GIDR WORKING PAPER SERIES
No. 226 : April 2015

# Climate Change Economics: A Review on Theoretical Understanding and Controversies

Chandra Sekhar Bahinipati
Unmesh Patnaik

Gujarat Institute of Development Research

# Working Paper No. 226

# Climate Change Economics: A Review on Theoretical Understanding and Controversies

**Chandra Sekhar Bahinipati**
**Unmesh Patnaik**

**April 2015**

**Gujarat Institute of Development Research**
Gota, Ahmedabad 380 060

Abstracts of all GIDR Working Papers are available on the Institute's website. Working Paper No 121 onwards can be downloaded from the site: http://www.gidr.ac.in/publication.php?type=2





First Published April 2015
ISBN 81-89023-84-5
Price Rs. 100.00

## Abstract

The neo-classical economics literature incorporated the notion of environment during the mid 20th century, but climate change has found its place in the economics discourse during the early 1980s. During the last three and half decades, numerous research studies have been carried out within the broader theme of climate change economics. In view of this, the present study aims to take stock of existing literature under two themes: (i) the journey of climate change economics literature, and (ii) existing controversies in the neo-classical economics literature.

**Keywords** : Climate change economics, Neo-classical economics, theories and controversies, Stern, Nordhaus

**JEL Classification** : Q54, A11, D61, D62, D63

## Acknowledgements

The authors thank Amalendu Jyotishi and P. K. Viswanathan for providing constructive comments on the earlier version of the manuscript. The usual disclaimers apply.

# Contents

# Climate Change Economics: A Review on Theoretical Understanding and Controversies

**Chandra Sekhar Bahinipati**
**Unmesh Patnaik**

## 1. Introduction

The neo-classical economics literature incorporated the notion of 'environment', often cited as 'natural capital', during mid of the 20th century. Later 'environmental economics (EE)'evolved as a separate discipline, an outcome of A. C. Pigou's extensive analysis on 'negative externality' with the onus being to look for the deeper inter-linkages between ecology and society, while adopting the neo-classical economics principles (Venkatachalam, 2007; see Sandmo, 2015 for the history of EE). The micro level studies within this discipline deal with issues related to optimal use of scarce resources (i.e., renewable and non-renewable), economic valuation of environmental goods and services (i.e., revealed and stated preferences), negative and positive externalities, market based instruments to address market failure (e.g., tax, subsidy, command and control approach, tradable emission permit, etc.), common pool resources, public goods, etc. On the other hand, studies at a macro scale establish the relationship between environment and variables like economic growth, population, etc., and of late, the concept of green accounting also emerging as a major issue in the EE discourse (see Dasgupta, 2009).

Furthermore, the notion 'climate change' has found its place in the economics literature, notably in the EE discourse during the early 1980s, mostly after the Rio 'Earth Summit' held in 1992[1]. For instance, only one paper which

Chandrasekhar Bahinipati (chandrasekharbahinipati@gmail.com) is Assistant Professor at Gujarat Institute of Development Research (GIDR), Ahmedabad; and Unmesh Patnaik (unmeshpatnaik@gmail.com) is Assistant Professor at the Centre for Climate Change and Sustainability Studies, School of Habitat Studies, Tata Institute of Social Sciences (TISS), Mumbai.

[1] It was the first milestone in the international climate policy under the auspices of UNFCCC (United Nation Framework Convention on Climate Change), and around 25,000 delegates including researchers, industrialists, NGOs, and activists etc attended this (Schelling, 1992, p.1).

addressed the economic dimensions of climate change was presented by Ralph C d'Arge at the First World Climate conference held in Geneva in 1979, and is believed to have the laid foundation for economists to analyze issues associated with the global environmental change (Spash, 2002). Consequently, a number of research papers addressing the economic perspectives of climate change are being published not only in mainstream economics journals but also in environment specific journals. Over the years, it has emerged as a leading area of research in natural and social sciences. The scientific evidences also assert that climate change poses a serious challenge to the entire human society and ecosystems now and in the coming decades (Parry *et al.*, 2007). However, until the mid of the last decade it was not an agenda in the development economics theme. For instance, '*eight eminent economists were invited to Copenhagen in 2004 to offer advice on how the world community could most usefully spend US$ 50 billion over a 5-year period, and in fact, they placed climate change at the bottom of their list of 10 alternatives*' (*c.f.* Dasgupta, 2007a, p.481). It is also noteworthy that there was no discussion on it during the first meeting of the commission on 'growth and development' in early 2006 (Dervis, 2008). However, things changed after the publication of Nicholas Stern's review on 'Economics of Climate Change' (e.g., see Stern, 2007) and the noble peace prize 2007 which was shared by the Intergovernmental Panel on Climate Change (IPCC) and Al Gore. Issues related to climate change remain active issues for investigation in the international research paradigm, with Stern's review injecting the key economic concepts into the climate change debate (Mendelsohn, 2008).

The history of climate change research which is around two centuries old has been dominated by the natural sciences, especially by a clique of climate scientists. However the complexities involved in understanding issues like global environmental change requires researchers to go beyond the boundaries of scientific literature (Spash, 2002), and for instance, bringing the economics discourse will emphasize the human dimensions to the complex environmental problems. In similar line, Tavoni and Levin (2014) highlight the need for a multidisciplinary approach to solve negative externalities of the global environmental change, faced by the modern societies. While the first assessment report of IPCC published in early 1990s (e.g., 1991) had focused mainly on the climate science, a

special emphasis on the economic dimensions of climate change[2] was given since the second assessment report published in the year 1995 (Spash, 2002). The IPCC has so far released five assessment reports (e.g., 1991, 1995, 2001, 2007 and 2013/2014) and a range of special reports[5], and since the third assessment report, the IPCC has been publishing three volumes in each report: (i) the physical science basis, (ii) impacts, adaptation and vulnerability, and (iii) mitigation of climate change; the latter two using principles of economics to address various issues associated with impact, vulnerability, adaptation and mitigation. In addition, the human development report 2007/08 of United Nation Development Programme (UNDP) had focused on 'fighting climate change: human solidarity in a divided world' (see UNDP, 2008). All these developments have resulted in making climate change a priority area of research in the EE discourse also. Within the economics stream although the early contributions were from neo-classical economic thinkers, later, other branches within economics disciplines like ecological economics, behavioural economics, experimental economics, etc. have substantially contributed to climate change research (e.g., see Gowdy, 2008, 2010; Brekke and Stenamn, 2008).

In the EE discourse, the crucial question for investigation was the role of economic discipline to address issues associated with the global environmental problems. Borrowing from the original definition of economics propounded by Lionel Robins[4], the EE discourse viewed atmosphere that assimilates different components of greenhouse gases (GHGs) and fosters problems like climate change or global environmental change, as a public good (which satisfies the characteristics of non-excludability and non-rivalness), and is a scarce resource that needs to be distributed sustainably across as well as within generations. The EE discourse mainly contributes by explaining how choices of an economic agent (individual, household, community and nation) lead to the global environmental change

---

[2] As part of the second assessment report of the IPCC, a special report is published as 'social and economic dimension of the climate change' (see IPCC, 1995).

