A SYNOPISIS OF THE RESEARCH WORK ENTITLED

“The Impact of Irrigation on Poverty Alleviation in India”

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Submitted to

BHAVNAGAR UNIVERSITY,

BHAVNAGAR - 364 001.

INDIA

In

STATISTICS

For the award of the degree of

DOCTOR OF PHILOSOPHY
THE IMPACT OF IRRIGATION ON POVERTY ALLEVIATION IN INDIA

AIM OF RESEARCH:

The aim of research is to study the marginal impact of irrigation on growth of productivity of all impacts and poverty reduction through irrigation. We also targeted that the effects of government expenditure on poverty, employment and development can help for poverty reduction. We also intended the role of irrigation in alienating rural poverty in content of statistical applications.

AREA OF STUDY

In this study, an attempt is made to analyze the incremental impact (input specific effects) of irrigation and other factor inputs on growth of total factor productivity and its implications on poverty alleviation in India over the last two and a half decades for 17 Major States of India.

OBJECTIVES OF THE STUDY:

The objectives of the study are as follows:

1. To study marginal impact of irrigation on growth of productivity of all impacts such as fertilizers, road infrastructure, rural literacy, HYV adoption rate.
2. To study the effect of government expenditure on poverty, employment & development
3. To study relationship between major – medium projects of irrigation and their impact on poverty reduction.
4. To study relationship between irrigation, TFP index and poverty across the states in India over the last two decades.
5. To analyze the role of irrigation in alienating rural poverty.
6. To analyze the role of groundwater and surface water irrigation in the growth of agricultural productivity.
Secondary data have been collected through sources such as books, Magazines, Web pages, Research Articles, Reports of Ministries, and Records kept by government agencies. The data thus collected and analyzed to interpret at various angles. A comparison is also be made at state level for India. At the end of the study attempt shall be made by us to highlight the recommendations and suggestions.

This research is a link between Economics and Statistics we define this as Econometrics. To analyze and inference regarding the economic problems, statistical tools require statistical data. Statistical methods are becoming more applied in socio-economic parameters and related problems.

**MULTIVARIATE TECHNIQUES:**

This research work has discussed some advanced multivariate techniques. It requires a high level of statistical knowledge. Multivariate methods deal with the simultaneous treatment of several variables. They have a useful role in analyzing data from developing country surveys. We first discuss the effective use of such methods: (a) as an exploratory tool to investigate patterns in the data; (b) to identify natural groupings of the population for further analysis; and (c) to reduce dimensionality in the number of variables involved.

- **POOLED PANEL DATA ANALYSIS:**

Pooled Panel data analysis is a method of studying a particular subject within multiple sites, periodically observed over a defined time frame.
Within the social sciences, panel analysis has enabled researchers to undertake longitudinal analyses in a wide variety of fields. The combination of time series with cross-sections can enhance the quality and quantity of data in ways that would be impossible using only one of these two dimensions (Gujarati, 638).

**ROBUST REGRESSION:**

Robust regression is an important tool for analyzing data that are contaminated with outliers. It can be used to detect outliers and to provide resistant (stable) results in the presence of outliers. In order to achieve this stability, robust regression limits the influence of outliers. In theory, when the assumption of normally does not meet, the standard least squares estimation for the regression coefficients $\beta$ will be biased and / or non efficient, see for example (Hampel et al. 1986). When the assumption of normally is not met in a linear regression problem, several alternative methods of the standard Least Squares (LS) regression had been proposed (Draper & Smith, 1998; Kutner et al., 2004; Ortiz et., 2006). Among these, the estimation methods we have applied are robust M-estimation, (Huber, 1964), least Absolute Deviations (LAD) method, (Dielman & Pfaffenberger, 1982) and (Bloomfield & steiger, 1983) and nonparametric (rank based) methods, (Adichie, 1967; Jureckova, 1971); Jaeckel, 1972) etc. LTS estimation (Rousseeuw, 1984), S estimation (Rousseeuw and Yohai, 1984), LMS estimation (Rousseeuw and Leroy, 1987),


➢ **STEP-WISE REGRESSION METHOD:**

Step-wise regression method is a very famous method of regression analysis. It gives a better idea of the independent contribution of each explanatory variable. Under these techniques, we have added the independent contribution of each explanatory variable into the prediction equation one by one, computing betas and $R^2$ at each step.

