SCIENCE VISION

QUARTERLY

Combined Volumes 10, 11 & 12

ISSN 1027-961X

Vol. 10 No. 1-4 (July, 2004 - June, 2005)
Vol. 11 No. 1-4 (July, 2005 - June, 2006)
and
Vol. 12 No. 1-4 (July, 2006 - June, 2007)

A Journal of Science for Development

SPECIAL ISSUE

COMSATS

Commission on Science and Technology for Sustainable Development in the South

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SCIENCE VISION

An International Quarterly Journal of the Commission on Science and Technology for Sustainable Development in the South (COMSATS)

SCIENCE VISION is published by COMSATS as a quarterly journal that contains scientific review as well as R&D papers related to advances in Science and Technology in the North and the South.

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Tables and Illustrations: (i) should be separate from the text; (ii) should be numbered according to the order in which they are mentioned in the text; (iii) facts and figures should be carefully revised and any discrepancies removed; (iv) each table should have a short explanatory caption.

References: should be numbered consecutively in the text and indicated preferably by superscript: 1,2 or 1-3 etc. References cited only in tables or figures should be numbered in sequence according to the first mention of the table or figure in text. The sequence for a standard journal article should be: author(s): title of paper: journal-name abbreviated (written in full if no abbreviation quoted) and year of publication, volume number, page numbers. Final proofs will not be sent to the author, unless specially requested.

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Subscription	Pakistan	Other Countries
Annual	= Rs. 1,000.00	US$ 50.00
Single Copy	= Rs. 250.00	US$ 12.50

Printed by New United Printers, Blue Area, Islamabad.

EDITORIAL

In the last few decades, there has been much call for global efforts for sustainable development, which is the basis of COMSATS' philosophy and this has caught the world's attention in recent years. After a span of 3 years, COMSATS is back with its quarterly journal 'Science Vision'. The last time when the combined volumes of this journal were published, was in July 2004. Since then, several major changes have taken place at the global level. Alongside these changes, varied significant activities also took place in the fields of science and technology, both at the regional and international levels. Economic prosperity, social development, and peace have always remained the core elements of sustainable development, and the role of S&T in this has been a major focus of attention throughout the world.

The world's focus has, however, been gradually altered due to various recent events. The most prominent of these happenings have been the ongoing Iraq War, and the worldwide fight against terrorism, justified by the United States on the grounds that Iraq posed a terror threat to them. As a consequence of this war, there has been bloodshed and mass-destruction within and outside Iraq. Hundreds and thousands of people have been mercilessly killed, while the remaining are surrounded by lingering shadows of hunger, poverty, and ignorance. The same is also true of almost half of the world's population living in underdeveloped regions of the world; which are still undergoing the processes of development and are trying to overcome major problems such as checking the population growth, reducing rates of illiteracy, combating diseases, alleviating poverty, etc,.

Recently, much has been said and partly done, in this regard. Worldwide campaigns for the sustainable development, particularly of this disadvantaged segment of the world's population, have received considerable attention at the world's forum. In view of this, the developed and developing countries of the world have frequently joined hands, in order to overcome these serious problems, by making timely applications of their resources. The importance of science and technology as a useful tool in this respect has been widely acknowledged and its innovative uses, to achieve the targets of developing and improving human conditions, have been greatly emphasized. Much has been done, and is still being done, to promote the applications of science and technology in every corner of the world.

Apart from this, other significant events also took place, in the field of science and technology. One such event was the 'Year of Physics', which was celebrated in 2005. The 'Year of Physics' marked the 100th anniversary of Einstein's 'Miracle Year', in which he published his three landmark papers, and the subsequent advances in the field of physics. In 1905, Albert Einstein submitted five papers for publication in Annalen der Physik, covering three topics: The Photoelectric Effect, Brownian Motion, and the Special Theory of Relativity. These diverse subjects were to become remarkable breakthroughs in the field of physics and they substantiate Einstein's genius. The year 2005, was thus, named 'Year of Physics', to recognize Einstein's outstanding contribution to the field of Physics, which the world has been benefiting from, till date, and will continue to benefit in future, too.

In view of these ongoing global events, collective wisdom in this fast-paced world scenario demanded much more research and attention to the activities involving global efforts for sustainable development, through effective use of science and technology throughout the world; especially in the underdeveloped third-world regions. To contribute to global development, has always been a key objective of COMSATS' strategy. COMSATS officials have been actively and effectively working on arranging conferences, covering the effect and backlash of current events, and publishing the relevant material such as books related to these events. It thus, shifted its focus from publishing reviews and research-articles in volumes of journals to more current activities and events taking place regionally and internationally. COMSATS has successfully arranged three international conferences during 2005 and 2006, followed by their publication in the form of four books, namely; Basic and Applied Industrial Applications; Physics in our lives; Road to Sustainable Development; and, Physics in Developing Countries: Past, Present and Future.

Now after a span of three years, COMSATS again brings the combined volumes 10, 11, and 12 of 'Science Vision'. The list of contents and indices of books published by COMSATS during these years, are listed in volumes 10 and 11, while volume 12 contains research and review papers.

SCIENCE VISION

Vol. 10. No. 1-4 (July 2004 to June 2005)
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COMSATS' Series of Publications on Science and Technology

Basic Research and Industrial Applications

Editors

Dr. Hameed A. Khan
Prof. Dr. M. M. Qurashi
Engr. Tajammul Hussain
Mr. Irfan Hayee

July 2005

The only contents of this particular book given in this compilation are its: Table of Contents, Foreword, Author Index and Subject Index. The full book, having 168 pages at a price US$ 10 or equivalent, can be obtained from COMSATS Headquarters.

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COMSATS' Series of Publications on Science and Technology

Basic Research and Industrial Applications

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COMMERCIALIZATION OF SCIENCE BASED TECHNOLOGIES

APPLICATIONS OF SCIENTIFIC BASIC RESEARCH IN SOME IMPORTANT FIELDS

FOREWORD

In an era where the standards and parameters for socio-economic development and prosperity are being dynamically shaped, continued scientific research is perhaps the only constant that lies at the heart of sustainable development and progress. Scientific research is the cardinal tool for human-beings to know and make use of nature. Its various types help play a distinct, yet overlapping role in the continuous uplift and betterment of mankind and its livelihood. In this context, the leading role of basic research, is momentous in creating new knowledge and providing scientific capital.

Basic or pure research is the extension of scientific and technical knowledge, not having any industrial and commercial intentions; it is the attempt of a researcher to access the frontiers of knowledge for the sake of knowledge alone. Nevertheless, it is the knowledge that basic research creates, which provides the intellectual material for formulating the applications that we today call technology. Without doubt, basic research lies at the heart of nearly every major discovery, known to us today.

It is no secret today that basic research, whether performed in scientific laboratories, R&D institutes, universities or within industry itself, has been critical in promoting nearly all sciences whether basic or applied. The knowledge-domains of physics, chemistry and other subjects are undergoing a metamorphosis, reflecting the dominance of inter-disciplinary unification, with the borders between the traditional research-areas being eroded and the continual merging of basic research and industrial applications. The inter-locking of basic discovery and technological innovation has today led to the emergence of chemical, engineering, electronics and transportation industries, as well as the many industrial uses of nuclear radiations, besides others.

Today, it is even more true than ever that basic research is the pacemaker of technological progress. Therefore, it must not be taken as a peripheral activity, but should be given due support in order to strengthen the industrial base for achieving development and progress especially in the developing countries.

To highlight the integral link between basic research and related industrial uses, COMSATS organized a meeting on "Basic Research and Industrial Applications" from 06 to 08 July, 2004, in collaboration with Chinese Academy of Sciences (CAS) and Islamic, Educational, Scientific and Cultural Organization (ISESCO). It further aimed at ascertaining the importance of basic research as one of the pre-requisites for innovation, which is essential for companies and nations, to remain competitive in the global village of today.

There were a total of 33 speakers in the meeting who made presentations in 7 Technical Sessions, of these 5 were foreign experts representing the countries of Switzerland,

United Kingdom and China. Other participants included eminent researchers, heads of S&T institutions, scholars, students and representatives from some major industrial concerns. The proceedings of the meeting presented here comprise a selection of papers and the recommendations, at the end, which emerged during the conference.

I would like to express my gratitude to Prof. Sixiong Zhao, Executive Director, International Centre for Climate and Environment Sciences (ICCES), Institute of Atmospheric Physics, Chinese Academy of Sciences and to Dr. Faiq Billal, Director, Islamic, Educational, Scientific and Cultural Organization (ISESCO), for their sincere cooperation and support in organizing this meeting. I would also like to acknowledge the efforts of Dr. M. M. Qurashi, Mr. Irfan Hayee, Ms. Zainab H. Siddiqui, Mr. Imran Chaudhry and Ms. Nagina Safdar from COMSATS, whose dedication made possible the publication of this book.

(Dr. Hameed Ahmed Khan, H.I., S.I.)
Executive Director

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COMSATS' Series of Publications on Science and Technology

Physics in Our Lives

Editors

Dr. Hameed A. Khan
Prof. Dr. M. M. Qurashi
Engr. Tajammul Hussain
Mr. Irfan Hayee

July 2005

The only contents of this particular book given in this compilation are its: Table of Contents and Foreword having 249 pages at a price US$ 10 or equivalent, can be obtained from COMSATS Headquarters.

