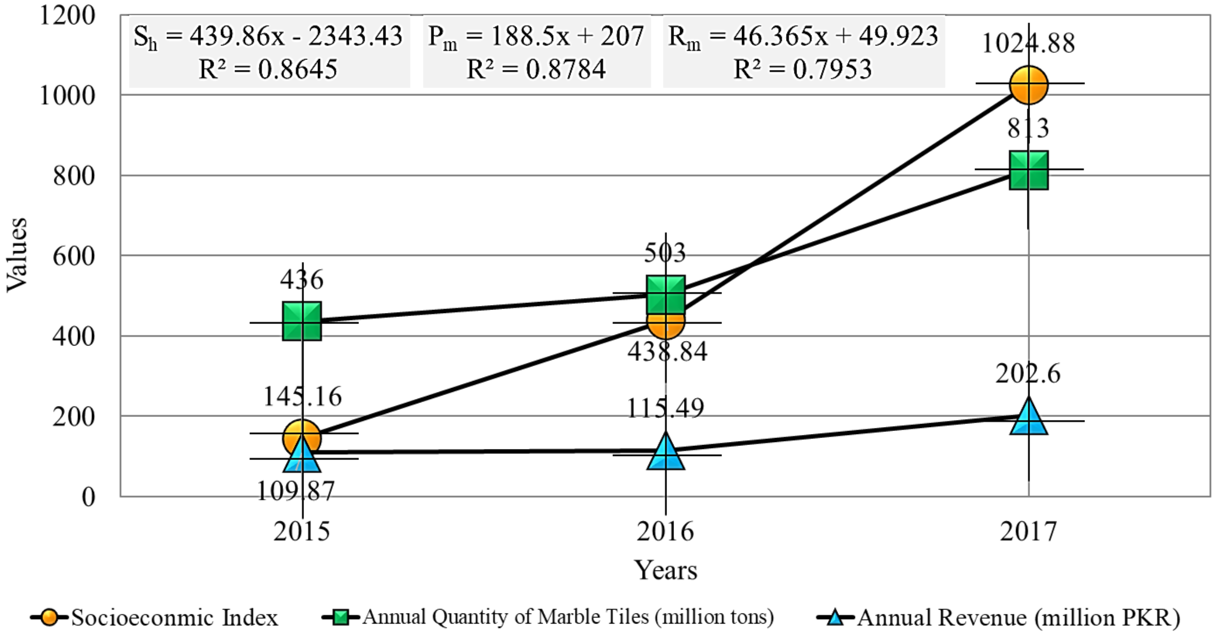
Revenue 'R_m'. As production of marble tiles increased, correspondingly, the revenue generated increased. Data values of revenue generated by selling of marble tiles (million PKR per year) were obtained from producers and investors through meetings and interviews. Summary of the data values is shown in table 6.

Table 6
Annual revenue 'R_m'

Year	Average Rate (million PKR per ton)	Quantity of Marble Tiles (million tons per year)	Selling (% of Quantity)	Revenue (million PKR per year)	Increase (%) in Revenue
2015	0.36	436	70%	109.87	-
2016	0.28	503	82%	115.49	5.1%
2017	0.28	813	89%	202.60	75.43%

Table 4, 5 and 6 gave values socioeconomic index, annual quantity of marble tiles and annual revenue generated for 2015, 2016, 2017. To find out representative equations, these values were fed into computational software GeoGebra. Digital graphs along with representative equations of three variables and co-efficient of determination 'R^2' values are shown in figure 7. Critical observation of figure 7 revealed that these variables are correlated with each other, meaning thereby that when production increased, revenue increased and socioeconomic status of households improved. Moreover, digital graphs for the three variables exhibited linear tendency. The co-efficient of determination values for the three graphs indicated accuracy of the estimates.

Figure 7. Digital Graphs of Data



(Source: Author's own calculations using software GeoGebra)

After this, we had to estimate value of socioeconomic index of households, production of marble tiles and revenue for next temporal node i.e. 2025, the year of likely completion and commissioning of MMC. This was important to estimate values for year 2025 because after 2025 MMC will start impacting the values of three variables and previous trend may change. For this estimation process, rate of change values and differential calculus was used. Rate of change or slope of line is the first differential of the line's representative equation. Calculations are shown in table 7.