➢ **WEIGHED LEAST SQUARE REGRESSION ANALYSIS:**

A special case of generalized least squares called weighted least squares occurs when all the off-diagonal entries of the correlation matrix of the residuals are 0.

The expressions given above are based on the implicit assumption that the errors are uncorrelated with each other and with the independent variables and have equal variance. The Gauss–Markov theorem shows that, when this is so, estimated co-efficient is a best linear unbiased estimator (BLUE). If, however, the measurements are uncorrelated but have different uncertainties, a modified approach might be adopted. Aitkin showed that when a weighted sum of squared residuals is minimized, the estimated co-efficient is BLUE if each weight is equal to the reciprocal of the variance of the measurement.

➢ **HETEROSKEDASTICITY & TRANSFORMATION:**

The model study is applicable to test the explanatory variables of models have the same inherent variability. That is to say, some observation may have a larger or smaller variance than other. This describes the condition
known as heteroskedasticity. Just as in the simple linear regression model, errors have an average value of zero for each value of the independent variables and are uncorrelated with one another. The difference in the model is that the variance of errors now depends on values of residuals, i.e. the observations to which it belongs. Indexing the variance with the residuals subscript is just a way of indicating that observations may have different amount of variability associated with them.

➢ **QUANTILE REGRESSION ANALYSIS:**

In regression, the desired estimate of $y / x$ is not always given by a conditional mean, although this is most common. Sometimes one wants to obtain a good estimate that satisfies the property that a proportion, $\tau$ of $y / x$, will be below the estimate. For $\tau = 0.5$ this is an estimate of the median. What might be called median regression is subsumed under the term *quantile regression*. We present a nonparametric version of a quantile estimator, which can be obtained by solving a simple quadratic programming problem and provide uniform convergence statements and bounds on the quantile property of our estimator. Experimental results show the feasibility of the approach and competitiveness of our method with existing ones.

➢ **TWO STAGE LEAST SQUARE REGRESSION ANALYSIS:**

The two stage least square regression estimator for latent variable models developed by Bollen (1996). The technique separately estimates
the measurement model and structural model of SEM (Structural Equation Models). One can therefore use it either as a standalone procedure for a full SEM or combine it with factor analysis, for example, establish the measurement model using factor analysis and then employ TSLS for the structural model only.

- **LIMITED INFORMATION & MAXIMUM LIKELIHOOD ESTIMATION (LIML):**

The way of estimating the parameters in linear regressions with endogenous regressors is limited information maximum likelihood estimation. The likelihood is based on normality for the reduced form errors $\nu$ and $\eta$ with covariance matrix $\Omega$, although consistency and asymptotic normality of the estimator do not rely on this assumption. This is a standard log likelihood function, with all the standard properties. In particular the asymptotic variance for the estimator can be found using the second derivatives of the log likelihood function. The main issue is that its maximization is a little tricky, involving Eigen values.

- **STEP-WISE LOGISTIC REGRESSION ANALYSIS:**

Modeling the relationship between explanatory and response variables is a fundamental activity encountered in statistics. Simple linear regression is often used to investigate the relationship between a single explanatory (predictor) variable and a single response variable. When there are several explanatory variables, multiple regressions is used. However, often the response is not a numerical value. Instead, the response is
simply a designation of one of two possible outcomes. Although responses may be accumulated to provide the number of successes and the number of failures, the binary nature of the response still remains. How does one model the relationship between explanatory variables and a binary response variable? The answer of the question is solved its analysis via logistic regression. Concepts from simple and multiple linear regressions carry over to logistic regression.

- **Spatial Analysis:**
  According to Anselin (1988), spatial econometrics addresses issues causes by space in statistical analysis of regional science regressions. In other words, spatial analysis is the combination of statistical and econometric methods that deal with problems concerning spatial effects. According to Anselin (1988), spatial econometrics addresses issues causes by space in statistical analysis of regional science regressions.