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COMSATS' Series of Publications on Science and Technology

PHYSICS IN OUR LIVES

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FOREWORD

Throughout world history, different civilizations have attempted to better their living through science and technology. Science and technology have had a fundamental impact on the way people live today, from the early use of the first metal-tools by Neolithic people, to children receiving vaccination-shots today. Different eras in history, like the period of Neolithic Revolution; eras of Classic Civilizations such as, the Greeks, Romans, and Chinese; Renaissance Europe; and the Golden Age of Islam, have been marked by important discoveries in science.

Ever since Galileo, physicists have been pioneers in research and their contributions in this field have ameliorated our way of living. Research in Physics allows us to look forward to a future that holds even more exhilarating breakthroughs and advances. The studies of physicists range from the tiniest particles of matter, to the largest objects in the universe. They have made possible the luxuries and conveniences inside our houses - such as energy-efficient heating-systems, personal computers and CD players. Much of the technological equipment and techniques used by other scientists were also originally developed by physicists, such as, X-rays, MRIs and other medical instruments, to safely study the human body, diagnose and treat diseases. From saving lives to saving our environment, and to promoting knowledge in other areas of science, the contributions of physicists have always been extraordinary.

Keeping in view the importance of Physics in the modern society and in order to celebrate the 100th anniversary of the most famous five papers published by Albert Einstein, the year, 2005, has been declared the 'World Year of Physics' (WYP) by the General Assembly of the UNO (United Nations Organization). WYP-2005 aims to facilitate the sharing of visions and convictions about physics amongst international community of physicists and the public.

In order to commemorate WYP-2005, COMSATS organized a two-day International Seminar on "Physics in Our Lives", on February 23-24, 2005, at Islamabad. This seminar was organized in collaboration with Pakistan Atomic Energy Commission (PAEC) and the National Centre for Physics (NCP), Quaid-i-Azam University, Islamabad. The basic purpose of conducting this Seminar was to bring to light the contributions that physicists have been making and can further make in the future; to improve the quality of life and; to provide a forum for interchange of ideas, between academia, research institutes and the industrial sector, pertaining to Physics and its role in society. Another objective of holding this Seminar was to facilitate the public awareness of physics, its economic necessity, its cultural contributions and its educational importance.

There were a total of 29 speakers in the Seminar who made presentations in five Technical Sessions, of which four were foreign experts representing countries of

Switzerland, Syria, Egypt and Sudan. Other participants included eminent physicists, heads of S&T institutions, scholars and students from various academic and research institutions.

The book contains eighteen papers from the afore-mentioned Seminar on 'Physics in Our Lives', and has been segmented into two broader categories, i.e., 'General Perspective' and 'Contributions of Physics to Specific Fields'. The papers in the first part take stock of the historic evolution of physics, while in the second part field-specific contributions of physics are detailed.

I would like to express my gratitude to Mr. Parvez Butt, Chairman, Pakistan Atomic Energy Commission (PAEC) and Prof. Dr. Riazuddin, Director General, National Centre for Physics (NCP) for their ardent cooperation and support for organizing this conference. Here, I would like to acknowledge the efforts of all the speakers and physicsts and my earnest praise also for Dr. M.M. Qurashi, Ms. Noshin Masud, Ms. Nageena Safdar, Mr. Irfan Hayee and Mr. Imran Chaudhry from COMSATS, whose devotion made possible the publication of this book.

(Dr. Hameed Ahmed Khan, H.I., S.I.)
Executive Director

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COMSATS' Series of Publications on Science and Technology

Road to Sustainable Development

Edited by
Dr. Hameed A. Khan

January 2006

The only contents of this particular book given in this compilation are its: Table of Contents, Foreword, Author Index and Subject Index. The full book, having 232 pages at a price US$ 10 or equivalent, can be obtained from COMSATS Headquarters.

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COMSATS' Series of Publications on Science and Technology

Road to Sustainable Development

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FOREWORD

Countries have always been involved in fierce economic competition, more so even than in war, though often including it! In the modern world this can be seen as having started with the first industrial revolution, and the accompanying amoral colonial conquests which gave old and well established countries access to riches all kinds belonging to others in less developed and/or newly discovered countries. Exploitation by any definition by countries of the generic North, of countries of the generic South! The recent and current industrial revolution, based not on coal or the steam engine, but on high technological advances centered on new electronic devices and computers have amplified the growth of life qualities in the North, generally by the formation of country cartels – the Economic European Community being a good example. The success of well-developed countries is largely to be attributed to the progress made towards sustainable development and management of society, economy and the environment. For countries of the South, massive poverty, inadequate education, healthcare facilities and low standards of living remain as the major stumbling blocks on the paths towards any real indigenous development. While the North mostly made full use of Science and Technology for its own development, the South lagged still further behind and now urgently needs to come up with vigorous scientific and technological programs of its own. No amount of external general 'aid' – with all its qualifications and special provisions – can possibly hide the need for integrated and systematic efforts to be made from within the South itself. My own opinion is that it is a moral duty on the North, however, directly to assist the South, without attached political strings, to fill the huge scientific divide separating the developing countries from the developed. In doing so the dignified deployment of extremely fine technological and scientific minds from the South itself must be a key element.

In this book Dr. Hameed Ahmed Khan and his colleagues specifically address the question of how the road to sustained development should be embarked upon, implemented and maintained. The key element of thought and practice is that whilst assistance and advice is critical, the motive force and effort must come from within. The reader will find that a striking match of scientific expertise with strategic administrative planning is vital to the cause, and this is a continuing underlying theme. Beginning from progress in the past the book comprehensively discusses current scenarios and points clearly to distinct sectors of science and technology from which sustainable development in the South will inevitably come. How the latest developments in various scientific and technological advances will be utilized is clearly set out, with corresponding concrete recommendations. In my opinion the book presents modern concerns that relate primarily to the issues of the South. Latest advancements made in various S&T fields are incorporated with tact and practicality, followed by concrete recommendations. It is my own opinion that when the reader views these recommendations with objectivity, it will be clearly seen that there is a definite plan outlined for proper effective realization of a sensible and practicable path

to real sustainable development. This is something which has long been sorely needed. Now it is necessary for the North, and time for the North, to join in as honest practicing partner, and to share as much of what has been learned as is sensibly possible and practical. It shouldn't be, but apparently is necessary to add that all of this must be carried out in a millieu in which all participants are equal humans in every possible sense.

The holistic view of the many and varied aspects of sustainable development which is a basic element of this book is extremely welcome. Triggering discussion from the commitments made at Rio Earth Conference (1992) and the follow-up actions until the Johannesburg World Summit (2002) the book presents an optimistic point of view in meeting the global challenges successfully. Here it is relevant to quote from the book directly. Thus, "the world surely can undo the failures that the decade after the Rio Summit witnessed by translating their words into action and by making good on their commitments. Doubtless, the path of global negotiations to world-wide problems is indeed a difficult one and there are no early successes. In fact, coming to a national resolve and undertaking national action is a primer to the success of international treaties. This has shifted the onus for action for most of the problems from the supra-natural to the national and even to the local level".

The specific details of various technologies which present the power to transform the way we live today, and the way they can positively affect a proper growth pattern, are clearly outlined. The book advocates an aggressive approach in building capacities in such technologies and their application for developmental purposes. Included are clean air technologies, energy technologies, biotechnology and information-communication technology. It requires both courage and a strong considered commitment to speak in favor of fostering the use of nuclear energy today, especially in the wake of growing concerns of its misuse. Nevertheless I am myself in total sympathy and empathy with the case presented for making use of nuclear energy for developmental purposes, whilst being glad for the inclusion of a discussion of concepts both in favour and against it The author writes "Success of the MDG's (Millennium Development Goals) and WSSD (World Summit on Sustainable Development) plan of action largely depends upon abundant clean energy availability. As hydro and renewables have been proved to have limited potential in the near future, the only alternative left for filling the clean energy supply-demand gap will be the nuclear energy which is a proven and reliable source of clean energy".

One of the most important aspects needing full attention at institutional and governmental levels is the creation of an enabling environment for regional cooperation science and technology. For this reason the last section of the book lays out guidelines for harnessing cooperation amongst all the stakeholders - especially between the countries of the South. Regional cooperation in science and technology should not be considered as either a free liberty or an exception. The fact remains, however, that by a process of quite natural evolution they have become imperative in the wake of global challenges set out by the World Trade Organization (WTO) and the

corresponding emerging so-called New World Order.

For concerned unblinkered scientists, for technologists, for students, and for members of the general public, and last but not the least for national politicians and diplomats everywhere – North and South – this book is the most up to date and conscientious presentation available. The message is clear. Countries of the South want and deserve, as a natural concomitant to independence, the kind of world environment which recognizes their community energy and vitality, their independence, and their wish fully to partake in the necessary establishment over time of a more comprehensive and understanding worldwide mankind. This is not a lofty ideal. It is perfectly achievable. What is required is widespread personal commitment and personal action!

Dr. Hameed Ahmed Khan is a distinguished leader and an adroit exponent of new ways. He has served both Pakistan and the world, first as an authoritative fundamental scientist, and then as an applied technologist, and as a distinguished leader of many national and international bodies. His professional and personal life is one of devotion to those less fortunate. As an individual scientist and citizen of Pakistan he is in the central genre described by that Pakistani Nobel Laureate Abdus Salam, who in Trieste coined the generic words North and South in order collectively to describe the developed and less developed countries, respectively. In a sense Hameed Khan is an Abdus Salam reincarnated for the present and a true disciple. From the word disciple comes the word 'discipline'. Hameed Khan has brought that human and discipline understanding to the Third World, which he thereby distinguishes, and to the position of Chief Executive Officer of COMSATS – Commission on Science and Technology for Sustainable Development in the South – and he has brought it to this book! It is a book one should read, think about, and act upon!