Table 7

Estimation of socioeconomic index, quantity of marble tiles and revenue for 2025

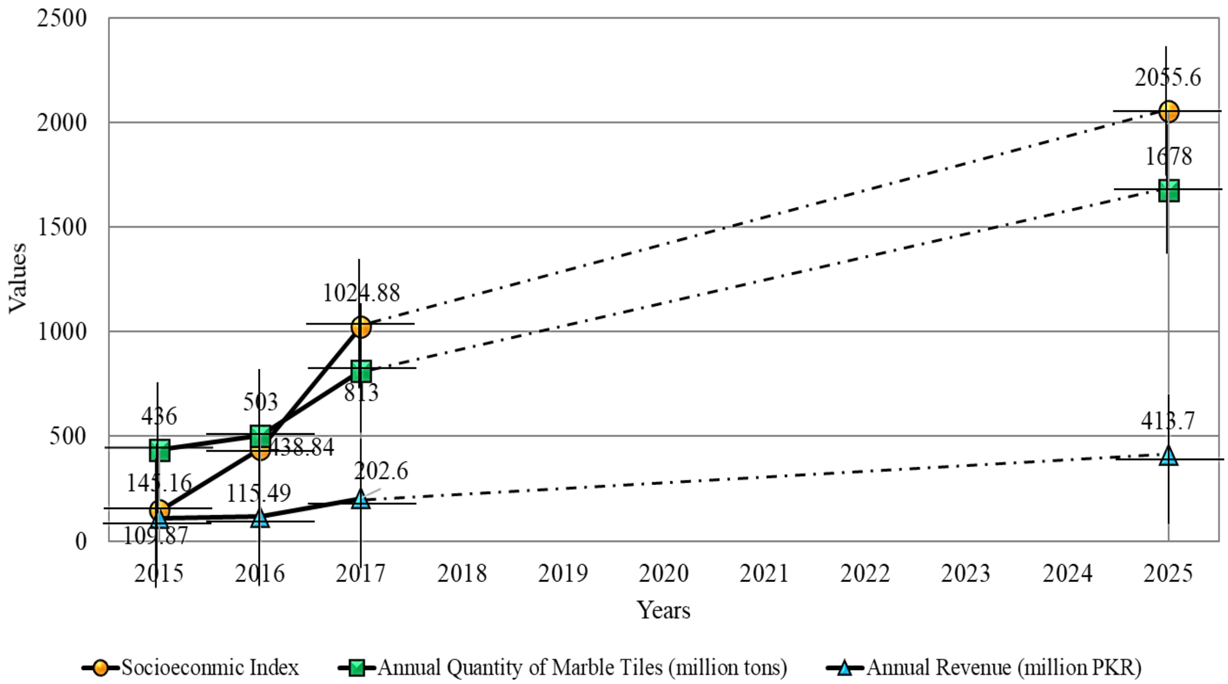
Year	Equation	R^2	Rate of Change or Slope	Values for 2025
Socioeconomic Index 'S_h'	S_h = 439.86x - 343.43	0.864	$\frac{dS_h}{dx} = 439.86\frac{dx}{dx} - 0$ $\frac{dS_h}{dx} = 439.86$	x=10 for 2025 S_h = 439.86(10) - 2343.43 = 2055.6
Quantity of Marble Tiles 'P_m'	P_m = 188.5x + 207	0.878	$\frac{dP_m}{dx} = 188.5\frac{dx}{dx} - 0$ $\frac{dP_m}{dx} = 188.5$	x=10 for 2025 P_m = 188.5 (10) - 207 = 1678 million tons per year

Revenue 'R_m'	$R_m = 46.365x + 49.92$	0.795	$\frac{dP_m}{dx} = 46.365 \frac{dx}{dx} - 0$ $\frac{dP_m}{dx} = 46.365$	x=10 for 2025 R_m = 46.365 (10) – 49.92 = 413.73 million PKR per year

(Source: Author's own calculations using software GeoGebra)

Values of three variables obtained for 2025 from rate of change values and differential calculus were plotted in relation to values in 2015, 2016 and 2017. Resultant digital graphs are shown in figure 8.

Figure 8. Digital Graphs of Data Extended to 2025



(Source: Author's own calculations using software GeoGebra)

A critical glance on figure 8 revealed that similarity in trend and rate of increase was still existing for the three variables. Values of socioeconomic index of households, marble tile production and revenue increased linearly with almost same trend and rate. The rate of increase in values is shown in table 8.