- **Simultaneous Equation System:**
  Simultaneous Equation System is generally defined with relations of affected parameters and variables. One who would like to establish the estimated equations must form the frame work of relations of variables. This system of equations majorly correlated to each other so to construct the equations there is a need of use to instruments for constructing equations and two stages least square regression analysis can be the best fit for models. To test the marginal effects of each of the variables it is necessary to differentiate the equations.
FACTOR ANALYSIS:

Factor analysis is by far the most often used multivariate technique of research studies, specially pertaining to social and behavioral sciences. It is a technique applicable when there is a systematic interdependence among a set of observed or manifest variables and the researcher is interested in finding out something more fundamental or latent, which creates this commonality.

DISCRIMINENT ANALYSIS:

Discriminent analysis technique requires interval independent variables and a nominal dependent variable. Discriminent analysis is considered an appropriate technique when the single dependent variable happens to be non-metric and classified into two or more groups, depending upon its relationship with several independent variables which all happen to be metric. The objective in discriminent happens to be to predict an object’s likelihood of belonging to a particular group based on several independent variables.

TIME SERIES ANALYSIS:

There exist many models used for time series; however, there are three very broad classes that are used most often. These are the autoregressive (AR) models, the integrated (I) models, and the moving average (MA) models. These models are often interred twined to generate new models. For example, the autoregressive moving average model (ARMA) combines the (AR) model and the (MA) model. Another example of this
is the autoregressive integrated moving average (ARIMA) model, which combine all three of the models. The most commonly used model for time series data is the autoregressive process. The autoregressive process is a difference equation determined by random variables. The distribution of such random variables is the key component in modeling time series.

The ARCH and GARCH were primarily developed for monetary and financial economics. These models are used for modeling fluctuations. Engle (1982) introduced the ARCH model to incorporate the lag or time-dependent error structure in estimation in econometrics. Bollerslev (1986) extended the ARCH to the GARCH model by including the lag structure for variance using the autoregressive and moving average process.

➢ CHANGE-POINT PROBLEM:

A sequence of random variables \(X_1, \ldots, X_n\) is said to have a change-point at \(r\) (1 \(\leq r \leq n\)) if \(X_i \sim F_1(x|\theta_1)\) (i = 1, ..., r) and \(X_i \sim F_2(x|\theta_2)\) (i = r + 1, ..., n), where \(F_1(x|\theta_1) \neq F_2(x|\theta_2)\). We shall consider the situation in which \(F_1\) and \(F_2\) have known functional forms, but the change-point, \(r\), is unknown. Given a sequence of observations \(x_1, \ldots, x_n\), the problem we shall be concerned with is that of making inferences about \(r\). The parameters \(\theta_1\) and \(\theta_2\), which could be vector-valued, may be known or unknown; in the latter case, it might be of interest to make inferences about these also.

Pandya and Jani [2006] Pandya and Bhatt [2007] Mayuri Pandya and
Regression analysis is an important statistical technique to analyze data in social, economic and engineering sciences. Quite often, in practice, the regression coefficients are assumed constant. In many real-life problems, however, theoretical or empirical deliberations suggest models with occasionally changing one or more of its parameters. The main parameter of interest in such regression analyses is the shift point parameter, which indexes when or where the unknown change occurred.

A variety of problems, such as switching straight lines (Ferreira, 1975), shifts of level or slope in linear time-series models (Smith, 1980), detection of ovulation time in women (Carter and Blight, 1983), and many others, have been studied during the last two decades. Holbert (1982), while reviewing Bayesian developments in structural change from 1968 onward, gives a variety of interesting examples from economics and biology.

The Two-phase linear regression model is one of the many models, which exhibits structural change. Holbert (1982) used a Bayesian approach, based on the TPLR model, to reexamine the McGee and Carlteon (1970) data for stock market sales volume and reached the same conclusion that the abolition of split-ups did hurt the regional exchanges.
BAYES ESTIMATION:

The ML method, as well as other classical approaches, is based only on the empirical information provided by the data. However, when there is some technical knowledge on the parameters of the distribution available, a Bayesian procedure seems to be an attractive inferential method. The Bayes procedure is based on a posterior density say, \( g(\alpha, \beta, m \mid X) \), which is proportional to the product of the likelihood function \( L(\alpha, \beta, m \mid X) \), with a prior joint density, say, \( g(\alpha, \beta, m) \) representing uncertainty on the parameters values.