Prof. Lewis Chadderton
Professor of Physics,
University of Copenhagen, and
The Australian National University
Canberra, Australia.

PREFACE

'Sustainable Development' is described as development in which total "welfare" is not decreasing over time. Just as economic development is sustainable, provided economic (or man-made) capital is non-decreasing, similarly sustainable development requires total capital -- that is, economic capital, human and social capital and environmental capital -- to be non-decreasing. "Capital" in this context refers both to the stock and to the quality of the resources -- for example, the skills, health and knowledge of the population, and the quality of environment and other natural resources.

A factor that is of utmost importance and must be realized is that, for assured smooth sailing in the direction of sustainable development, the human capital has to be equipped with modern science and latest technologies in order to cope with the challenges that are multifaceted and global in nature. Science and technology provides the developing countries with the much-needed vehicle to speed up their growth and development, and also to sustain the same pattern. Countries like China, Malaysia and South Korea, which had taken concrete steps to incorporate science and technology in their developmental processes and agenda, are now economically better off within a short span of half a century. It is in this perspective that the developing countries can make apt use of the frontier sciences and technologies for continuous growth and development and can avoid compromise on any of other capital.

COMSATS - the Commission on Science and Technology for Sustainable Development in the South—which was established to serve the developing countries of the South with S&T-led initiatives, has been making humble efforts for the last ten years in promoting the cause of sustainable development. This manuscript titled 'The Road to Sustainable Development' is an effort in the same direction. The book comprehensively takes stock of the role that science and technology has to play for achieving the goals of sustainable development. Though the road to sustainable development is intricate and requires focus and concerted effort to cover safe distances, the book shows the way by highlighting the role of some important frontier science and technologies.

Leading the discussion from the Resolutions of the Earth-Summit in Rio in 1991, and making an appraisal of what had been achieved till the follow-up meeting in Johannesburg in 2002, the book uncovers myths and realities about sustainable development and discusses various aspects of development. In the later sections, the book provides insight into various frontier sciences and technologies that posses revolutionary powers and can lead the way towards sustainable development. These include renewable and nuclear energy technologies, biotechnology and biodiversity in the field of bio-sciences, and information communication technologies. In the concluding sections, a range of global developmental tools in the form of regional

cooperation are discussed and a suggestive roadmap, especially for the developing countries is provided in order to ensure involvement of all the stakeholders. I am very grateful to the team of authors that contributed chapters to this book, and took pain and time out in making the book a worthwhile resource on sustainable development. Most of the authors, besides me, belong to COMSATS headquarters, who have ample experience with COMSATS in working in its various thrust areas. I am also grateful to the team of COMSATS who made possible the publication of this very useful book and would like to make particular mention of Dr. M. M. Qurashi, Mr. Irfan Hayee, Mr. Imran Chaudhry and Ms. Nageena Safdar for this.

I conclude with the hope that the readers of this book will have an enlightening experience, after going through various chapters and I would welcome any suggestions and comments which shall help us bring an even better publication next time.

(Dr. Hameed Ahmed Khan, H.I., S.I.)
Executive Director

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COMSATS' Series of Publications on Science and Technology

Physics in Developing Countries: Past, Present and Future

Editors

Dr. Hameed A. Khan
Prof. Dr. M. M. Qurashi
Engr. Tajammul Hussain
Mr. Irfan Hayee

April 2006

The only contents of this particular book given in this compilation are its: Table of Contents, Foreword, Preface, Author Index and Subject Index. The full book, having 217 pages at a price US$ 10 or equivalent, can be obtained from COMSATS Headquarters.

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COMSATS' Series of Publications on Science and Technology

Physics in Developing Countries: Past, Present and Future

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PREFACE

It is a hard reality that the countries of the Third World lag far behind the developed world, primarily due to the absence of well-equipped scientific institutions, universities and facilities. The level of training and research in physics varies remarkably across the world, with the most advanced nations producing far more PhDs in Physics than the developing countries. Realizing this deficiency, it is imperative for the developing countries to have a good-quality system for science-education in place, if they want to grow economically. It is also true that, in the past, individuals made significant discoveries, but now teamwork is essential to achieve that. Presently, useful contributions come mostly from groups of highly educated and skilled individuals who are working on big machines and in centers with huge infrastructure and sophisticated equipment. Today, no single developing country in isolation can accumulate enough experience or infrastructure to cater for its scientific, technological and consequent economic needs. South-South cooperation and, where needed, South-North cooperation are imperative in this regard.

In order to (a) highlight the importance of Physics in development, (b) bring forward the experiences of developed and developing countries in which physicists have contributed towards the growth of the economy, and (c) devise strategic recommendations for promoting Physics and related disciplines for sustainable development, COMSATS organized an International Seminar on Physics in Developing Countries: Past, Present and Future, on July 27-28, 2005, at Islamabad. This seminar was organized in collaboration with the Islamic Educational, Scientific and Cultural Organization (ISESCO). Other objectives of holding this Seminar included enhancing awareness of the potentials of Physics for improving the lives of the people, particularly those of the developing world, and emphasizing the role of international co-operation in Physics and requisite modalities of instituting and promoting South-South and South-North cooperation.

It was a welcome coincidence that the world's physics community was celebrating the International Year of Physics-2005 when this seminar was organized in Islamabad. The objectives of the seminar were closely related to those prescribed by the IYP-2005. As a matter of fact, the present seminar constituted a part of the IYP-2005 celebrations from Pakistan's scientists and turned out to be a useful component of the celebrations of the International Year. A comprehensive compilation in this context has been included in the present proceedings, which describes the genesis of the IYP-2005, the UN support it received, some salient contributions from the physicists of Pakistan,

conclusions, and recommendations. In a way, this analytical review of the IYP-2005 supports and complements several other papers presented in the International Seminar on "Physics in Developing Countries: Past, Present and Future". It is recommended that the reader may like to synchronize the output of this review with those emerging from several other papers included in the current proceedings.

There were a total of 20 speakers in the Seminar who made presentations in 6 Technical Sessions, of which 7 were foreign experts representing the countries of Egypt, Sudan, Sri Lanka, and Tajikistan. Other participants included eminent physicists, heads of S&T institutions, scholars and students from various academic and research institutions. The proceedings of the Seminar include the contents of the presentations made by the speakers and the recommendations that emerged during the various sessions of the seminar.

I would like to express my deep sense of appreciation for Dr. Ishfaq Ahmad, N.I., H.I., S.I., Special Advisor to the Prime Minister of Pakistan, for his guidance, advice and support for this seminar. My gratitude is also due to Dr. Faiq Billal, Director, Islamic, Educational, Scientific and cultural organization (ISESCO), for his ardent cooperation and help in organizing this conference. My earnest praise also for Dr. M.M. Qurashi, Mr. Irfan Hayee, Ms. Zainab Hussain Siddiqui, Ms. Noshin Masud and Mr. Imran Chaudhry from COMSATS whose devotion made publication of the proceedings of this seminar possible.

(Dr. Hameed Ahmed Khan, H.I., S.I.)
Executive Director

FOREWORD

From the pure beauty of general relativity to modern high technology, Physics is a fascinating and worthy subject, leading to both new applications and in-depth observations about the universe. The influence of physics in the enhancement of old technologies and the development of new ones is enormous. Both the methods and the subject-matter of physics are vital to technological development, leading to increased productivity in the economy.

The year 2005 was declared the International Year of Physics (IYP) by the General Assembly of the United Nations Organization. IYP 2005 was a worldwide celebration for physics and its importance. The year 2005 also marked the 100th anniversary of Albert Einstein's three important papers describing ideas that have since influenced all of modern physics. The IYP-2005 provided an opportunity to celebrate Einstein's great ideas, and their influence on our lives in the 21st century.

The celebrations were arranged all over the world. The scientific community of Pakistan, particularly the physicists, took special interest in celebrating the IYP-2005. Academia, researchers, scholars, young science-students and media participated in several activities arranged for this purpose.

COMSATS has played an active role in the celebrations related to the IYP-2005, it arranged and co-sponsored several seminars, symposia, meetings, etc. The present seminar, "Physics in Developing Countries: Past, Present and Future" was a part of these activities.

It is appropriate that the outcome of such an important seminar should be widely disseminated for the benefit of large section of our society. The proceedings of the event will adequately serve this purpose. The seminar, comprising 18 papers on diverse aspects of the title, presented by renowned experts in the respective fields, gives a thought-provoking opportunity to the physicists and policy-makers for devising necessary strategies for a better future of Physics. The areas covered in the proceedings represent, physics education, research in physics, development and technology and, quite appropriately, some historic perspectives. The message emerging from the seminar is clear: that quality of physics teaching and research can be appreciably enhanced by encouragement from the governments, policy-makers and other informed sections of the society. At the world level, the prospects of a better physics would brighten with enhanced international cooperation and through free exchange of knowledge.

I would like to take this opportunity to praise the efforts of Dr. Hameed Ahmed Khan H.I., S.I., and his team who organized this event to enlighten the researchers, businesses and the public about the importance of investment in physics, which can ultimately lead to economic development and an enhanced quality of life.