[3] Apart from these reports, the IPCC has been published various special reports, e.g., special report on emission scenario, carbon dioxide capture and storage, renewable energy sources and climate change mitigation, managing the risks of extreme events and disasters to advance climate change adaptation, etc.

[4] 'Economics as the science which studies human behaviour as a relationship between ends and scarce means which have alternative uses' (*c.f.* Barker, 2008: 5).

problem while treating the atmosphere as a public good, estimating potential impacts of climate change on human and ecosystems, and recommending policies (i.e., both normative and positive) to alleviate it while maximizing the economic welfare of both the current and the future generations (Nordhaus, 1993; Stern, 2007; Barker, 2008). While addressing these, simultaneous issues have also evolved, like how fast we should graze our global commons, how to distribute the global commons with regard to the intra- and inter-temporal scenarios, should we use conventional cost-benefit analysis to identify the extent of use of the global commons, how much we should invest and when, etc. (Nordhaus, 1982, 1993; d'Arge *et al.*, 1982; Arrow *et al.*, 2004; Dervis, 2008). In fact, the prime research question for the policy makers dealing with climate change right now is whether we should adapt or mitigate or is there a trade-off between these two (Nordhaus, 2007a). The economics discourse, in general, facilitates both positive and normative policies to solve issues related to the climate change (Goulder and Pizer, 2006). Neither scientists nor economists are able to solve the moral ethics of it, i.e., what should we do about it, and hence, there are critics on its empirical findings and fundamental assumptions as well as value judgments on which it is based (Toman, 2006).

Given this background, the present study reviews the relevance of EE theory to address issues associated with the global environmental change. In particular, two concepts are discussed in the remainder of the paper: (i) the journey of climate change economics literature so far, and (ii) existing controversies in the neo-classical economics discourse. The structure of the paper is as follows: the second section outlines the theoretical understanding of climate change economics which is mainly referred to economics of mitigation and adaptation, and the third section highlights the existing theoretical controversies, especially between two noted economists William D Nordhaus and Nicholas Stern; and finally, the fourth section presents the concluding remarks.

## 2. Economics of Climate Change: Understanding of Economic Theory

It is well understood that climate change induced events generate negative externality for human society and ecosystems as a whole. There are two broad policy responses to deal with it, namely, 'mitigation' and 'adaptation'. A large number of research studies have been undertaken in the context of former compared to the latter (Pielke *et al.*, 2007), but it emerged as an

important research issue in the international paradigm after the CoP (Conference of Parties) meeting held in Bali in 2007 (Bahinipati, 2011). The next section discusses how economics discourse so far has addressed issues related to mitigation and adaptation.

### *2.1. Mainstreaming Climate Change in Environmental Economics*

Climate change has been analysed in the EE discourse since the early 1980s, and initially, it is treated as akin to the other environmental problems such as pollution, acid rain, etc. Over the years, however, this has become unique and also grabbed attention of many environmental economists. It is due to five reasons: first, it is global in its origin, risk and impacts; second, the emission of the GHGs and other trace gases are irreversible and non-separable; third, the potential impacts are long-term and its scale is trans-boundary in nature; fourth, the extent and nature of uncertainties; and fifth, uneven distribution of costs and benefits across the space and time (Hanley *et al.*, 1997; Goulder and Pizer, 2006; Spash, 2007a; Stern, 2008).

In general, the environmental problems are being addressed in two ways in the EE discourse: (i) loss of human welfare which is analysed through market and price mechanism, and (ii) implementing institutional regulation to control it through taxation, tradable permits, command-and-control approach, etc. (Spash, 2002; Bahinipati, 2011). But, the uniqueness of the climate change problem has posed additional complexity issues: risk and uncertainty, inter-generational and inter-temporal equity, un-even distribution of emissions and impacts, and economic ethics, i.e., notion of rights, justice and freedom, sustainability and stewardship (Spash and d'Arge, 1989; Mendelsohn *et al.*, 2006; Stern, 2007).

In the EE literature, the notion climate change is being viewed as a 'public good' (Hanley *et al.*, 1997; Dasgupta, 2007b), which fosters 'free rider' problem as this provides an opportunity to an entity to emit the GHGs without any limit. Based on the standard economic theory, the entity emits up to the zero marginal benefit, i.e., 'economical optimum point' – a situation of market failure as we do not consider externality and fail to reach the social optimum point; it is the point of highest difference between total cost and total benefit (Hanley *et al.*, 1997). As a result, the developed nations have been emitting the GHGs into the atmosphere without any limit since the pre-industrialisation,

and in recent past decades. The developing nations like India, China, Brazil, South Africa, etc. are also rapidly increasing their share of GHG emissions. Because of the past and ongoing rapid emissions, the complexity for the policy makers lies in deciding who should reduce emission now and how much; more importantly, its impact on the economy of that particular nation. The issues associated with public goods could be overcome by adopting policies, proposed by Wicksell and Samuelson, such as public provision and publicly subsidized private provision (Dasgupta, 2007b). However, the climate change problem not being confined within the boundaries of a single country, needs involvement of the multi-national government entities (Dasgupta, 2007b).

In addition, climate change has both positive and negative externalities upon human society and ecosystems. For instance, while nations situated in global north have benefited from it, the nations in the global south are the worst affected (Mendelsohn *et al.*, 2006). Further, it has the unique property of trans-boundary externality (Hanley *et al.*, 1997), and hence, the issue of 'carbon or ecological debt' has emerged in the literature, i.e., 'compensation principle' with the modern welfare economists pointing out that the developed nations should facilitate funding to the developing nations to reduce loss and damage occurring due climate change induced events (Parikh, 1994)[5]. Since it satisfies both the properties of public good and a negative externality, Stern viewed it as a 'biggest market failure'[6] which the world has ever seen (Stern, 2008). Besides this, it has challenged international communities on the distribution of carbon footprint among different nations on the basis of differentiation in terms of geography, standard of living, per capita income, etc. The existence of the notions of externality, public good, and market failure are the starting point for the economic discourse to discuss it within the EE framework.

---

[5] While the Alliance of Small Island states (AOSIS) had first tabled the proposal of 'insurance mechanism' (i.e., compensating the vulnerable countries) in 1991, the term 'loss and damage' was appeared in the Bali Action plan in 2007.

[6] Market failure occurs when the market does not generate an efficient allocation of resources – the perfectly competitive market where private decisions lead to a social optimum, and it has six characteristics: incomplete markets, externalities, non-exclusion, non-rival consumption, non-convexities, and asymmetric information (Hanley et al., 1997).

Under the backdrop of above description, it could be highlighted that the climate change has become a serious challenge for the international communities, because of the uniqueness in characteristics compared to the other environmental problems. Since the society needs precautionary principles to mitigate it, there are three options to follow: do nothing and conduct 'business as usual', adapt to the extreme events (likelihood to reduce costs of the potential impacts), and reduce the emission of the GHGs- mitigation (likelihood to reduce the frequency and intensity of the climate related events) (Spash, 2002). Therefore, since the early 1980's, literature has been looking for alternative strategies to reduce or slow down the level of GHG emissions at a modest rate while considering the welfare of the future generation, i.e., Pareto-efficiency (Nordhaus, 1993; Stern, 2007), and estimating both market and non-market damages – through change in price and supply of the goods (Goulder and Pizer, 2006).