\[
g(\alpha, \beta, m \mid X) = \frac{L(\alpha, \beta, m \mid X) \cdot g(\alpha, \beta, m \mid X)}{\sum_{m=1}^{n-1} \int_{\alpha_1} \int_{\alpha_2} \int_{\beta} L(\alpha, \beta, m \mid X) \cdot g(\alpha, \beta, m \mid X) d\alpha_1 d\alpha_2 d\beta}
\]

The Bayes estimator of a generic parameter (or function thereof) \( \alpha \) based on a Squared Error Loss (SEL) function \( L_1(\alpha, d) = (\alpha - d)^2 \), where \( d \) is decision rule to estimate \( \alpha \), is the posterior mean. As a consequence, the SEL function relative to an integer parameter,

\[
L_1'(m, v) \propto (m - v)^2, \quad m, v = 0, 1, 2, \ldots
\]

Hence, the Bayesian estimate of an integer-valued parameter under the SEL function \( L_1'(m, v) \) is no longer the posterior mean and can be obtained by numerically minimizing the corresponding posterior loss. Generally, such a Bayesian estimate is equal to the nearest integer value.
to the posterior mean. So, we tell the nearest value to the posterior mean as Bayes Estimate.

Other Bayes estimators of $\alpha$ based on the loss functions

\[ L_2 (\alpha, d) = | \alpha - d | \]

\[ L_3 (\alpha, d) = \begin{cases} 0, & \text{if } | \alpha - d | < \epsilon, \epsilon > 0 \\ 1, & \text{otherwise} \end{cases} \]

is the posterior median and posterior mode, respectively.

**ASYMMETRIC LOSS FUNCTION**

The Loss function $L (\alpha, d)$ provides a measure of the financial consequences arising from a wrong decision rule $d$ to estimate an unknown quantity (a generic parameter or function thereof) $\alpha$. The choice of the appropriate loss function depends on financial considerations only, and is independent from the estimation procedure used. The use of symmetric loss function was found to be generally inappropriate, since for example, an over estimation of the reliability function is usually much more serious than an under estimation.

In this study, we derive Bayes estimators of change point $m$ under different asymmetric loss functions using two prior considerations. A useful asymmetric loss, known as the Linex loss function was introduced by Varian (1975). Under the assumption that the minimal loss at $d$, the Linex loss function can be expressed as,

\[ L_4 (\alpha, d) = \exp [q_1 (d - \alpha)] - q_1 (d - \alpha) - I, q_1 \neq 0. \]
The sign of the shape parameter \( q_1 \) reflects the deviation of the asymmetry, \( q_1 > 0 \) if over estimation is more serious than under estimation, and vice-versa, and the magnitude of \( q_1 \) reflects the degree of asymmetry.

Another loss function, called General Entropy loss function (GEL), proposed by Calabria and Pulcini (1996) is given by,

\[
L_5(\alpha, d) = \left(\frac{d}{\alpha}\right)^{q_3} - q_3 \ln(\frac{d}{\alpha}) - 1,
\]

Whose minimum

**SOCIO-ECONOMIC PARAMETERS AND RELATED PROBLEMS:**

The socio- occurs at \( d = \alpha \), minimizing expectation \( E [L_5 (m, d)] \). economic parameters we have chosen to study using the official statistics are mainly rural poverty, irrigation, irrigation through groundwater, irrigation projects for surface water and related problems.

**RURAL POVERTY:**

In India, only 28% of population was living in urban areas as per 2001 census (Pranati Datta, 2006). There is still a large pressure of population in rural India. So, the best way to study poverty in India would be to study rural poverty of India. Poverty in rural India has declined substantially during the period of 1970-1993 decades. With few exceptions (Bardhan 1973; Griffin and Ghose 1979), most of these studies have found an inverse relationship between growth in agricultural income and the incidence of rural poverty. Our purpose of the research is also to investigate the contribution of agricultural growth & other socio-economic parameters as well in rural poverty reduction in India. The
poverty measure we have used to study is poverty Head-count ratio (HCR). The poverty headcount ratio (HCR) is the proportion of the national population whose incomes are below the official threshold (or thresholds) set by the national government. The main chosen responsible factors for our study are rural development expenditure by government (DEV), percentage of cropped area sown with high yielding varieties (HYV), percentage of cropped area irrigated (IRR), percentage of villages electrified (ELE), percentage of rural population that is literate (LITE), road density in rural India (ROAD), total factor productivity growth in Indian agriculture (TEP), changes in rural wages (WAGES).