(**Dr. Ishfaq Ahmad, N.I., H.I., S.I.**)
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REVIEW ARTICLES

ENERGY POLICIES FOR THIRD-WORLD COUNTRIES

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1. INTRODUCTION

It is universally recognized that energy is one of the most important inputs to economic growth and development; the consumption of energy is considered as one of the critical indicators of the level of development of any country. Developed countries use more energy per unit of economic output and far more energy per capita than developing countries. Energy-use per unit of output does decline somewhat over time in the more advanced stages of industrialization, reflecting the adoption of increasingly more efficient technologies for energy production and utilization as well as changes in the composition of economic activity. At present, over a billion people in the industrialized countries use some 60 percent of the world's commercial energy supply, while 5 billion people living in the developing countries consume the remaining 40% – a large number of them are really poor. It is estimated that about two billion people around the world have no access to modern energy-services and as a result, struggle to meet their basic daily needs. Economic growth is the key to changing this situation, and for economic growth energy is vital.

The energy demand is expected to increase significantly, due to fast industrial growth in the developing countries, as well as for meeting the energy-needs of the people deprived of basic necessities of life. The projection for World Energy-consumption broken up by natural resources is indicated in Figure 1. This will of course be supplemented by the development and commercialization of non-conventional sources of energy.

2. PRESENT ENERGY STATUS IN THE THIRD-WORLD COUNTRIES

General

- Per-capita consumption of energy is extremely low. The per-capita consumption is 14M Btu in Pakistan, 34M Btu for China and 92M Btu for

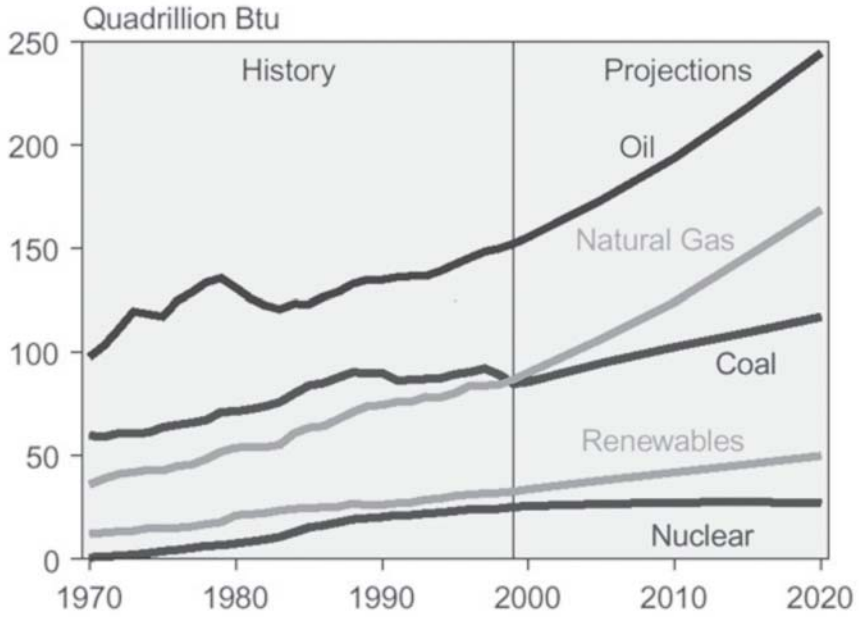

Figure - 1: World-Energy Consumption by Natural Resources Types 1970-2020

Source: History: Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and International Energy Annual 1999, DOE/EIA-0219(99) (Washington, DC, January 2001). Projections: EIA, World Energy Projection System (2001)

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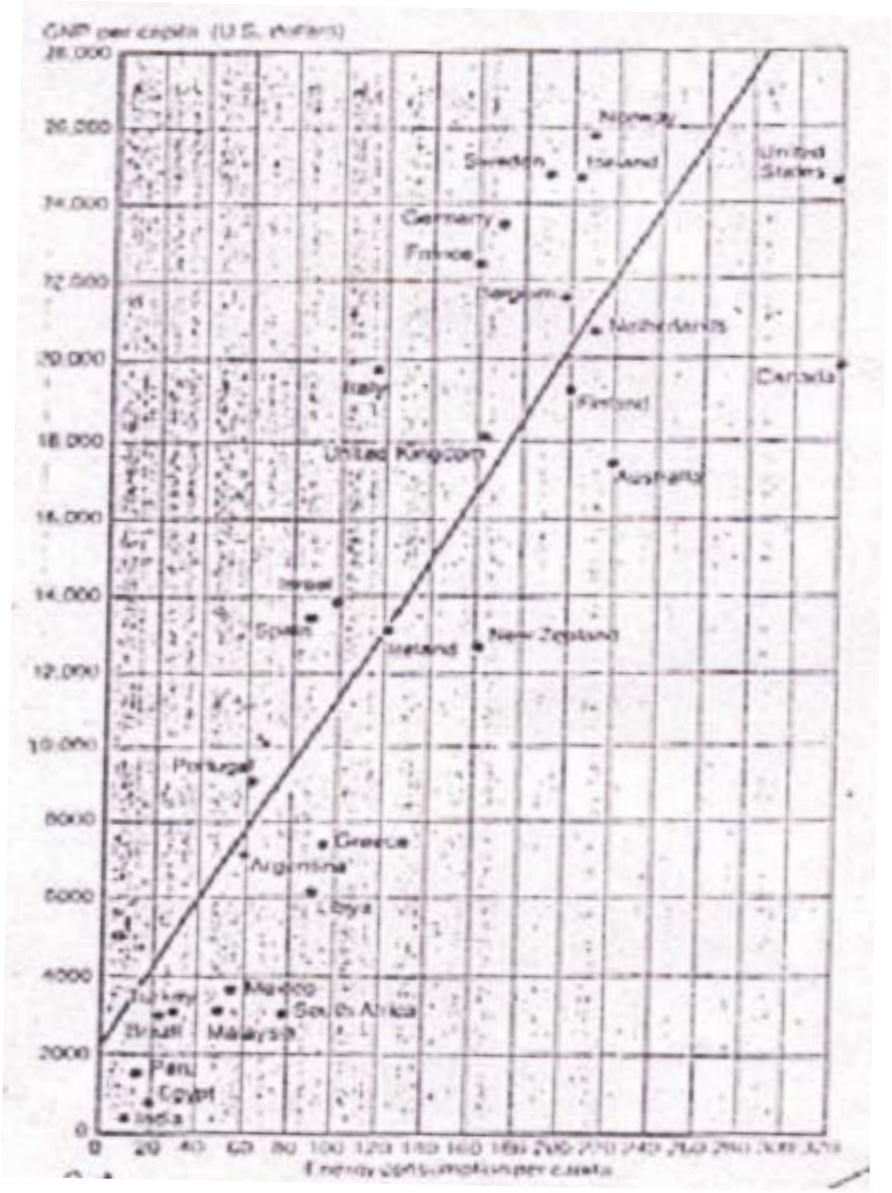

Figure - 2

Energy and GNP. Energy consumption rises with increasing gross national product. Because the internal-combustion engine accounts for a large share of national energy consumption, this graph is a statement both of economic development and of the role of mass transportation, automotive efficiency, and mechanization of agriculture and manufacturing in different national economies. On the graph, energy units are in gigajoules. Data from World Bank.

Malaysia. For Pakistan it is estimated that the energy consumption is half of the average of all developing countries, one ninth of the world average and 1/48 of the US average. The electric power generation is much lower than the requirements.

- Millions of villagers consume/utilize biofuels for domestic energy, causing deforestation, soil-erosion and environmental degradation.
- Commercial energy needs and the fuels used are steadily changing as per demand, stage of development and process of industrialization. In Pakistan, for example the total commercial

Table - 1: Economic Indicators and Agriculture's Share of Labour

Country Group	Per Capita GNP[a]	Per Capita Energy Consumption[b]	Percent of Labour Force in Agriculture
Least Developed Countries	270	4.3	74
All Developing Countries	1250	855	61
Industrial Countries	20,900	5259	8

needs are today met by Gas (49.7%), Oil (29.9%), Hydro (12.7%), Coal (6.5%), and Nuclear (0.8%), whereas in 1947 the major energy sources were 55.1% coal, 37.8% oil and 3.1% Hydro, indicating a major shift from coal towards gas and hydro power.

- Major portion of the energy, in terms of electricity, fuel and wood, is utilized for domestic purposes: upto 48% and, in some cases, it may go to 70% depending on the stage of economic development.
- The transmission and distribution power-losses often range between 20 and 30 per cent. Appropriate technical and administrative measures should be taken to improve efficiency of operational management. Power losses and theft are rampant in the big cities in some countries.
- There is little effort made for energy conservation and energy efficiency in industries, agriculture and transportation and for developing integrated energy-systems for decentralized sectors.

Nuclear and Hydro-Power etc.

- Few third-world countries have nuclear power plants to supplement the energy-need. The industrialized countries are hesitant to construct, install and operate the nuclear power plants in the third-world countries, fully knowing that these plants are least polluting, are capable of providing sustainable supply of fuel and are economically viable. The population in third world countries is likely to keep growing for several decades, so the energy-demands will increase faster and hence nuclear power generation is a possible option.
- Hydro power provides about 5% of the world's power. Micro-hydel and mini-hydel energy generation is simple and easy to operate, but not adopted properly in the mountain-regions for want of local skills, distribution-system and billing.
- Known technologies are available for solar pump, drying, heating, wind-energy and photo-voltaic electric generation system, etc, but not utilized /popularized due to high cost of installation, maintenance, repair and instrumentation.

To Sum-up:

Dozens of the Third World Countries continue to import oil to meet the local demands at whatever costs. Pakistan imports oil to meet 90 percent of its oil-requirements and spends 60-70 per cent of total foreign-exchange earnings on it. Heavy reliance on fossil fuels, albeit limited supply and at high cost, is the major source of atmospheric concentration of toxic emissions and rising temperature of earth. Dependable and affordable supply of energy is of critical importance in order to improve/accelerate the economy and to alleviate poverty. The known energy-potential of many third-world countries is much larger than the present need of exploitation. If carefully planned and efficiently implemented and managed, this potential is sufficient to provide immediate relief to the national economy.