Table 8

Rate of increase in the values of variables

Year	Value 2017	Value 2025	Increase	Rate (%)	Time Span (Years)	Annual Rate (%)
Socioeconomic Index 'S_h'	1024.88	2055.6	1030.72	100.5	10	10.05
Quantity of Marble Tiles 'P_m'	813	1678	865	106.39	10	10.63
Revenue 'R_m'	202.6	413.73	211.13	104.21	10	10.42

(Source: Author's own calculations using software GeoGebra)

Values in table 8 were significant. It validated the fact that values of three variables increased with almost same average annual rate (roughly over 10%), almost linearly. It also indicated the existence of correlation between the three variables. Now, it could be easily inferred that, ceteris paribus, if one variable was increasing with a specific rate, other two would increase with almost the same rate. But, there was a twist to this fact; the completion and functioning of MMC.

It is expected that MMC will be completed and fully functional by 2025 which shall change the prevailing trend due to following reasons:

- One, latest technology, machines and manufacturing tools including modernized packing and lifting machines.
- Two, improved infrastructure and communication network including roads and parkings.
- Three, uninterrupted energy availability, improved health and educational facilities.
- Four, greater job opportunities with increased pay for experts and workers.
- Five, modern transportation and cargo facilities.
- Six, improved working and living environment for experts and workers.
- Seven, relaxation by government in custom duties, taxes and trade laws.

These seven factors will exponentially increase value of socioeconomic index of households living in surroundings of MMC, quantity and quality of marble tiles and consequently revenue generated. This increase was required to be estimated. This was done by computational software, GeoGebra using mathematical framework of exponential rate model as shown in equation (3). Summary of calculation is shown in table 9.

Table 9

Summary of calculations for exponential rate model

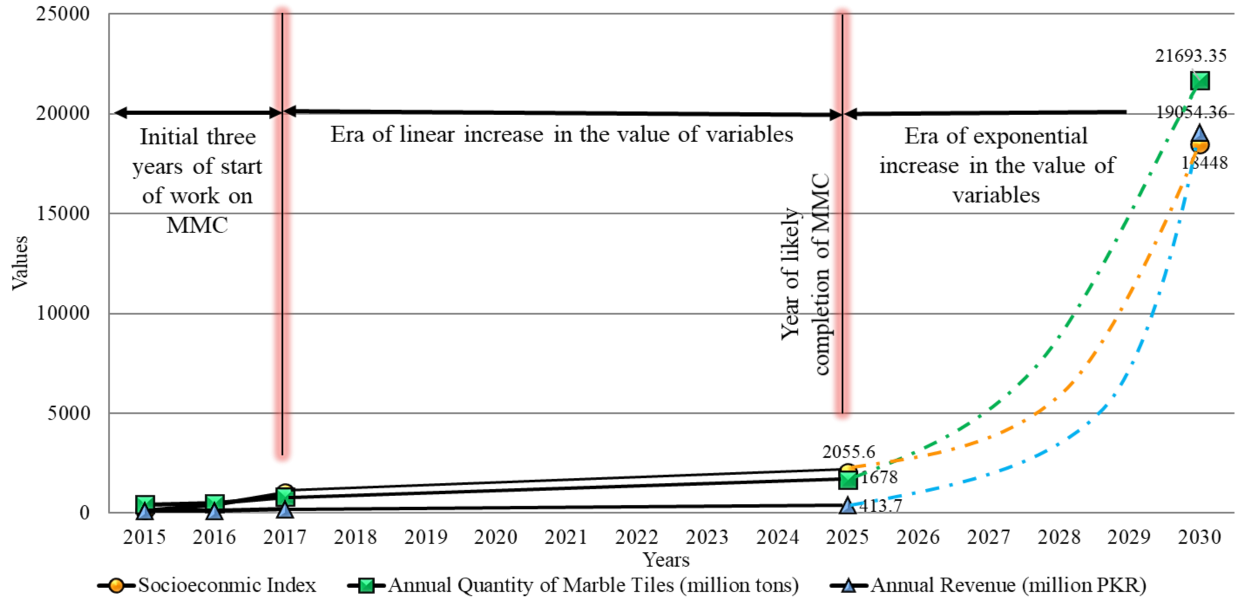
<table>
<tr><th>Year</th><th>Equation</th><th>μ</th><th>v_{2025}</th><th>t (Years)</th><th>Values in 2030</th></tr>
<tr><td>Socioeconomic Index ‘S_h’</td><td rowspan="3">S_h, P_m, R_m values in 2030 $= v_{2025} + \left[\frac{(1+\mu)^t - 1}{\mu}\right]$</td><td>10.05</td><td>2055.6</td><td>5</td><td>18448</td></tr>
<tr><td>Quantity of Marble Tiles ‘P_m’</td><td>10.63</td><td>1678</td><td>5</td><td>21693.35 million tons per year</td></tr>
<tr><td>Revenue ‘R_m’</td><td>10.42</td><td>413.73</td><td>5</td><td>19054.36 million PKR per year</td></tr>
</table>