➢ **IRRIGATION IN INDIA**

Agriculture and irrigation sectors have always been a prime focus world over for reforms because of their importance in world economy and farmers’ livelihoods (also employs 41% of world total labor). The World Bank has also lent some 35 billion dollars for irrigation development or an equivalent seven percent of all its lending since 1950’s (Plusquellec, 1999). In spite of such huge investments, irrigation sector continued to be trapped in a vicious circle. It has been observed worldwide that lack of basic infrastructure for irrigation, poor maintenance of existing systems, and reducing government investments on repair and rehabilitation (R&R) of systems have been the major precursors for the irrigation reforms (Gulati et al., 2005; Madhav, 2007; Vermillion, 2001). Irrigation reforms stated as early as 60s in Bangladesh and USA, 70s in Mali, New Zealand and Colombia and to 80s in the Philippines, Tunisia and Dominican Republic. The new century interventions have taken place in Sudan
and Pakistan (2000), India (1990’s), China (2002) and more recently in some of the Central Asian countries. Presently more than 60 countries in the world have undergone some type of irrigation sector reforms (Munoz et al., 2007). These countries constitute around 75% of the world population and represent some 80% of the irrigated area of the world (FAOSTAT, 2003).

Major problems facing Indian irrigation sector include: a) declining investment on maintenance; b) low levels of system efficiency; c) poor financial working; and, d) low quality, reliability, and system-wide equity. Further, there is a competing demand for water from other sectors. It was considered that to improve the overall situation in irrigation water management, important is to involve end users/farmers in the operation and maintenance of the irrigation conveyance systems. The basic idea behind Farmers Managed Irrigation Systems (FAMIS) was to improve the overall efficiency of irrigation system, generate sense of ownership among farmers and to improve the irrigation revenue recovery rate.

This laid the seeds for Participatory Irrigation Management (PIM) in India. Pant (2007) described the process of Indian PIM having passed through four distinct phases during the last three decades: i) first from 1975-85 where emphasis was on creating outlet based water user organization, ii) second phase from 1985-90 where focus shifted to experimentation and establishments of pilot PIM projects with help of government, international donors and non-governmental organizations (NGO’s), iii) third phase from early 1990’s where few of the progressive states such as Maharashtra propagated the idea of turnover of management of irrigation systems to the farmers. During this phase came the India first farmers Management of Irrigation System Act by Andhra Pradesh in 1997.
Even after the completion of the eighth and ninth five year plans, there was no pronounced effect in the net irrigated area through canals. Similar trends were noticeable for quality of maintenance of conveyance systems, timeliness and equity of water delivery (DSC, 2003), and efficiency of water fee collection. This was the situation despite emphasis for both government investments in irrigation and involvement of end users in irrigation management. Research studies have also shown that even after the enactment of IMT/PIM act in various states, performance of transferred systems has improved only marginally (Parthasarathy, 2000; van Koppen et al., 2002;). Some of the reasons for this are: a) haste in creating WUAs without any capacity building of farmers as in Andhra Pradesh, b) transfer of systems without complete repair & rehabilitation (R&R) work as in Gujarat, or c) lack of appropriate legal back up for end user organizations as in Punjab and West Bengal.