### *2.2. Economics of Mitigation*

In the context of mitigation, the mainstream economics literature address two issues: (i) optimal path of emission control (e.g., see Nordhaus, 1993, 1994; Nordhaus and Yang, 1996; Stern, 2007), and (ii) possibilities of energy substitution (Goulder and Pizer, 2006). These issues are analysed through market instruments such as tax, subsidies, emission quotas, tradable emission allowance, performance standards, etc. (Goulder and Pizer, 2006).

The society incurs two types of costs associated with mitigation: (i) abatement cost (e.g., switches to more expensive cleaner fuels and re-capture the emissions through reforestation), and (ii) social cost of carbon (e.g., potential negative impacts on sensitive sectors like agriculture, health, water, etc.) (Mendelsohn, 2008). The obligation for economics discourse is to identify an efficient policy that could minimize present costs and enhance welfare of households across the generations. For empirical assessment, the economics literature is centered on the traditional economic tool of cost-benefit analysis (Nordhaus, 1993; Stern, 2007) – the equilibrium point is arrived where marginal abatement cost (MAC) is equivalent to marginal damage cost (MDC). In doing so, the neo-classical economics has given more emphasis on rationality, via use of utility maximisation and on equilibrium. But, it has neglected strong kind of uncertainty, particularly fundamental uncertainty that persists in the future as consequences of the

climate change (Barker, 2008). Further, the entire theoretical analysis has replaced the long term uncertainty with the certainty-equivalent damages and treated individual preferences as fixed and utilities that could be aggregated and converted into well behaved mathematical equations in a 'social welfare function' (Barker, 2008). However, controversy pertaining to the selection of discount rate in order to estimate the present value of future benefits with the abatement cost still persists. The ethical question is how we treat our future generation, which has raised the issue like 'inter-generational or inter-temporal equity' (Spash and d'Arge, 1989).

Stern's review (2007), on the other hand, adopted the IAMs (Integrated Assessment Models) – alternatively cited as dynamic cost-benefit analysis – to assess the potential damages of the climate change and cost of abatement, and to highlight emission paths that minimize the present value sum of damage and control costs. A lively debate persists in this perspective on the extent to which the conclusion of the IAMs was driven by the discount rate. It is sensitive not only to the discount rate but also to the inter-generational welfare function (Stern, 2008). In fact, the traditional cost-benefit analysis tool was criticised on three grounds: discount rate, accuracy of the present value of the future costs and benefits, and ethics in terms of selecting negative or positive or infinite social discount rate (d'Arge *et al.*, 1982) which are discussed in the next section.

### *2.3. Economics of Adaptation*

During the early 1980s, both mitigation and adaptation have received equal importance in the climate change discourse. Over a period, the notion 'adaptation', however, was missing from the mainstream literature (Pielke *et al.*, 2007), as the objective of the UNFCCC (United Nation Framework Convention on Climate Change) – particularly the 'article 2' – is to stabilize GHGs in the atmosphere (McCarthy *et al.*, 2001, p. 881). It has bounced as a front runner issue in the climate change debate, as the world is already committed to some of the potential impacts of climate change, even if we adopt stringent mitigation policy now (Pielke *et al.*, 2007). The recent scientific studies, for instance, predict that the world temperature would definitely increase by 2-4$^{0}$C in 2100, given the past emission of GHGs (Panda, 2012), and as a result, we

have to undertake various adaptation mechanisms to counteract the consequences of such increasing temperature. Further, it is also known that the frequency and intensity of extreme events will increase in the near future due to climate change (see IPCC, 2012; Wagner and Weitzman, 2015).

It is well-known that all living beings are adapting to the changing climatic patterns over the years, i.e., autonomous adaptation. But, in the recent years, the impacts from the climate change have overwhelmed adaptive capacity of various entities, so that it requires pro-active adaptation policy, i.e., planned adaptation. In the climate change economics literature, the notion adaptation has been used in two discourses: 'impact assessment' and 'vulnerability assessment'; both are different in terms of not only the research question they ask but also the way in which they assess adaptive capacity (Bahinipati, 2011). While following a prescriptive or normative approach, impact studies estimate likelihood impact cost, includes both adaptation and unmitigated costs, based on the various projected emission scenarios (see Tol *et al.*, 1998); these studies calculate the cost in terms of net impact minus adaptation (Bahinipati, 2011). The vulnerability studies, in contrast, adopt a descriptive or positive approach, which views adaptation as a 'starting point', i.e., current ability to cope with risk and secure livelihoods given the socio-economic, environment and political conditions where the entity resides (Bahinipati, 2011). Within both the approaches, there are three issues which capture attention of economic discourse: (i) cost of adaptation, (ii) financing adaptation, and (iii) households' adaptive behaviour and effectiveness of adaptation measures.

In December 2007 during Bali Action Plan (CoP-13), the developed nations have agreed to provide adequate, predictable, sustainable financial resources for developing country parties in order to adapt to the climate change (World Bank, 2010). Therefore, a large number of studies (i.e., both at macro and micro levels) have emerged to estimate 'price tag' for adaptation to help policy makers in the global, regional and local context (Bahinipati, 2011). On a macro scale, few studies have been carried out to estimate the adaptation cost for different regions and sectors separately (see Agrawala and Fankhauser, 2008; Parry *et al.*, 2009; Fankhauser, 2010; World Bank, 2010). At a micro level, Mckinsey (2009) identifies cost-effective adaptation options adopting a conventional cost-benefit analysis.

Applying joint probability distribution method, Palanisami *et al.* (2015) estimate cost of various farm-level adaptation measures in the major river basins in India. Though there are limitations on the methods adopted by the above studies (see Bahinipati, 2011), the advantage is that it gives a figure for adaptation cost which helps policy makers to negotiate. Nonetheless, a few philosophical questions arise like who will facilitate funding and how much aid each developing nation could receive; in this context, various issues have been put forward as fairness, equity and justice (Adger and Paavola, 2006). Another research issue within adaptation concerns right time to invest on adaptation, i.e., whether we should invest now or wait for technological advancement for less adaptation cost; here, the most persisting issue is uncertainty associated with the climate change.

In the context of assessing households' adaptive behaviour, a large number of studies have been emerged in agriculture, which is highly sensitive to the climate change and where the prime objective is to assess determinants of various farm-level adaptation options, in the context of Africa, Latin America, China and South Asia. Considering adaptation as a binary choice, Bryan et al. (2009), Deressa *et al.* (2011) and Di Falco *et al.* (2011, 2012) investigate factors influencing farmers' decision to adapt with farmers adopting various options which are either mutually exclusive or inclusive. Treating adaptation options as independent, Panda *et al.* (2013) and Wood *et al.* (2014) identify major determinants of them. However, these studies did not take into account the relationship between various adaptation mechanisms. While the options are not mutually exclusive, Nhemachena and Hassan (2007), Piya *et al.* (2013), Bahinipati and Venkatachalam (2015), Patnaik and Narayanan (2015), and Patnaik *et al.* (2016) find out factors influencing various adaptation options while allowing complementarities and substitutability relationship among them. When the choices are mutually exclusive, the studies identify factors influencing choice of an adaptation measure over no adaptation (Kurukulasuriya and Mendelsohn, 2007; Seo and Mendelsohn, 2008; Hassan and Nhemachena, 2008; Gbetibouo, 2009; Deressa *et al.*, 2009; Wang *et al.*, 2010). Further, following crop diversity literature, Bahinipati (2015) assesses farmers' adaptive behaviour to farm-level adaptation diversity, i.e., number of adaptation options.