Because of the close association of energy and economic development, a basic disparity between societies is clear. Countries that can afford high levels of energy-consumption, through production or purchase, continue to expand their economies and to increase their levels of living. Those without access to energy, or those unable to afford it, see the gap between their economic prospects and those of the developed states growing ever greater.

Per-capita energy-consumption

This is a common measure of technology-advancement of nations, because it broadly correlates with per-capita income, degree of industrialization, and use of advanced technology (see Figure 2). In fact, the industrialized countries use about 10 times more energy on a per-capita basis than developing economies do. The consumption, rather than the production of energy, is the concern. Many of the highly developed countries consume large amounts of energy, but produce relatively little of it. Japan, for example, must import from abroad the energy-supplies that

its domestic resource-base lacks. In contrast, many less developed countries have very high per-capita or total energy production figures but, primarily, export the resource (petroleum). Libya, Nigeria, and Brunei are a case in point.

The advanced countries developed their economic strength through the use of cheap energy and its application to industrial processes. But energy is cheap only if immense capital-investment is made to produce it at a low cost per unit. The less advanced nations, unable to make those necessary investments or lacking domestic energy resources, use expensive animate energy or such decreasingly available fuels as firewood. The data presented in Table 1 clearly indicates that industrial countries are consuming ten times more energy per capita than the Third World countries, where over 65% of the population is engaged in agriculture, the main occupation of the populace, whereas only 8% of the labour force in the industrial countries is employed in agriculture.

3. VARIOUS SOURCES OF ENERGY AND PROJECTIONS

Conventional	Non-Conventional
• Gas • Oil • Coal • Hydro-energy	• Geothermal Energy • Nuclear Energy • Mini & Micro-hydel • Solar Energy - Biomass Energy - Wind Energy - Wave and Tidal Energy - Photo-voltaic electric generation system

There are few countries in the Third World that are bestowed with conventional as well as non-conventional sources of energy. For example, Pakistan is utilizing oil, gas, coal, hydropower and nuclear power for generating electricity and utilizing it for commercial, industrial and domestic purposes. Also it has established institutions and some demonstration units to harness non-conventional sources of energy (solar, biomass, micro-hydel, wind, tidal, wave and photovoltaic solar technology). The power demand is projected to grow at an annual average rate of 7.9 per cent during the five years (2005-10) and will increase from about 15,5000 MW in 2005 to 21,500 MW in 2010 (Table 2). The major demand is concentrated in industrial and domestic sectors. Various mega-projects and regulatory bodies have been approved and some are functioning in hydro-power, oil, coal, nuclear technology and renewable energy technologies to meet the power demand.

3.1 Conventional Sources of Energy

Except for the brief and localized importance of water-power at the outset of the industrial revolution, modern economic advancement has been heavily dependent on the mineral fuels: coal, petroleum, and natural gas. Also known as fossil fuels, these non-renewable energy-sources represent the capture of the sun's energy by plants and animals in earlier geological times and its storage in the form of hydrocarbon compounds in sedimentary rocks within the earth's crust. About 75% of the world's energy-supplies presently come from these fossil fuels, barely 2 percent from hydro-power resources, 13% from biomass while about 10% of energy requirement is met from nuclear power.

Coal was the earliest in importance and is still the most plentiful of mineral fuels. Although coal is a non-renewable resource, world supplies are so great (of the order of 10,000 billion (1013) tons) that its resource-life expectancy is measured in centuries, not in the much shorter spans usually cited for oil and natural gas. Worldwide, the most extensive deposits are concentrated in the industrialized middle latitudes of the Northern Hemisphere (Table 3). Two countries, the United States and China, accounted in roughly equal shares for more than 50% of total world coal-output at the start of the 21st century; Russia and Germany both with large domestic reserves, together produced less than 9%. Utilization of coal for power-

Table - 2: Estimated, Sector-Wise Power Demand in Pakistan (2005-10)

Year	Domestic	Commercial	Agriculture	Industrial	Other	Total
2005-06	7,199	1,216	1,763	5,891	1,035	15,500
2006-07	7,585	1,251	1,820	6,481	1,086	16,600
2007-08	8,127	1,312	1,893	7,252	1,159	17,900
2008-09	8,783	1,354	1,979	8,181	1,243	19,600
2009-10	9,531	1,408	2,079	9,267	1,341	21,500

Source: Planning Commission of Pakistan

Table - 3: Proved Reserves of Petroleum, Natural Gas and Coal, January 1, 2001

	Share of Total Petroleum (%)	Share of Total Natural Gas (%)	Share of Total Coal (%)
North America[a]	6.1	4.9	26.1
Europe	1.9	3.5	12.4
Former Soviet Union	6.4	37.8	23.4
Of which: Russian Fed.	4.6	32.1	15.9
Others	1.8	5.7	7.5
Central and South America	9.0	4.6	2.2
Africa	7.1	7.4	6.2
Middle East[b]	65.3	35.0	--
Australia/New Zealand	0.3	0.8	9.2
Japan	--	--	0.1
China	2.3	0.9	11.6
Other Asia Pacific	1.6	5.1	8.8
Total World	100.0	100.0	100.0
Of which OPEC[c]	77.8	44.2	NA

[a]: includes Canada, Mexico, U.S.A
[b]: Middle East includes Arabian Peninsula, Iran, Iraq, Israel, Jordan, Lebanon, Syria
[c]: OPEC: Organization of Petroleum Exporting Countries. Member nations are, by world region:
South America: Venezuela
Middle East: Iran, Iraq, Kuwait, Qatar, Saudi Arabia, United Arab Emirates (Abu Dhabi, Dubai, Ras-al-Khaimah, and Sharjah)
North Africa: Nigeria
Asia Pacific: Indonesia
Source: BP Amoco, BP Amoco Statistical Review of World Energy

generation is as high as 75% in China, 54% in India and 29% in Pakistan.

Petroleum, first extracted commercially in the 1860s in both the United States and Azerbaijan, became a major power source and a primary component of the extractive industries only early in the 20th century. The rapidity of its adoption as both a favoured energy resource and a raw material important in a number of industries from plastics to fertilizers, along with the limited size and the speed of depletion of known and probable reserves, suggest that petroleum cannot continually retain its present position of importance in the energy-budget of countries. Assuming total extraction from known reserves and a constant end-of-century rate of extraction, proven reserves at these estimates would last only about 40 years. More optimistic assessments assure us that petroleum reserves that could be extracted at acceptably competitive prices would last for about 150 years at present consumption rates.

On a world basis, petroleum accounted for 47% of commercial energy in 1973, but had dropped to 40% by 2001 as a reflection of its increasing cost and of conservation measures to offset those increases. The worldwide demand for oil would rise at the rate of approx. two per cent annually between now and 2020, which means that consumption of oil will rise from 77 million barrels per day (mbd), in 2000, to 94 mbd in 2010. The price has already crossed 65 dollars. Oil shall be costly and rare due to the high demand in industrial countries and the high pace of industrialization in China and India. For instance, America being five per cent of the world's population consumes 25 per cent of world's oil, and imports 60 per cent of its requirements, with little concern for depleting oil-resources. Petroleum is among the most unevenly distributed of the major resources. Seventy-five percent of proved reserves are concentrated in just 7 countries; and 83% in only 10: Iran and the Arab states of the Middle East alone control nearly two-thirds of the world total (Table - 3). Therefore, there is great pressure on Middle Eastern countries to share oil resources. Scarcity of oil in the near future is inevitable. Wars will be fought not over ideology but over diminishing supplies of the world's most precious natural resources, particularly oil.

Natural gas has been called the nearly perfect energy-resource. It is a highly efficient, versatile fuel that requires little processing and is environmentally benign. Ultimately recoverable reserves, those that may be found and recovered at very much higher prices, might last another 200 years. As for coal and

petroleum, reserves of natural gas are very unevenly distributed. (Table-3), 37.8% in former Soviet Union, 35.0% in Middle East, 7% in Africa and 5% in North America. For the world as a whole, gas consumption rose more than 60% between 1974 and 2000, to 25% of global energy consumption. The source of energy through natural gas is increasing rapidly due to escalating cost of petroleum in some developing countries.

3.2 Nuclear Energy

Nuclear energy for power generation is considered an important alternative for the alarming rise in oil prices and dependency on foreign sources and routes. Nuclear power plants are operating in 30 countries around the world. Till 1985, 382 reactors were operating and now there are 438 nuclear plants running safely in the world. And around sixteen percent of the world's electricity is now being generated through nuclear reactors. India had 6 reactors in 1985 and now 3 more, Pakistan had one in 1985, now one more is in operation and another one under construction. Nuclear technology can contribute significantly towards sustainable development in terms of food security, clean water, health care, pollution-free environment, and reliable energy supply.

In some of the European countries, the proportion of the total electricity generated through nuclear power plant is as high as 65% (France – 65.4%, Belgium – 60.4%, Sweden – 43.4%, Switzerland – 40%). The developing countries should also endeavour to build nuclear plants having advantages, such as:

i. sustainable supply and security
ii. compatibility with environment
iii. long-term economically viable
iv. it may spin off new technologies and business ventures.