INDIA'S IRRIGATION DEVELOPMENT: TRENDS AND SHIFTS

Recognizing the importance of irrigation as a crucial input in India's agricultural development, harnessing of water resources for irrigation has been given an important place in our successive five-year Plans (FYP). The ultimate irrigation potential of the country from major and medium projects is assessed at 58.5 million hectare (M. ha). The irrigation potential from minor projects is estimated at 55 M. ha, which is undergoing reassessment in view of the possible improvements in water management practices. As against this, the irrigation potential created during the pre-plan period was 22.6 M. ha. Further, an estimated 62 M. ha of additional irrigation potential has been created during 1951-96. Consequently, up to 1996, 74.5 per cent of the total irrigation potential has been harnessed for expanding irrigation facilities.
Major and medium irrigation programs accounted for 38 per cent of the additional irrigation potential created while the remaining 62 per cent of the added irrigation potential came through minor irrigation programs. Initially, starting from I FYP, major and medium irrigation programs contributed around two-third of the additional irrigation potential created. Minor irrigation programs contributed the remaining one-third. This emphasis was gradually changing and completely reversed from IV FYP onwards extending up to VIII FYP. As a result of this, both surface and ground water resources were harnessed at varying levels across space and time with resultant variations in their multiple impacts, which are highlighted later.

**CANAL IRRIGATED AREA**

Among the major states, canal-irrigated area, during 1972-82, the percentage increase was the highest in case of Gujarat (82.8 per cent) followed by Madhya Pradesh (41.6 per cent), Maharashtra (34.4 per cent), Bihar (33.9 per cent) and Orissa (33.1 per cent). Remaining states registered less than one-third increase in canal irrigated area over the 1972 level. Kerala and West Bengal registered decline in canal irrigated area during this period. Marginal decline in canal-irrigated area was also observed in case of Punjab and Tamil Nadu. During 1982-93, canal irrigated area registered impressive expansion in states like Karnataka, Madhya Pradesh, Rajasthan, Maharashtra and Gujarat. All these states registered more than one-third increase in canal-irrigated area in 1993 over the 1982 level. Orissa, West Bengal and Haryana states have recorded 14 to 17 per cent increase in canal-irrigated area during 1982-93 period. Bihar, Tamil Nadu, A.P and Jammu & Kashmir registered decline in canal irrigated area during this period.
Considering both the time periods together, it was observed that states like Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Orissa and Rajasthan have consistently increased the area under canal irrigation during 1972-93. In case of Tamil Nadu, the decline in canal irrigated area is consistent although only marginally (3.2 and 5.5 per cent during 1972-82 and 1982-93 respectively). For other states both expansion and contraction in canal-irrigated area was observed during this time period 1972-93.

- **TANK IRRIGATED AREA**

  Among the major states, maximum expansion in tank irrigated area was observed during 1972-82 in case of Maharashtra (32.5 per cent), followed by Andhra Pradesh (28.6 per cent), West Bengal (23.3 per cent) and Orissa (18.2 per cent). Among the states with declining tank-irrigated area during the same period, Haryana and Rajasthan were leading with 52.4 to 54.5 per cent fall, followed by Uttar Pradesh (48.3 per cent), Bihar (30.5 per cent), Kerala (23 per cent) and Tamil Nadu (20 per cent). During 1982-93, Rajasthan registered maximum expansion in tank-irrigated area with 143.5 per cent followed by Haryana (100 per cent), Orissa (44 per cent), Maharashtra (36.5 per cent), Madhya Pradesh (31.1 per cent) and Bihar (28 per cent). Maximum decline in tank irrigated area during 1982-93 was observed in case of Uttar Pradesh (54.8 per cent), followed by Gujarat (35 per cent), Andhra Pradesh (30.2 per cent) and West Bengal (29.5 per cent).

  Across two time periods covering 1972-93, only Maharashtra and Orissa have consistently expanded the area under tank irrigation. On the other hand, Uttar Pradesh, Tamil Nadu, Karnataka and Kerala have registered continuous decline
in tank-irrigated area during the same periods. For other states both expansion and contraction in tank-irrigated area was observed during 1972-93.

**WELL IRRIGATED AREA**

Well-irrigated area includes the area irrigated by both wells and tube wells. During 1972-82, except Kerala and Gujarat, all other states registered increase in the area irrigated by wells by over 25 per cent. Expansion in well-irrigated area was the highest in West Bengal and Orissa. This was followed by states like Haryana, Bihar, Karnataka, Madhya Pradesh, Rajasthan and Uttar Pradesh accounting for more than 50 per cent expansion in well-irrigated area during this period. Well-irrigated area declined only in case of Kerala and Gujarat during 1972-82. During 1982-93, Orissa and Madhya Pradesh recorded maximum expansion in well-irrigated area. Bihar, Himachal Pradesh, Karnataka, Rajasthan and West Bengal sustained the growth in well-irrigated area during 1982-93 also by registering above 50 per cent growth during this period.