In addition, it is also well-recognized that farm-level adaptation measures could reduce potential impacts of the climate change (Tol *et al.*, 1998; see Bahinipati, 2011). In the recent years, Di Falco *et al.* (2011), and Di Falco and Veronesi (2013 and 2014) estimate the benefits of undertaking adaptation measures in Ethiopia. While Di Falco *et al.* (2011) and Di Falco and Veronesi (2014) calculate benefits of undertaking adaptation (which is treated as a binary variable) to address food insecurity problem at the household-level, Di Falco and Veronesi (2013) compute benefits of adopting various adaptation strategies (e.g., changing crop varieties, water conservation strategies and soil conservation strategies) in isolation or combination. These studies find that past adaptation decreases risk of crop failure and the implementation of adaptation strategies is a successful risk management strategy that makes the adapters more resilient to climatic conditions.

## 3. Controversies in Climate Change Economics

As pointed out in the previous section, it is a challenging task for both the natural scientists and the economists as well to design effective policy to mitigate potential impacts of the global environmental change. At present, the international community is vexed with a crucial issue as what should be done right now to avoid the future potential impacts – whether we should adopt 'strong policy' (i.e., invest now) or 'wait and see principle', where it seems that the future wealthier generation would bear the burden (Broome, 2008). Alternatively, it could be asked as whether we should respond to the problem now or pass it to the future generation, and ensure that they will respond to it efficiently due to the possible improvement of the technological efficiency that could reduce cost, and the notion uncertainty could have solved by that time. The answers to these crucial questions depend upon how the future generation is being viewed in the telescope of the mainstream economic thinkers. While addressing the above research questions, climate change economics studies have come across a few controversial issues, e.g., discount rate, uncertainty, and cost of action and inaction (Mendelsohn, 2008; Heal, 2008). In the following sections, we explain each of them separately, and also summarize the comments by various scholars on the work by Stern and Nordhaus, particularly on 'discount rate'.

*3.1. Theoretical Controversies*

Since the early 1980's, the climate change economics studies, as highlighted above, have been focusing on the optimal path of mitigation. The standard economic theory suggests that the role of economics is to minimize the present value of the abatement plus damage costs (Mendelsohn, 2008), and therefore, a large number of studies have adopted the conventional cost-benefit analysis (CBA) to solve the long standing environmental problems. Later this was criticized due to its economic assessment, and ethical as well as methodological standpoint (Spash, 2002). In particular, the crucial issue persists here as how the economists are discounting future generation relative to the current, i.e., choosing a discount rate – pure rate of time preference, market rate of interest or consumption discount rate. Most of literature has adopted Ramsey (1928) equation on 'Theory of saving which is shown in equation 1.

$$\rho = \delta + \eta g \text{L L} \quad (1)$$

Here, 'δ' refers to the discount rate, and 'η' is the elasticity of consumption, and 'g' depicts the growth rate of the consumption. Both the discount rate and elasticity of consumption[7] have dominated the entire controversy in the climate change economics literature (see Dasgupta, 2007c; Nordhaus, 2007a, b; Mendelsohn, 2008).

In the context of discount rate, it is well-known that there are two types of discount rate: pure time preference rate (PRTP) and consumption discount rate (CDR) or market rate on interest (Heal, 2008). Basically, economists are discounting the value of the future generation relative to now because they are living in different time periods and having different income levels. In doing this, concern about the existing intra-generational equity is neglected, for example: someone could get same kind of judgment with valuing the utility of household say in Asia differently from that of household in Africa (Heal, 2008). In addition, most of the models follow a general equilibrium model considering the whole world as one country model rather than giving importance to the notion of existing inequality (Heal, 2008). In the perspective of choosing discount rate, Dasgupta (2008a) has raised wide range of questions as: how should society chose the discount rate – PRTP or CDR, how

[7] It measures the society's aversion to inter-personal inequality and risk of consumption.

are they related to the notion of inter-generational justice and equity, should they be constant over time or could they depend on date, do they reflect the opportunity cost of the capital, if so, how the society determines what that cost is, whether the discount rate is positive or negative, and how the consumer prices future consumption with the existing uncertainty. In addition, the positive or higher discount rate has the disadvantage to give negligible present value of future disastrous event, even if it could bring huge damage cost in the future. For example:

"*Suppose that Denmark needs to be evacuated due to flooding. Current real estate value in Denmark is estimated at about USD$238 billion. If a discount rate of 5 percent is applied, then over 500 years, the same real estate would be worth just $6. Hence, if they did not enlarge their property in the meantime, the loss of all real estate in Denmark would be compensated if, today, we make a saving equivalent to half a barbeque chicken with potato fritters*" (Gardiner, 2004: 572).

Since it is a controversial issue in the literature, Heal (2008) suggests that it would be better to choose a lower discount rate, as most of the literature, including Stern's review, in the current decade is following the lower discount rate. It will be more appropriate to choose zero or near to zero as discount rate, because it has given equal importance to the each generation. However, few neo-classical economists have argued that it would be unfair between the current poor and the future wealthier generation. Apart from this, the other controversial factor is elasticity of consumption. For instance: a low (high) value of it implies that decision gives little (much) attention about whether the future is richer or poorer than the present.

Further, the notion uncertainty has dominated the controversies in the climate economic literature. While the science is not uncertain, its' estimations are too uncertain. For instance, will the temperature rise to $2^{O}$ or $6^{O}$ Celsius with respect to the temporal as well as spatial scale. Likewise, the change in the patterns of precipitation, humidity, ocean circulation, and melting of ice sheets are too uncertain, and more importantly, its implication on the social and economic activities are still not clear. Therefore, it has become difficult to take decision regarding the future, given the existing uncertainty. As the traditional economic model of decision making under uncertainty assumes known state space as well as

probability distribution, and an expected utility function, the characteristics of the climate economics do not satisfy the above mentioned conditions. Though we have some knowledge on the likelihood impacts in the future period, it does not sufficient to build probability distribution and additionally consequences also being irreversible (Heal, 2008).