(Source: Author’s own calculations using software GeoGebra)

Table 9 clearly indicated that MMC will have exponential effect on values of three variables. Values jumped exponentially from 2025 to 2030. To get a clear picture, these values were plotted using GeoGebra as shown in figure 9.

In fact, figure 9 summarized the whole study. It showed that in initial three years of initiation of the project, socioeconomic index of households, quantity of marble tiles and revenue had a kick start. From 2017 to 2025, values of three variables increased with a linear trend. In 2025, it is likely that MMC will be completed and functional. Therefore, from 2025 onwards values of three variables increased exponentially. By 2030, we shall achieve a high socioeconomic index for the households living surrounding of MMC, we shall be able to annually produce 2.17 billion tons of excellent quality marble tiles and generate revenue of 1.9 billion PKR per year.

Figure 9. Digital Graph of Data Extended from 2025 to 2030

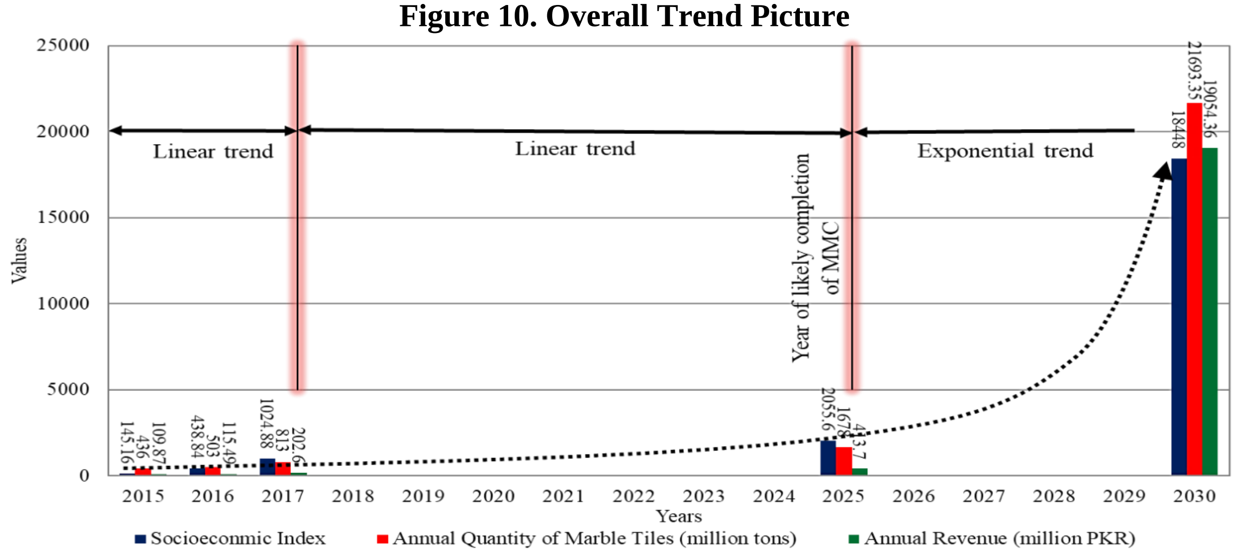


(Source: Author's own calculations using software GeoGebra)

7. **Conclusions and Policy Recommendations**

After detailed analysis of data, it is concluded that socioeconomic index of households, marble tiles production and revenue from marble trade will increase exponentially after completion and construction of MMC. Overall trend curve before construction of MMC exhibited linear trend while after completion of construction trend changed to exponential showing geometric growth of marble trade and resultantly socioeconomic status of households living in surrounding of MMC improved. Overall trend is clearly depicted in figure 10.