While Andhra Pradesh accelerated the well irrigation growth during this period, Tamil Nadu, Haryana, Maharashtra, Punjab and Uttar Pradesh slowed down as compared to the earlier period of 1972-82. Considering both the periods together, impressive and consistent growth of more than 50 per cent in each period is observed in case of several states like; Bihar, Himachal Pradesh, Karnataka, Madhya Pradesh, Orissa, Rajasthan and West Bengal. Barring Jammu and Kashmir with decline in well-irrigated area and Kerala with no change in well-irrigated area, all other states have expanded the area under well irrigation during the later period of 1982-93. Consequently, at all India level also, well-irrigated area has gone up continuously by 52.3 and 42.6 per cent respectively in 1972-82 and 1982-93.
➢ **TOTAL IRRIGATED AREA**

Total irrigated area across the sources has gone up consistently by over 25 per cent during each of the period namely 1972-82 and 1982-93. Only Tamil Nadu has stagnated in providing additional irrigation facilities. Both consistency and improvement in irrigation expansion was observed in case of Karnataka, Madhya Pradesh, Orissa, Rajasthan, and West Bengal. In case of Gujarat and Kerala, total irrigated area declined during 1972-82 but expanded subsequently in 1982-93. In all the remaining states, total irrigated area continued to expand in both the periods but with a declined rate of growth in the later period.

➢ **SHIFTS IN IRRIGATION SOURCES**

Varying magnitudes of growth in source-wise irrigated area over time has also resulted in perceptible shifts in the importance of different sources of irrigation over space and time. At all India level, canals dominated the source of irrigation with 41.5 per cent in 1972, closely followed by wells with 38.7 per cent. However in 1982, wells became the dominating source of irrigation with a share of 46.5 per cent, which further increased to 53 per cent in 1993. Consequently, the share of canals in the irrigated area has come down to 34.1 per cent in 1993. Tanks as a source of irrigation also came down from 11.9 to 6.5 percent during the period 1972-93.

➢ **RELATION BETWEEN IRRIGATION & POVERTY**

Within agriculture, irrigation water is a vital resource for many productive and livelihood activities. As a production input in agriculture, irrigation water is an important with a positive role in poverty alleviation. Irrigation water can also become a worthless when it leads to problems such as waterborne diseases (Malaria, Schistosomiasis), and land degradation including water logging and salinity, water pollution and associated destruction of living beings and natural
ecosystems (negative externalities associated with irrigation). The poor population, with limited resources remain unable to adopt preventive or defensive measures, are most affected by consequences of water. Access to reliable irrigation water can enable farmers to adopt new technologies and intensify cultivation, leading to increased productivity, overall higher production, and greater returns from farming. This, in turn, opens up new employment opportunities, both on-farm and non-farm, and can improve incomes, livelihoods, and the quality of life in rural areas. Overall, irrigation water, like land, can have an important income-generating function in agriculture specifically, and in rural settings in general.

We identify five key dimensions of how access to good irrigation water contributes to socioeconomic uplift of rural communities and alleviates poverty. These are production, income and consumption, employment, food security, and other social impacts contributing to overall improved welfare. These poverty-reducing variables are interrelated. In general, access to good irrigation allows poor people to not only increase their production and incomes, but also enhances their opportunities to diversify their income base, and to reduce their vulnerability to the seasonality of agricultural production and external shocks. It should be noted that the poor also use water for other farm and non-farm production activities, particularly small-scale rural enterprises such as livestock rearing, fish production, brick making and so on. These enterprises are part of the poor’s livelihood strategies and contribute to poverty alleviation. Thus, access to good irrigation water can contribute to poverty reduction, and to moving people from ill-being to well-being.
CHAPTERIZATION

Thesis is divided into 8 chapters. They are organized in the following way:

CHAPTER: 1

This chapter gives a detailed introduction of the study and its genesis. We have discussed about the relation of irrigation and poverty reduction in India. It has the detail discussion towards the water management and irrigation projects development and poverty.