Referring to cost of action, there is not much controversy as most of the literature agrees with certain points. For example, the Fourth Assessment Report of the IPCC estimates that the cost of maintaining the emission of $CO_{2e}$ below 450 ppm was 3% of world's GDP by 2030 and less than 5.5% by 2050 (Heal, 2008, p. 18). Stern (2007) estimates that keeping the concentration of $CO_{2e}$ less than 500-550 ppm requires 1 to 3% of world's GDP. Since the estimation of the costs are represented in terms of the proportion of GDP, Heal (2008) raises the issue as whether cost of reducing emission will rise in proportion to income. For example: suppose GDP doubles then the cost will also double, i.e. if income doubles, does the value of land lost due to sea level rise double? (Heal, 2008, p.18). Further, Nordhaus estimated an optimal carbon tax for 2005 of around $30/ton in current prices, and it will rise to $85/ton by the mid of this century and again raise over a period (Nordhaus, 2007b, p.201). Stern (2007), in contrast, proposed $300/ton carbon tax at current price, which is 10 times higher than the earlier estimation. However, Mendelsohn (2008) argues that whether Stern's review is an economic analysis, as the onus is to minimize the present value of the abatement plus damage costs. Besides this, it does not estimate the present value of the sum of damages and abatement costs of its preferred policy, and in particular, also does not compare with the other alternative efficient polices cited by the mainstream literature (Mendelsohn, 2008). In the context of cost of inaction, much controversy persists in the mainstream economics literature. In particular, the result basically depends upon the five factors: (i) assigned value to the costs of climate change, (ii) choice of discount rate, (iii) elasticity of marginal utility of consumption, (iv) non-market impacts, and (v) issue related to uncertainty (Heal, 2008, p.20).

### *3.2. Controversies between Nordhaus and Stern's Approach*

While Stern suggests that we should adopt stringent mitigation policy in the near future, Nordhaus supports for reducing emission of GHGs in a moderate manner. Various scholars have criticized the methodology followed by both the studies in order to arrive at these conclusions.

Similarly the selection of discount rate is a major disagreement between both the studies. Nordhaus adopts market rate of interest for long-term risk free bond to discount future benefits and costs, as he views it as an opportunity cost of alternative investment, say, infrastructure and capital. Stern's approach, in contrast, is more pluralistic giving importance to the ethical principles of economics, and therefore, it has adopted ethical discount rate, which is near to zero at 0.1 (Barker, 2008). But, it gives less emphasis to income inequality, thereby it saves a great deal for the future and real return is low. Nordhaus, in contrast, assumes a high discount rate and aversion to inequality, thereby the current savings rate is low and the real return is high (Nordhaus, 2007b). On Nordhaus's approach, Barker (2008) points that it has given emphasis on rationality via the use of utility maximisation, general equilibrium model, whereas neglected uncertainty and irreversible impacts. Further, the whole analysis is based on the single country approach, and the aggregated utility is shown in a well-behaved social welfare function in order to investigate implication on consumption of different generations (Barker, 2008).

Broome (2008) has commented on the Nordhaus's approach as it has followed the principles of ''prioritarianism' – which gives priority to the less well off, whereas on the Stern's approach, he observes that it has pursued the principles of 'utilitarianism'- which gives equal benefit to each generation and does not matter who receives it. Nordhaus (2007b) distinguished it as the 'descriptive' – discount rate that determines actual political and economic decisions, and 'prescriptive' approach – ethical parameters determine the discount rate. Barker (2008) described it as traditional (i.e., Nordhaus) and new economic (i.e., Stern) approach. Besides these, the Stern's review was criticized by the various scholars, for example Dasgupta (2007c, 2008a), Nordhaus (2007a, b), Spash (2007a), Mendelsohn (2008), etc. In particular, Mendelsohn (2008) criticizes the Stern's review on several grounds like: time horizons, discount rates, abatement costs, environmental impacts of alternative energy sources,

market and non-market damages and the role of uncertainty. Likewise, Spash (2007a) criticizes it on the ground of strong uncertainty, incommensurability, plural values, non-utilitarian ethics, rights, distributional inequity, poverty, and treatment of future generations.

Based on these, it is observed that Stern's review (2007) was severely criticized on the basis of using traditional cost-benefit analysis to sort out the global environmental change problem, over-estimating the abatement cost of mitigation (i.e., 10 times higher than the other calculation given by the other conventional economists), and also mistreating the notion discount rate (Spash, 2007b). Stern (2007), on the other hand, treats the whole problem as a simple externality with reference to Pigou without any reflection on the critical literature of the intervening 90 years (*c.f.* Spash, 2007b, p.709). However, Stern (2007) highlighted the economic ethics that need to reckon the impacts on the future generation and argued that the earlier discounting, taken by the follower of the neo-classical economists, is unethical (Spash, 2007a). Apart from the controversial issues, the Stern's review (2007) has some advantages with including the estimation of the non-market damages and for the first time, it has estimated the potential impacts beyond the 21st century. More importantly, it has given emphasis to the ethics of economics as he stated that "*it is not possible to provide a coherent and serious account of the economics of climate change without close attention to the ethics underlying economic policy raised by the challenges of climate change"* (*c.f.* Stern, 2007b, p.38).

## 4. Concluding Observations

It is well established now that climate change poses serious challenges to the human society and ecosystems as well. Up to the early 1980s, the whole climate change research was dominated by the natural scientists, and their findings being inconclusive; for instance, whether the world temperature would increase $2^{O}$ or $6^{O}$C, and to what extent the global environmental change impact on different nations. The mainstream EE discourse entered into the climate change debate during the early 1980s treating atmosphere as a public good and its impact as a negative externality; Stern (2007) pronounces it as a biggest market failure the world ever seen. Numerous economic studies have emerged after the Stern's review on 'economics of climate change'; but it was the first to inject economic underpinnings into the climate change research.

There are two broad policy responses to address problems related to the global environmental change: mitigation and adaptation; the latter being overlooked by many earlier studies, however, its importance emerged during the mid of the last decade. Mitigation studies basically identify optimal path of emission control and estimate economic cost of energy substitution. In the case of former, the studies particularly adopt conventional cost-benefit analysis technique to estimate present cost and benefits of various projected emission scenarios – the onus is to identify an efficient path of mitigation that could minimize the present costs and enhance households' welfare across generations. In this context, the whole controversy is with choice of discount rate. Since the world is already committed to some of the impacts from climate change, it is necessary to undertake pro-active adaptation policy to mitigate the potential impacts in the near future. It is found that the discourses have used two notions of adaptation: impact assessment and vulnerability assessment. While the impact assessment views adaptation as an end-point approach with estimating net impact (impact minus adaptation), the vulnerability studies consider it as a starting-point approach, i.e., current ability to cope with risk and secure livelihoods (Bahinipati, 2011). In both the approaches, three issues have captured attention of the economists: cost of adaptation, financing adaptation and households' adaptive behaviour and effectiveness of adaptation. In the mainstream economics literature, the controversies persist with a few issues such as discount rate, uncertainty, and cost of action and inaction, and in fact, the major debate between Stern and Nordhaus, being also related to the treatment of discount rate and elasticity of consumption.

## References


Agrawala, S. and S. Fankhauser, (Eds.) (2008), "*Economic Aspects of Adaptation to Climate Change: Costs, Benefits and Policy Instruments*" OECD, Paris.

Arrow, K., Dasgupta, P., Goulder, L., Daily, G., Ehrlich, P., Heal, Geoffrey, Levin, S., Maler, K. G., Schneider, S., Starrett, D. and Walker, B., (2004), 'Are we consuming too much', The *Journal of Economic Perspectives*, 18(3): 147-172.

Bahinipati, C. S., (2011), "Economics of Adaptation to Climate Change: Learning from Impact and Vulnerability Literature" *MIDS Working Paper No. 213*, Madras Institute of Development Studies (MIDS), Chennai, India.