Greater demand for nuclear power generation is envisaged in Asia particularly in China, Pakistan and India, with an eye to accelerating transition of the base-load from oil and gas, to nuclear in view of the depletion of oil and the subsequent peaking of gas usage around 2030. Pakistan plans to increase domestic nuclear power generation from the present 430 MW to 8800MW in the next 25 years. This may appear too ambitious a target to realize, but there is no alternative. With $ 65/barrel, oil import costs 5 billions dollars, a burden difficult to bear.

The long-term availability of different fuels is listed below:

Uranium (once through)	150 years
Breeder reactor	1000 years
Thorium Cycle	Several thousand yrs.
Oil	40 years
Gas	60 years
Coal	200 years

It is obvious that, barring coal, no other fuel has any long-term sustainable supply. In comparing the pollutionability, the coal is most polluting, followed by oil and gas, while the nuclear energy is the least polluting, as given in Table - 4 below:

While it is correct that no new nuclear power plants were built in the United States or Britain for over 20 years, the "fear factor" linked to the accidents at Three Mile Island and Chernobyl which reduced the market demand. But this should not be discouragement in adopting nuclear power technology, as no other large-scale technology, worldwide, has a comparable overall safety record. Also to waive off the worst effects of climate change, massive expansion in nuclear power generation is required which produces hardly any carbon dioxide. Intensification and self-sufficiency in using nuclear energy for power-generation is the only immediate solution to curb the energy-deficit situation. The new breed of safer and better performing reactors marks the new era of cleaner, safer and, perhaps, cheaper energy resource. Nuclear power for meeting the energy-needs is poles apart from

Table - 4: GHG Emissions from Electricity-Production for Chains

Energy Source	Emissions (GCeq/kWh)
Nuclear	2.5-5.7
Wind Power	2.5-13.1
Large Hydro	4-6
Solar PV	27-76
Natural Gas	120-188
Oil	219-246
Coal	264-357

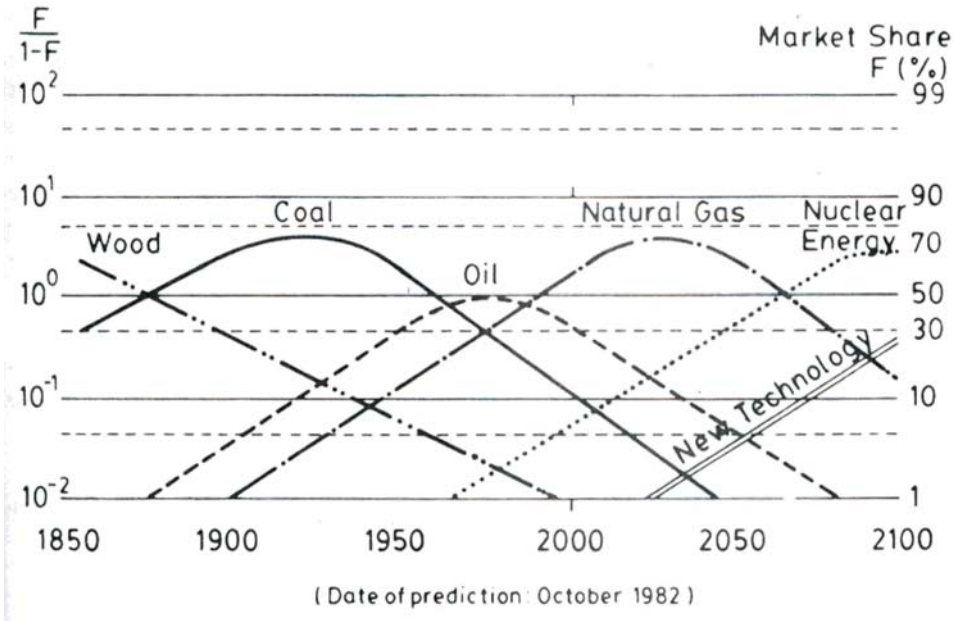

Figure - 3: Showing the schematic representation by C. Marchetti of the rise and fall of the market shares of various energy-forms over the period from 1850 to 2100 A.D.

nuclear proliferation for weapon-use.

Thus we can see that the proportion of Nuclear Energy usage in Third-World countries also likely to increase steadily, as it has done in the developed world. In fact, the estimates for the future are that, once the use of gas has peaked (somewhere around 2030), the contribution from Nuclear Energy would begin to increase rapidly, as indicated by the inclined dotted line in the conceptual diagram from Marchetti (Figure-3). This is further supported by the fact that Nuclear power contributes directly towards sharing the base-line load in the city or area concerned.

3.3 Renewable Energy

The fossil fuels (coal, oil and gas), beside limited reserves, have harmful effects on the environment and release toxic gases containing Sulphur, NOx, CO and heavy metals, which are great health-risk. The Kyoto Protocol (1997) directs that the Developed countries shall by 2008-2012 reduce the total emission of six key greenhouse-gases by at least 5% from the 1990 level. This is possible only if use of renewable technologies is increased substantially. In year 2000, the developing countries' electric power capacity (1,500,000 MW) was 45% of world electric power (3,400,000 MW). World's fossil fuels account for about two-third of generating capacity, with the remaining third being composed of large hydro (20%), nuclear (10%) and other renewable energy (3%) units. Electric Energy consumption in the developing world is increasing with economic growth and they will need to double their current generation capacity by 2020.

3.3.1: Solar Energy

Amongst all renewable energy resources solar energy is in great abundance, freely available, widely distributed and can easily be converted into other processes of energy. Over 1000 million people live in underdeveloped economic conditions around the world between latitudes 35°N~35°S. In general greatest amount of solar energy is found in two broad bands around the earth between latitudes 15° and 35° north and south of the equator. Three approaches to the utilization of this solar energy are (a) use of low-grade heat; (b) direct conversion to electric energy; and (c) photosynthesis and biological conversion processes. Solar energy covers a wide range of applications, some of which are mentioned below. These are old technologies, improved upon over the ages while some have been recently introduced:

i. Solar room heating system

Table - 5: Renewable Energy Sources

Technology	All Countries	Developing Countries
Small hydropower[a]	43,000	25,000
Biomass power[b]	32,000	17,000
Wind Power	18,000	1,700
Geothermal power	8,500	3,900
Solar thermal power	350	0
Solar photovoltaic power (grid)	250	0
Total renewable Power capacity	102,000	48,000
Large hydropower	680,000	260,000
Total world electric power capacity	3,400,000	1,500,000

Source: Renewable energy in developing countries-lessons for the market" Renewable Energy World, July-August 2003, p.55

Notes:

(a) Small hydro is usually defined as 10MW or less, although the definition varies by country, sometimes up to 30 MW

(b) Biomass figures omit electricity from municipal solid-waste and landfill gas; commonly, biomass and waste are reported together.

ii. Solar water heaters
iii. Solar cookers
iv. Solar fruit and vegetables dryer
v. Solar desalination
vi. Solar thermal power system
vii. Photovoltaic(PV) power generation

Photovoltaic solar cells devices enable conversion of sun's energy into electric power. Tremendous research in new materials, as well as processing technologies for the production of solar electricity has resulted in reduction in the price by two orders of magnitude during the last 30 years. Besides providing electricity, even in remote areas, PV applications are in satellite equipment, telecommunication, navigation, information technology etc. Photo-voltaic systems have virtually no operational and maintenance costs. They can provide energy security without any embargoes like oil or nuclear embargo.

There is burgeoning demand for photovoltaic panels, both domestically in the United States and overseas. American solar manufacturers estimated that the solar market has grown 40 percent roughly in the last five years, albeit less in comparison to Japan and Germany. Germany consumes 39 percent of all the solar panels in the world, with Japan next at 30 percent and the United States a distant third at 9 percent. Japan had the greatest solar capacity by the end of 2004, at 1,100 MW followed by Germany with 790 MW and the United States with 730 MW. However, there is little response to use solar photo-voltaic technology in the third-world countries and the highest impediment is its cost. The average cost per kilo-watt hour is 20-40 US cents whereas that of oil, gas, thermal electric power is 3-10 cents per kilo-watt hour. In some countries steps have been taken to provide electricity through PV cells. In Kenya 20,000 small-scale PV systems have been installed since 1986 and play a prominent role in decentralized, sustainable electrification. Although efforts /initiatives were made since 1981 in Pakistan to manufacture PV Cells/Panels, but with little success and confined to laboratory. PCRET has installed a number of PV systems in the areas of rural electrification, illumination, water pumps etc. The third-world countries, which have abundant solar energy, should develop joint ventures with firms in Japan, Germany and USA for installation and popularization of PV systems for rural electrification.

3.3.2 Biomass Energy

The FAO estimates that wood accounts for atleast 60 percent of the fuel used in the third world countries and exceeds 90 percent in the poorest countries such as Ethiopia and Nepal. Demand for fuel wood continues to grow inline with growing populations. Declining supplies are having serious human and natural consequences. Over 1.5 Billion people meet their needs only by serious depletion of wood resources upon which they totally depend, mainly living in Asia and drier regions of Africa. In parts of Tanzania and highlands of Nepal, it takes 200-300 workdays to fill the yearly firewood needs of a single household. This is the energy crisis of the poor. The use of wood for cooking, heating and other purposes, besides causing deforestation and environmental degradation, is also the cause of suffering to children and women due to smoke

generated in process of cooking (blindness, respiratory diseases and cancer) These countries, being mainly agriculture based, breed sufficient livestock for different purposes; and the animal waste is utilized for generation of energy. Currently all such animal waste is burned in dry form as a domestic source of energy, although it could be used for producing biogas on a community basis:

- Biomass energy is obtained by converting animal and agricultural waste and Industrial processing to useful fuels, which is renewable, environment-friendly and a sustainable source. Current biomass energy takes separate forms which includes distillation to produce alcohol, and fermentation to produce gases through various types of biogas digesters, which can be directly used for cooling, heating and running of power generators. Biogas technology is an option, which could offset, albeit partially, the fossil-fuel and fuel wood consumption. There are different biogas plant models and the selection depends on the geographical, economic and continued availability of waste. The various biogas uses and its requirements for different applications are as given in Table-6. The exhaust slurry of biogas plant is an enriched organic fertilizer, widely used in vegetable fields in China. Social customs, habits, prejudices, correct knowledge about the selection of model, etc. pose problems for popularization of the biogas technology.