CHAPTER: 2

The chapter deals with application of multivariate technique different multiple regression models on irrigation development projects and effects on poverty reduction strategies for selected states of India. The official data source for the study is the PUBLICATION BY CENTRAL WATER COMMISSION (CWC) - INDIA 2005. The different regression models we have discussed here are as under.

1. Pooled Panel Regression Model
2. Robust Regression Model
3. Step Wise Logistic Regression Model

CHAPTER: 3

This chapter deals with the impact of irrigation on rural poverty alleviation for selected states of India. The official data source for the study is the WORLD BANK DATA.
In this chapter we have studied, Heteroskedasticity and Weighted Least Square Method on transformed data of poverty head count ratio and other related variables.

In this chapter, we also proposed shifting regression model. An Application of shifting regression model is done for rural poverty and irrigation data from the official statistics of the World Bank. Bayesian estimation of regression coefficient is done using informative priors and under asymmetric loss function.

CHAPTER: 4

We have studied application of multivariate spatial analysis technique on rural population under poverty of Andhra Pradesh line on socio-economic parameters we discussed about the geographical position of Andhra Pradesh and the effects of poverty due to the location. We justify the spatial regression analysis for BPL families of 22 districts of Andhra Pradesh. The official statistics used here is the MORD (Ministry of Rural Development – 2011 BPL records). We have developed two spatial error models. Our focus was to apply such model, which minimize the spatial error. Jean H.P. Paelinck in the early 1970s, originates as an identifiable field in Europe because sub-country data in regional econometric models are needed to deal with and been fast developed & grown during the 1990s (Anselin,1999). We also studied, Stepwise Regression Analysis on Socio – Economic Determinants Affecting the Poverty Study on the Districts of Andhra Pradesh
CHAPTER: 5

The government spending on rural poverty and employment programs has increased substantially in recent years. Government spending can have direct and indirect effects on poverty. We discussed econometric model on IFPRI data tables which can be formulated and estimated that permits calculation of the number of poor people raised above the poverty line for each additional million rupees spent on different expenditure items. We consider the Infrastructure, education, productivity and production growth, rural employment and wages and rural poverty as base variables and defined the exogenous and endogenous variables. We have tested the equations by using Two Stage Least Square Model and the final conclusions for marginal effects of government expenditures on poverty have been tested.

CHAPTER: 6

On the bases of FINANCIAL ASPECTS OF IRRIGATION DEVELOPMENT 2009-10 REPORT published by CWC, we have studied the Factor Analysis, we tested the groundwater recharge scenario which is affected by different factors and due to how government bare the cost for irrigation expansion. Factor analysis is by far the most often used multivariate technique of research studies, specially pertaining to social and behavioral sciences.

In this chapter, we have also done application of First order autoregressive process with exponential error with change point on official statistics source CENSUS. Bayesian inferences, particularly estimation of auto regressive
coefficient are derived under prior considerations and using Linex and General Entropy loss functions. Exponential autoregressive model studied by Bell - Smith (1986) and Mayuri Pandya (2013) are for instance, very powerful in the analysis of such time series.

CHAPTER: 7

In chapter-7, we have applied the Discriminant Analysis technique to test the state wise major – minor and ERM project details for irrigation on

FINANCIAL ASPECTS OF IRRIGATION PUBLICATION BY CENTRAL WATER COMMISSION – INDIA in 2005. The application for 17 major states of India shows the affects of major, medium and ERM irrigation projects on poverty reduction.

CHAPTER: 8

The government spending for poverty reduction program needs to test the existence of government expenditure indicators in major 14 states of India. We have applied most recent models of time series on Government Expenditures for poverty reduction in India. We have studied the following time series models on poverty data sets on official statistics of WORLD BANK:

1. Autoregressive – AR (1) Time Series Model (AR – 1 Model)
2. Moving Average Time Series Model (MA Model)
3. Autoregressive Integrated Moving Average Model (ARIMA)
4. Autoregressive Conditional Heteroskedastic Model (ARCH Model)
5. Generalized Autoregressive Conditional Heteroskedastic Model
 Anselin, L. (1999), Spatial econometrics, Bruton Center, School of Social Sciences, University of Texas at Dallas, Richardson, TX 75083-0688.


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