Bahinipati, C. S. (2015), 'Determinants of farm-level adaptation diversity to cyclone and flood: insights from a farm household-level survey in Eastern India', *Water Policy*, 17(4): 742-761.

Bahinipati, C. S. and L. Venkatachalam, (2015), 'What drives farmers to adopt farm-level adaptation practices to climate extremes: Empirical evidence from Odisha, India', *International Journal of Disaster Risk Reduction*, 14(4): 347-356.

Barker, T., (2008), "The Economics of Avoiding Dangerous Climate Change" *Working Paper No. 117*, Tyndall Centre for Climate Change, University of East Anglia, Norwich, U.K..

Brekke, K. A. and Stenman, O. J., (2008), 'The behavioural economics of climate change', *Oxford Review of Economic Policy*, 24(2): 280-297.

Broome, John, (2008), 'The Ethics of Climate Change: Pay Now or Pay More Latter', *Scientific Americans*, June, pp: 97-102.

Bryan, E., Deressa, T., Gbetibouo, G. A. and Ringler, C. (2009), 'Adaptation to climate change in Ethiopia and South Africa: Options and constraints', *Environmental Science and Policy*, 12(4), 413–426.

Cline, W. R., (1991), 'Scientific Basis for the greenhouse effect', *The Economic Journal*, 101(407): 904-909.

D'Arge, R.C., Schulze, W. D. and Brookshire, D. S., (1982), 'Carbon dioxide and intergenerational choice', *American Economic Review*, 72(2): 251-256.

Dasgupta, P., (2007a), 'Nature and the Economy', *Journal of Applied Ecology*, 44: 475-487.

Dasgupta, P., (2007b), *Economic: A Very Short Introduction*, Oxford University Press, New York.

Dasgupta, P., (2007c), 'Commentary: the Stern review's economics of climate change', *National Institute Economic Review*, 199: 4– 7.

Dasgupta, P., (2008a), "Discounting Climate Change", *SANDEE Working Paper No. 33*, South Asian Network for Development and Environmental Economics (SANDEE), Kathmandu.

Dasgupta, P., (2008b), 'Nature in Economics', *Environmental and Resource Economics*, 39: 1-7, http://qed.econ.queensu.ca/pub/faculty/garvie/eer/Dasgupta%202008%20Nature%20in%20Economics.pdf

Dasgupta, P., (2009), 'The welfare economic theory of green national accounts', *Environmental and Resource Economics*, 42(1): 3-38.

Deressa, T. T., Hassan, R. M. and Ringler, C. (2011), 'Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia', *Journal of Agricultural Science*, 149(1): 23–31.

Deressa, T. T., Hassan, R. M., Ringler, C., Alemu, T. and Yesuf, M. (2009), 'Determinants of farmers' choice of adaptation methods to climate change in the Nile basin of Ethiopia', *Global Environmental Change*, 19(2): 248–255.

Dervis, K., (2008), "The Climate Change Challenge" *WIDER Annual Lecture 11*, UNU-WIDER, Helsinki, Finland. http://www.wider.unu.edu/publications/annual-lectures/en_GB/AL11/; accessed on 21st January, 2015.

Di Falco, S., and Veronesi, M. (2013), 'How African agriculture can adapt to climate change? A counterfactual analysis from Ethiopia', *Land Economics*, 89(4): 743-766.

Di Falco, S., and Veronesi, M. (2014), 'Managing environmental risk in presence of climate change: The role of adaptation in the Nile Basin of Ethiopia', *Environmental and Resource Economics*, 57: 553-577.

Di Falco, S., Veronesi, M. and Yesuf, M. (2011), 'Does adaptation to climate change provide food security? A micro-perspective from Ethiopia', *American Journal of Agricultural Economics*, 93(3): 829–846.

Di Falco, S., Yesuf, M., Kohlin, G. and Ringler, C. (2012), 'Estimating the impact of climate change on agriculture in low-income countries: Household level evidence from the Nile basin, Ethiopia', *Environmental and Resource Economics*, 52(4): 457–478.

Fankhauser, S., (2010), 'The Costs of Adaptation', *Willey Interdisciplinary Reviews: Climate Change*, 1(1): 23-30.

Gardiner, S. M., (2004), 'Ethics and Global Climate Change', *Ethics*, 114: 555-600.

Gbetibouo, G. A. (2009), "Understanding farmer's perceptions and adaptation to climate change and variability: The case of the Limpopo basin, South Africa", *IFPRI Discussion Paper 00849*, International Food Policy Research Institute, Washington D.C.

Goulder, L. H. and Pizer, W. A., (2006), "The Economics of Climate Change" *Discussion Paper 06*, Resources for the Future (RFF), Washington D.C.

Gowdy, J. M., (2008), 'Behavioural economics and climate change policy', *Journal of Economic Behavior and Organization*, 68(3-4): 632-644.

Gowdy, J. M., (2010), "Behavioral economics, neuroeconomics, and climate change policy: Baseline review for the Garrison Institute initiative on climate change leadership", *Working Paper No. 1010*, Department of Economics, Rensselaer Polytechnic Institute, NY, USA.

Hanley, N., Shogren, J. F. and White, B., (1997), *Environmental Economics: In Theory and Practice*, London: MacMillan Press Ltd.

Hassan, R. and Nhemachena, C. (2008), 'Determinants of African farmer's strategies for adapting to climate change: Multinomial choice analysis', African *Journal of Agriculture and Resource Economics,* 2(1): 83–104.

Intergovernmental Panel on Climate Change (IPCC) (2012), "*Summary for Policymakers*" In: Field *et al.* (Eds.), *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*: *A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp 3-21.

Intergovernmental Panel on Climate Change (IPCC), (1995), 'Climate change 1995: economic and social dimensions of climate change', Contribution of working group III to the Second Assessment Report of the intergovernmental panel on climate change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Intergovernmental Panel on Climate Change (IPCC), (2014), "*Summary for policymakers*", In: Edenhofer *et al.* (eds.), 'Climate Change 2014, Mitigation of Climate Change', Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Kurukulasuriya, P. and Mendelsohn, R. (2007), Crop selection: Adapting to climate change in Africa, *World Bank Policy Research Working Paper 4307*, World Bank, Washington D.C.

McCarthy, J. J., Osvaldo F. C., Neil A. L., David J. D. and Kasey S. W. (Eds.) (2001), "*WG II: Climate Change 2001: Impacts, Adaptation & Vulnerability*", Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change , Cambridge University Press, pp. 1000.

Mckinsey (2009), "*Shaping Climate Resilient Development – A Framework for Decision Making*" A report of the Economics of Climate Adaptation Working Group.

Mendelsohn, R., (2008), "Is the Stern review an economic analysis?" *Review of Environmental Economics and Policy*, 2(1): 45-60.

Mendelsohn, R., A. Dinar and L. Williams, (2006), "The distributional impacts of climate change on rich and poor countries" *Environment and Development Economics*, 11: 159-178.

Nhemachena, C. and Hassan, R. (2007) Micro-level analysis of farmers' adaptation to climate change in Southern Africa. *IFPRI Discussion Paper 00714*, International Food Policy Research Institute, Washington D.C.