3.3.3. Geothermal Energy

Geothermal energy is one of the oldest forms of renewable energy with the longest industrial history. The four main sources of geothermal energy are: underground hot fluids (hydro thermal), hot dry rocks, geo-pressurized system, and (volcanic) magma; so far only hydro thermal sources are exploited. The potential geothermal energy is estimated equal to 5.0 x 1012 Gj/year which is 12.5 times the current annual energy consumption. Presently only 0.01% of this value is being used. 39 countries have been identified that could be powered 100% geothermally, mostly in Africa, Central and South America and the Pacific, representating 620 million people. Geothermal energy with a total capacity of 15000 Megawatt is being utilized in the following manner:

1. 42% for geothermal heat pumps
2. 31% for space heating
3. 11% for bathing
4. 9% for greenhouses
5. 3% for industrial
6. 1% for agriculture

Geothermal energy is a clean renewable energy,

Table - 6: Biogas Requirements for Typical Applications

Purposes	Specifications	Gas Required, (M^3)	Country
Cooking	Per person	0.5 / day	China
	Per person	0.34-0.43/day	India
	Per person	0.425/day	Nepal
Gas Stove	5 cm dia.	0.33/h	
Gas Stove	10 cm dia	0.47/h	
Boiling Water	15cm dia	0.64/h	
Boiling Water	Per gallon	0.28/h	
Lighting	200-candle power	0.1/h	China
	40-watt bulb	0.13/h	India
	1-mantle	0.07-0.08/h	
	2-mantle	0.14/h	
	3-mantle	0.17	
Gasoline engine	Per hp	0.45/h	India (Engine efficiency 25%)
	Per hp	0.41/h	Pakistan (Engine efficiency 28%)
	Per hp	0.43/h	Philippines
Diesel engine	Per hp	0.45/h	Pakistan (Consumption ratio 20)
Generating Electricity	Per kWh	0.616/h	
Refrigerator	Per m^3	1.2/h	U.K
Incubator	Per m^3	0.5-0.7/H	Nepal
Table fan	30 cm dia	0.17/h	
Space heater	30 cm dia	0.16/h	

sustainable and independent of both time and weather and operates 24 hours a day. Hence geothermal power-generating capacity needs to be increased to provide electricity.

3.3.4 Wind Energy

This is the fastest growing renewable source of energy, with annual growth rate of 40%. This is supposed to replace 10% of EUs annual electricity production by conventional source by the year 2010. The total installed capacity around the world in 2001 was 24,900 MW. These are about 55000 wind-mills stalled and 70,000 people are employed in the industry, globally with the investment of US$ 5 billion. The commercial viability depends on the availability of required mean wind-velocity that is 4 m/s for commercial exploitation. The wind turbine technology is fully matured and commercially viable. Cost of power generation with wind energy is quite comparable with other sources. Many modern high-speed horizontal-axis and vertical-axis machines with much higher efficiencies have been designed and are available in the market. The wind-produced electricity, can often be fed into the local or sub-network directly without any storage of energy being needed, with resulting saving of cost.

3.3.5 Tidal & Wave Energy

Today, wave energy is only used on a small-scale to power buoys, the average power-output of these systems ranges from 70 to 120 MW. Tidal power can be harnessed at specific sites, where the tidal amplitude is several meters and where the coastal topography is such as to allow the impoundment of a substantial amount of water with a manageable volume of civil works. Potential sites for Tidal Power stations have been surveyed in 25 countries, including Mauritius, China, Brazil, Chile, India, Burma and Madagascar.

3.3.6 Mini/Micro Hydro-Power

In general, hydro-power is considered as a conventional source of energy. However small hydropower sources (less than 1MW) are now included in the list of renewable sources of energy. The technology is well-developed and is effectively being used as rural energy in many countries of the world, particularly in the terrain, where natural and manageable water falls are abundantly available. For instance, in Pakistan, several sites have been identified in the northern mountainous regions and the PCRET has installed 236 units with potential generation of 2.8 MW electricity in collaboration with the local population. Perennial waterfall is channelized and allowed to fall on the turbine from the forebay, through a penstock. In Austria there are 1690 small hydro-power plants with a total of 600 MW capacity. In Pakistan so far 290 Mini-hydel plants with local generation capacity of 4MW have been installed, electrifying about 300 villages comprising 25000 homes.

4. LUKEWARM ATTITUDE TOWARDS RENEWABLE ENERGY

The industrialized countries are not so keen to invest in R&D for the development of renewable technologies as long as the conventional sources of energy are available at affordable cost. The Third World countries are shy even to adopt the known technologies in the renewable energy sector. Akhtar in his paper published in JSTD. Tech in 2001, gave a number of reasons for this attitude:

i) lack of education and knowledge
ii) fear of high cost
iii) lack of motivation and incentives
iv) inadequate demonstration of effective use
v) unavailability of suitable appliances
vi) non-existence of proper infrastructure
vii) trained manpower
viii) market development and feed back services

The initiatives taken by Germany for the promotion of renewable energy and enhancing energy efficiency is worth consideration. German Chancellor and International Financial Institutions have pledged in the International Conference for Renewable Energies in June 2004, to establish a special facility with an investment of Euro 500 million for the promotion of renewable energy and enhancing energy efficiency in the developing countries. This facility includes low-interest leased loans to public and private sector institutions in the developing countries for the establishment of renewable energy projects and enhancing energy efficiency. These measures are an effort to control the rising atmospheric concentration of toxic emissions because of heavy reliance on fossil oils, particularly petroleum products. Several delegates emphasized for action oriented commitment towards the promotion of “cleaner energy” (renewable energy) to achieve goals set under the Kyoto Protocol viz-a-viz reducing toxic emissions’ level by 2008-12. The leaders pledged future investments and measures to bring sources of renewable energies – sun and wind-under use to

actively demonstrate their will to combat rising temperature of earth and counter climate change. The Third World countries should come forward and avail this assistance.

5. CONCLUSION: SOME PRIORITY AREAS IN ENERGY SECTOR

A series of conferences, seminars and workshops have been organized in recent years, both by developed, as well as developing countries in cooperation with the United Nations and International Agencies/Institutions, to solve the energy problems and assist in acquiring and adopting known technologies. Some of the priority areas in the energy sector identified are:

1. Energy conservation and energy efficiency in industries, agriculture, transportation and domestic use, and developing integrated energy systems for the decentralized sectors;
2. Acquisition of basic nuclear technology for a self-reliant programme of nuclear power generation. In addition, increased production of nuclear energy to replace gas as it phases out after 2030.
3. Research and development in renewable energy sources, including direct solar, biomass, geothermal, ocean and wind energy;
4. Production of methanol and methane gas through fermentation of vegetables and animal residues;
5. Technologies for coal beneficiation and converting coal into gaseous and liquid fuel;
6. Developing enhanced-recovery techniques for different oil-fields, including the application of nuclear energy towards the improvement of recovery from the power sources
7. Formulate national action programmes to promote and support reforestation and national forest regeneration.
8. Promote wide dissemination and commercialization of renewable energy technology-transfer mechanisms.
9. Build capacity for energy planning and programme management in energy efficiency, as well as for the development, introduction and promotion of new and renewable sources of energy
10. Cooperate in identifying and developing economically viable, and environmentally sound sources to promote the availability of increased energy supplies to support sustainable development and to provide light in the homes of millions of rural population.

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SOME ASPECTS OF TRANSFER OF FOREIGN TECHNOLOGY IN PAKISTAN

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1. ABSTRACT

Technology-Transfer is a complicated process and it involves many dimensions. The technology-developing organizations (from developed countries), keeping the economic interests on the top, often exploit the technology-receiving countries of third world. In addition to high costs, the technologies transferred by them are obsolete or going to be obsolete in the near future, in general. In some cases the technology transferred is not environment-friendly. These malpractices are facilitated by a weak institutional setup (required for assessment and forecasting of imported technologies) at the government level, in the buying countries. This study presents some analysis of the problems faced by developing countries like Pakistan while buying technology from the organizations of developed countries. It also suggests some policy measures to be taken by the technology-buyers and governments, before any agreement leading towards technology-transfer.

2. INTRODUCTION

According to the report of world economics, Pakistan ranks at number 83 in terms of Technology Index, while the ratings of China's and India's stand at number 49 and 50 respectively (14). Apparently this seems to be due to a weaker R&D base in our country. This is one of the main reasons for the country's dependence upon imported technologies.

At present no systematic information is available regarding the Pakistani expenditure on the imports of technology. Previously, a study was done in Pakistan in the eighties (10) according to which for a period between 1980-85 over Rs.1500 million were spent annually as direct cost for patents, licenses and imported technical services, apart from direct cost on the import of machinery and other similar hardware. The recent data shows that during the financial year 2004-05, 21% of the total imports are contributed by machinery, excluding the transport equipment (2).