Figure 10. Overall Trend Picture



(Source: Author's own calculations using software GeoGebra)

Based on data analysis and input obtained from experts, few policy recommendations are proffered for optimal reaping of benefits and consolidation of socioeconomic gains. In a recent document, Pakistan Stone Development Company elucidated that marble and stone trade can reach to $2.5 billion in short term if policy and structural bottlenecks are removed. In this context, some recommendations are enlisted below.

- Pakistan has huge potential of marble trade. Sizeable marble quarries are available in different parts of the country. However, policy framework for marble trade is not available. There is a need to formulate comprehensive policy on marble trade covering both inland trade and export. To give boost to this potential sector, short term relief and incentive package may be announced for producers, sellers and consumers.
- Presently marble industry is in crude shape lacking modern machine and advance quarrying techniques. Some of the pertinent areas for improvement are suggested below. With these improvement marble trade will boost manifold.
    - Mechanized marble quarrying and mining techniques should be used for optimum output like developed countries. Current blasting practices in Pakistan cause a huge loss of precious stone. Global quarrying statistics show that standard wastage of marble in the world is 45%, whereas in Pakistan it is 85%. To minimize these losses, modern quarrying machines may be procured and provided to manufacturers and producers on rebated rates.
    - Handling, cutting, storing and transportation of marble products may be focused significantly. Modern cutting tools, transportation means and storing ware houses may be introduced. This will improve the efficiency, productivity and quality.
    - Infrastructure development and clustering of marble industries may be done at all potential sites where reservoirs are available. Marble sector can not be expanded without sound infrastructure including availability of energy and road network.
    - Mine safety, rescue and labour welfare procedures may be streamlined to attract skilled and unskilled labour towards marble industry. This aspect is presently neglected.
- Market demand may be considered while expanding production volumes and quantities. Designs, texture, dimensions and other factors of quality should be based on market demands.
- Recently, Saudi Arabia has shown interest in Pakistani marble for construction of new cities incurring an expenditure around $260 billion. Similarly, Italy and other European countries are ready to provide their modern machinery for marble industry as an exchange for Pakistani marble. These windows of opportunity may be explored.
- Facilitate investors to overcome shortfalls; especially energy requirements. Policy framework aiming at facilitating investors may be formulated immediately.
- Skilled manpower can play a cutting-edge role in optimizing quarrying operations and manufacturing process. Government should establish vocational and skill training centres at appropriate locations close to marble reservoirs.

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Appendix – 1

Summary of Data on Explanatory Variables for Estimation of Socioeconomic Index

Variables	Umar Banda	Nawab Sher Koroona	Utmanzai	Shal Koroona	Average	Standard Deviation	Skewness	Kurtosis
2015								
I	115409	103908	99670	102789	105444	6881.1	1.585	-0.23
W	6906	4689	5303	5893	5698	943.6	0.542	-3.21
E_m	5233	4981	5117	4940	5068	133.6	0.529	-5.40
E_f	1093	956	890	933	968	87.7	1.417	-0.71
H	3209	6109	7090	8211	6155	2143	-1.087	-1.79
E	349	693	671	761	619	183.7	-1.734	0.13
2016								
I	118906	109676	98609	124708	112975	11403.3	-0.529	-4.23
W	5908	6098	3908	7609	5881	1519.5	-0.476	-1.58
E_m	5833	6309	6023	4905	5768	607.4	-1.386	-0.86
E_f	1018	1023	936	988	991	39.9	-1.229	-2.43
H	6506	6098	5339	2789	5183	1668	-1.529	-0.85
E	613	724	615	544	624	74.4	0.787	-1.29
2017								
I	104507	113505	123506	126610	117032	10049.3	-0.564	-5.21
W	4605	7203	7101	6505	6354	1206	-1.640	-0.57
E_m	5809	6503	5590	6303	6051	424	-0.037	-6.88
E_f	1289	1233	813	936	1068	230	-0.191	-7.49
H	3119	3980	5998	6809	4977	1717	-0.024	-6.94
E	530	740	620	754	661	106.0	-0.570	-5.79