Nordhaus, W. D. and Yang, Z., (1996), 'A regional dynamic general equilibrium model of alternative climate change strategies', *American Economic Review*, 86(4): 741-765.

Nordhaus, W. D., (1982), 'How Fast Should We Graze the Global Commons', *American Economic Review*, 72 (2): 242-246.

Nordhaus, W. D., (1993), 'Reflections on the Economics of Climate Change', *The Journal of Economic Perspectives*, 7(4): 11-25.

Nordhaus, W. D., (1994),"Managing the Global Commons: The economics of climate change", The Massachusetts Institute of Technology Press, Cambridge, Massachusetts.

Nordhaus, W. D., (2007a), 'A Review of the Stern Review on the Economics of Climate Change', *Journal of Economic Literature*, XLV: 686-702.

Nordhaus, W. D., (2007b), 'Critical Assumptions in the Stern Review on Climate Change', *Science*, 317: 201-202.

Palanisami, K., Kakumanu, K.R., Ranganathan, C.R. and Sekhar, N.U., (2015), 'Farm-level cost of adaptation and expected cost of uncertainty associated with climate change impacts in major river basins in India', *International Journal of Climate Change Strategies and Management*, 7(1): 76-96.

Panda, A., (2012), 'The world beyond two degrees: where do we stand?', *Current Science*, 103(8): 895-901.

Panda, A., Sharma, U., Ninan, K. N. and Patt, A. (2013), 'Adaptive capacity contributing to improved agricultural productivity at the household level: Empirical findings highlighting the importance of crop insurance', *Global Environmental Change*, 23(4): 782–790.

Parikh, J., (1994), 'North-South Issues for Climate Change', *Economic and Political Weekly*, 29: 2940-2943.

Parry M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., (2007), "*Climate Change 2007: Impacts, Adaptation and Vulnerability*", Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, 1000pp.

Parry, M. *et al.*, (2009), "*Assessing the Costs of Adaptation to Climate Change – A Review of UNFCCC and Other Recent Studies*", International Institute for Environment and Development and Grantham Institute for Climate Change, Imperial College London, U.K.

Patnaik, U. and Narayanan, K. (2015), 'Are Traditional Coping Mechanisms Effective in Managing the Risk against Extreme Events? Evidences from Flood Prone Region in Rural India', *Water Policy,* 17(4): 724-741.

Patnaik, U., Das, P. K., and Bahinipati, C. S., (2016), 'Coping with climatic shocks: Empirical evidence from rural coastal Odisha, India', *Global Business Review*, 17(1): 1-15.

Pielke, R. Jr., Prins, G., Rayner, S. and Sarewitz, D., (2007), 'Lifting the Taboo on Adaptation', *Nature*, 455(8): 597-598.

Piya, L., Maharjan, K. L. and Joshi, N. P. (2013), 'Determinants of adaptation practices to climate change by Chepang households in the rural Mid-Hills of Nepal', *Regional Environmental Change*, 13, pp. 437–447.

Ramsey, F. P., (1928), 'A Mathematical Theory of Saving', *The Economic Journal*, 38(152): 543-559.

Sandmo, A., (2015), 'The early history of environmental economics', *Review of Environmental Economics and Policy*, 9(1): 43-63.

Schelling, T. C., (1992), 'Some Economics of Global Warming', *American Economic Review*, 82(1): 1-14.

Seo, S. N. and Mendelsohn, R. (2008), 'An analysis of crop choice: Adapting to climate change in South American farms', *Ecological Economics*, 67(1): 109–116.

Spash, C. L. and d'Arge, R. C., (1989), 'The Greenhouse Effect and Intergenerational Transfers', *Energy Policy*, 17(2): 88-96.

Spash, C. L., (2002), *Greenhouse Economics: Value and Ethics*, London: Rutledge Publication.

Spash, C. L., (2007a), 'Climate Change: Need for New Economic Thought', *Economic and Political Weekly*, 42(6): 483-490.

Spash, C. L., (2007b), The Economics of Climate change Impacts a la Stern: Novel and Nuanced or Rhetorically Restricted?', *Ecological Economics*, 63(4): 706-713.

Spash, Clive L. and d'Arge, Ralph C., (1989), 'The Greenhouse Effect and Intergenerational Transfers', *Energy Policy*, 17(2): 88-96 (April).

Stern, N., (2007), *Stern's review on Economics of climate change*, London: Cambridge University Press.

Stern, N., (2008), 'The Economics of Climate Change', *American Economic Review*, 98(2): 1-37.

Tavoni, A. and Levin, S., (2014), 'Managing the climate commons at the nexus of ecology, behaviour and economics', *Nature Climate Change*, 4: 1057-1063.

Tol, R., (2008), 'Why worry about climate change? A research agenda', *Environmental Values*, 17: 437-470.

Tol, R., S. Fankhauser and J. B. Smith, (1998), 'The Scope for Adaptation to Climate Change: What Can we learn from the Impact Literature?', *Global Environmental Change*, 8(2): 109-23.

Toman, M., (2006), 'Values in the Economics of Climate Change', *Environmental Values*, 15: 365-379.

United Nations Development Programme (UNDP) (2008), "*Human Development Report 2007/2008: Fighting Climate Change – Human Solidarity in a Divided World*" United Nations Development Programme. Retrieved from http://hdr.undp.org/en/reports/global/hdr2007-2008/; accessed on 10th February 2011.

Venkatachalam, L., (2007), 'Environmental economics and ecological economics: where they can converge?', *Ecological Economics*, 61: 550-558.

Wagner, G., and M. L. Weitzman, (2015), *Climate shocks: The economic consequences of a hotter planet*, Princeton University Press.

Wang, J., Mendelsohn, R., Dinar, A. and Huang, J. (2010), 'How Chinese farmers change crop choice to adapt to climate change', *Climate Change Economics*, 1(3): 167–185.

Wood, S. A., Jina, A. S., Jain, M., Kristjanson, P., and DeFries, R. S. (2014), 'Smallholder farmer cropping decision related to climate variability across multiple regions', *Global Environmental Change*, 25: 163-172.

World Bank, (2010), *The Economics of Adaptation to Climate Change*, A Synthesis Report, Final Consultation draft, August 2010, Washington: The World Bank.

## THE GIDR WORKING PAPER SERIES (No. 191 onwards)

191. Keshab Das, "Agency and Access under Decentralised Governance: Water Supply and Sanitation in Kolkata City", February 2009. Rs. 35.

192. Shiddalingaswami Hanagodimath, "Economic Reforms and Expenditure on Health in India", March 2009. Rs. 35.

193. Amita Shah and Sunny Jose, "Asset Creation and Local Economy under NREGS: Scope and Challenges", April 2009. Rs. 40.

194*. Jeemol Unni and Suma Scaria, "Governance Structure and Labour Market Outcomes in Garment Embellishment Chains", July 2009. Rs. 35.

195. Tara S. Nair, Jan Postmus and Rachayeeta Pradhan, "Social Responsibility of Indian Microfinance: A Critical Review", December 2009. Rs. 35.

196. Jharna Pathak, "Does the Method of System of Rice Intensification (SRI) Outperform Conventional System? A Case Study of Gujarat", January 2010. Rs. 35.

197*. Keshab Das and K. J. Joseph, "On Learning, Innovation and Competence Building in India's SMEs: Challenges Ahead", February 2010. Rs. 45.

198*. N. Lalitha and P. K. Viswanathan, "Pesticide Applications in Bt Cotton Farms: Issues Relating to Environment and Non-Tariff Barriers", March 2010. Rs. 35.

199*. Cassandra Sweet and Keshab Das, "Institutional and Procedural Challenges to Generic Production in India: Antiretrovirals in Focus", October 2010. Rs. 35.

200. Itishree Pattnaik, "Analysis of Agricultural Performance in Andhra Pradesh and Orissa: 1960-61 to 2005-06", March 2011. Rs. 35.

201. Rudra N. Mishra and Udaya S. Mishra, "Assessing Characteristic Differential in Dichotomous Outcomes: A Case of Child Undernourishment", April 2011. Rs. 35.

202. P. K. Viswanathan, "Will Neoliberal Policies Resolve Water Sector Dilemmas? Learnings from Maharashtra and Gujarat", May 2011. Rs. 45.

203. Jharna Pathak, "Agroforestry in Tribal Areas of Gujarat: Move towards Sustainable Agriculture?", June 2011. Rs. 45.

204*. Madhusudan Bandi, "The Telangana Turmoil: Apprehensions and Hope", August 2011. Rs. 30.

205. Tara S. Nair, "Two Decades of Indian Microfinance: Trajectory and Transformation", September 2011. Rs. 40.

206. Biplab Dhak and Amita Shah, "International Migration from Gujarat: An Exploratory Analysis", September 2011, Rs. 35.

207* Anil Gumber, Biplab Dhak and N. Lalitha, "Declining Free Healthcare and Rising Treatment Costs in India: Analysis of National Sample Surveys, 1986-2004", October 2011, Rs. 40.

208 Tara S. Nair, "Power to Women through Financial Services: Revisiting the Microfinance Promise", November 2011, Rs. 30.

209 N. Lalitha, "Protecting IPRs of Siddha Practitioners through People's Biodiversity Register", December 2011, Rs. 35.

210* Amita Shah, Dipak Nandani and Hasmukh Joshi, "Marginalisation or Mainstreaming? Evidence from Special Economic Zones in Gujarat", July 2012, Rs. 45.

211 P. K. Viswanathan, "Rationalisation of Agriculture in Kerala and its Implications for Natural Environment, Agro-Ecosystems and Livelihoods", September 2012, Rs. 40.

212 Keshab Das, "Situating Labour in the Global Production Network Debate: As if the 'South' Mattered", December 2012, Rs. 40.

213 Jaya Prakash Pradhan and Keshab Das, "Determinants of Regional Patterns of Manufacturing Exports: Indian Firms since the Mid-1990s", January 2013, Rs. 40.

214 Madhusudan Bandi, "A Review of Decentralisation in India with Particular Reference to PRIs in Gujarat", February 2013, Rs. 30.

215 Madhusudan Bandi, *"Samras* in the Context of Gujarat Gram Panchayats: A Threat to the Idea of Democracy?", March 2013, Rs. 30.

216 P. K. Viswanathan and Amita Shah, "Has Indian Plantation Sector Weathered the Crisis? A Critical Assessment of Tea Plantation Industry in the Post-reforms Context", April 2013, Rs. 40.

217 Keshab Das, "Developing Regional Value Chains in South Asian Leather Clusters: Issues, Options and an Indian Case", May 2013, Rs. 45.

218. Chandra Sekhar Bahinipati, "Determinants of Farm-Level Adaptation Diversity to Cyclone and Flood: Insights from a Farm Household-Level Survey in Eastern India', August 2013, Rs. 40.

219. Chandra Sekhar Bahinipati and L. Venkatachalam, "Determinants of Farm level Adaptation Practices to Climate Extremes: A Case Study from Odisha, India", December 2013, Rs. 40.

220*. Tara S. Nair, Milind Sathye, Muni Perumal, Craig Applegate and Suneeta Sathye, "Regulating Microfinance through Codes of Conduct: A Critical Review of the Indian Experience", March 2014, Rs. 45.

221. Keshab Das, "The Sector Reforms Process in Rural Drinking Water and Sanitation: A Review of the Role of WASMO in Gujarat", August 2014, Rs. 100.

222. Itishree Pattnaik, Amita Shah, "Trend in Agricultural Growth and Decomposition of Crop Output in Gujarat: A Recent Evidence", September 2014, Rs. 100.

223. Madhusudan Bandi, P. K. Viswanathan, "Forest Governance Sustainability in India: Determinants and Challenges", October 2014, Rs. 100.

224. Jharna Pathak, "Class Gains in Fisheries Management Problems and Prospects", December 2014, Rs. 100.

225. Keshab Das, "Provisioning Drinking Water in Gujarat's Tribal Areas: An Assessment", February 2015, Rs. 100.

---

* Also published elsewhere

**About GIDR**

The Gujarat Institute of Development Research (GIDR), established in 1970, is a premier social science research institute recognised and supported by the Indian Council of Social Science Research (ICSSR) of the Government of India, and the Government of Gujarat.

The major areas of research at the Institute are the following:

1. **Natural Resources Management, Agriculture and Climate Change**
   Research under this area concerns the broad realm of environment and development. Studies have focused on economic viability, equity, environmental impact assessment and institutional mechanisms. Issues in common property land resources, land use and water harvesting have been researched extensively. Implications of climate change risks for Asia and the adaptation and mitigation strategies at the local levels have begun to be studied.

2. **Industry, Infrastructure and Trade**
   The main themes include policy dimensions concerning the micro, small and medium enterprises, industrial clusters and intellectual property rights. Studies on basic infrastructure and linkages between infrastructure and regional growth have also been carried out. Trade and development and finance are new areas of interest.

3. **Employment, Migration and Urbanisation**
   Studies under this theme relate to employment, labour, diversification of economic activities and migration. International migration has emerged as an additional theme along with urban services and aspects of urban economy and governance.

4. **Poverty and Human Development**
   Issues examined include access, achievement and financing of education and health sectors. Studies on poverty relate to conceptual and measurement aspects, quality of life, livelihood options and social infrastructure. There is an increasing interest in understanding urban poverty, rural-urban linkages and issues in microfinance.

5. **Regional Development, Institutions and Governance**
   Recent studies enquire into regional underdevelopment and the dynamics of local level institutions. Tribal area development mainly relating to livelihood promotion and human resource development has been a focus area. Recent analyses have also looked into Panchayati Raj Institutions, Forest Rights Act, MGNREGA and Right to Education Act.

Much of the research informs national and regional policies. The Institute also undertakes collaborative research and has a network with governments, academic institutions, international organisations and NGOs. A foray into specialized training and doctoral programme has just been made.

*Gujarat Institute of Development Research*

Phone : +91-02717-242366, 242367, 242368
Fax : +91-02717-242365
Email : gidr@gidr.ac.in
Website : www.gidr.ac.in
Gota, Ahmedabad 380 060, Gujarat, India.