The process of technology-transfer is a crucial issue, as it involves many factors. The recipients of technology in most cases are developing and least-developed nations. The technology-vendor companies of developed nations, mostly look after their own commercial interests on long-term basis, while the recipient nations due to lack of institutional arrangements, often import the technologies at a very high-cost, with other expenditures on repair and maintenance paid to the vendors on continuous basis. Further, the export of obsolete machinery/ technology from the developing nations is frequently reported. This import of obsolete technology, most of the time, results in environmental and social problems.

After the acquisition of information about "Appropriate Technology", the assessment of technology is the most important factor for the importing enterprises, as the economic future of the firms, depends upon the successful exploitation of the technology. "Technology-Assessment" means a system of technology-information including procedures for studying or evaluating the interrelations between the various dimensions of the various technologies involved (5).

The objectives of our study are to deliberate upon the various issues of technology-transfer in the context of developing countries like Pakistan. One aspect of the study deals with the methods of technology-transfer, the choice and acquisition of technology and its sources, while the other aspect of the study includes the problems and impediments relevant to acquisition of technologies from abroad. Policy-issues are also mentioned, in order to resolve the problems. Furthermore, the implication of TRIPS' agreement of technology-transfer, is also mentioned. In the end, the study mentions the present status of institutional support and suggests some policy measures for a reasonable institutional setup, to facilitate technology-transfer (from developed nation) in Pakistan.

3. METHODS FOR THE TRANSFER OF TECHNOLOGY

3.1 Commercial Methods: The licensing of industrial property-rights and the supply of know-how, and joint ventures with the firms of developed nations, are the main methods employed for the commercial transfer of technology to developing countries including Pakistan (1).

The supply of know-how, may be the subject of an agreement to communicate technical information and skills concerning the use and

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application of industrial techniques (some times referred to as " technical know-how " or technical information and skills) and may be described in documentation or demonstration and orally, or through demonstration and training by engineers, technicians, specialists or other experts.

Know-how may also be supplied through consultants or other professional experts, who provide services and assistance covering the basic engineering of an industrial plant or its machinery and equipment, and the installation operation and maintenance of an industrial plant and the training of its personnel.

The commercial transfer of technology may also, in fact, take place with the sale and import of machinery and equipment and other capital goods, parts or other intermediate goods, parts or other components, that embody technology, and related literature.

The commercial transfer of technology may also occur in connection with the system of the franchising or the distributorships of consumer goods and services. The services may extend to the rental of consumer or power equipment or to hotel operation or dry-cleaning facilities. The outlet for the marketing of such goods and services, is usually based upon a trademark or services-mark, combined with technical information, or technical services and assistance.

3.2 Non–Commercial Methods: Another way in which technology is transferred to developing countries is through non-commercial channels, including initiatives taken by international organizations, by the governments of developed countries and by non-governmental organizations (NGOs).

This can involve many types of mechanisms. One process, for example, is the vertical transfer of technologies from international research centers (such as those belonging to the Consultative Group on International Agricultural Research, CGIAR) to research centers, farmers and firms in developing countries. Other channels include the development projects of multilateral organizations (11).

Another mechanism of technology-transfer to developing countries, is the development and transfer by NGOs of appropriate technologies to address specific problems of given countries.

3.3 Informal Methods: These methods include the technology-transfer without formal agreements and payments. This consists of, ineralia, the transfer through reverse engineering, through movement of skilled personnel from one country or organization to another, through consulting technical reports and general, and through technical visits and participation seminars, conferences and trade fare.

4. THE CHOICE OF TECHNOLOGY TO BE TRANSFERRED

The issue of transfer of technology in the above context has been deliberated upon in the last two decades, in-depth at the appropriate international forums, and is a central issue in North-South for a new social and economic order. The Vienna programme of action on science and technology for development (1979) has explicitly agreed to strengthen the scientific capacity of developing countries, as well as their capacity to create, transfer and adapt technology for the solution of development problems.

In this regard, it is imperative that each developing country, including Pakistan, should formulate the policy on the acquisition and transfer of technology, as an integral part of its national policy for scientific and technological development. Such a policy should provide for a technological spectrum, ranging from the most simple to the assimilation and adaptation of imported technology.

An essential aspect of technological self-reliance in developing countries, is the development of capability to exercise suitable technological choice and to ensure that the acquisition-absorption and development of selected technology is consistent with and complementary to the growth of national scientific and technological capacity, in the relevant production and services sectors (3).

Issues of technological choice and the process of acquisition and development of technologies, have posed considerable difficulties for developing countries, partly because of inadequate knowledge and experience of alternative technologies, lack of appropriate attention of the various economic sectors, including rural and urban areas, and partly

because of the weaker bargaining position of those countries.

Technological choice refers not only to the use of a particular technological process, but also to the complex choices which may constitute an integrated project or programme in a particular sector. There are choices to be made, for example, between large-scale production between labor intensive and capital-intensive techniques, between importing technology from abroad and developing it from local sources, or between adapting the imported technology to suit specific social, economic, or climatic conditions, on the one hand, and developing or upgrading indigenous techniques and processes on the other hand. In order to independently formulate and answer such questions, and to exercise effective control over such choices, Pakistan must relate the technological choice to the social and economic conditions under which the technology will be applied, and also ensure that the technology chosen responds to the real needs and the resources of the people and their environment. Pakistan needs to select import of those technologies, which increase employment and are more appropriate to the economic and social environment of the country (13).

Apart from appropriate technological choice, institutions, enterprises and other users in developing countries, need to ensure that a chosen technology is acquired on suitable terms and conditions, enabling its rapid absorption, adaptation and development into the context of local conditions and resources. It is also necessary to strengthen the ability of developing countries, to generate technology from within the terms of adaptation and innovations. These aspects would necessitate consideration of policies, institutional measures and appropriate mechanisms which would, on the one hand, improve the conditions under which foreign technology is acquired and on the other, encourage the choice and application of indigenous technologies.

5. SOURCES OF TECHNOLOGY

The foremost task in the process of technology-transfer is the identification of technological needs, which is a complex process. This is reflected in the fact that only a few developing countries have been able to formulate comprehensive technology development plans and policies. The reason is to be found mainly in the lack of domestic expertise and experience. There is, however, a growing awareness that technological needs must be identified on a systematic basis; that they must be split into their various components; the domestic absorptive and adaptive capabilities must be developed to take care of as many of them as possible, and that foreign technology must be acquired selectively to complement and strengthen domestic capabilities.

Once the nature and extent of technological inputs has been assessed, (whether precisely or in broad terms), the next question that arises for consideration is the identification and selection of the sources from which they can be obtained. This requires the building up of an adequate technology information system. At the outset, it must be mentioned that this is inevitably a continuous and dynamic process, given the nature and complexity of the world technology market. On one side, information on all aspects of the technologies needed by the country's economic, technical, financial, legal, social, environment, etc., will have to be built up as comprehensively as possible. This could be regarded as the "theoretical" side of the information process. On the other side, is the information needed from the practical standpoint such as the major technology suppliers, including machinery and equipment suppliers, their experience and reputation in the international arena, the view points of technology expertise on the merits and demerits of their technologies, the terms and conditions of technologies supply contracts concluded by them elsewhere and there technologies covered by patents and those that are exclusive and non-patented. The difficulties involved in building up such a comprehensive technological information system, cannot possibly be underestimated. Much of this kind of information may be of a secret nature and may not be easily available.

5.1 Commercial Sources

5.1.1 Large Enterprises: The developing countries' main sources of commercial technology, have so far been the large enterprises of developed countries, mainly because of their predominant role in direct investment or participation in production or the provision of services. It is noteworthy, that the number of the enterprises involved in the business of transferring technology in "high-tech" areas is relatively less (4), and

these firms are mostly Multinational Companies (MNCs). Licensing arrangements have also primarily involved large enterprises. In the case of consumer goods and services, such arrangements may reflect the desire of the licensee to obtain access to a well-known product or brand name, but in the primary production, they are often related to the control by large enterprises of marketing channels in world markets and their vast financial resources. Similarly, technology-services have so far been provided by primarily internationally renowned designs, consultancy and engineering companies, which are often linked to capital goods' producers and major financial institutions. The impact of technology-transfer by large enterprises on the economic and technological development of developing countries, however, has been a subject of much debate.

5.1.2. Small & Medium Enterprises (SMEs): There are many alternative sources of technologies, including small and medium enterprises, public institutions, the international information system etc., which Pakistan needs to explore and utilize much more actively. Research has shown SMEs play an important role in the economic development of the country (8).

The machinery and equipment, producers in most sectors, for example are small and medium-sized enterprises (SMEs), with notable exception such as transport, heavy electrical and telecommunications equipment. For most production activities, there are many alternative techniques available ranging from un-mechanized and labor-intensive methods to sophisticated and highly-automated technologies. Even though SMEs are known for their innovative capacity and often act as subcontractors to large enterprises in advanced technologies, the empirical research indicates that the less advanced or standard the technology, the more likely is the source of technology to be an SME. Furthermore, in their transactions, SMEs are usually more willing to transfer detailed information on the technologies and subsequent technological improvements, than are large enterprises, and are less likely to include restrictive clauses in contractual arrangements. Their management style is also likely to be much closer and more compatible with that of the majority of Pakistani firms of similar size, and they would be willing to enter into majority joint ventures associate and with firms in Pakistan (3).

But, SMEs by their very nature are not well-known in international markets, at least in developing countries. As a matter of fact, their very size limits their strategies to addressing local or at the most selected country's markets. Their products, services and technologies are not known beyond limited geographical boundaries, their production capacity and their own financial assets are also limited, so that they do not figure prominently in developing countries. The question arises as to what are the obstacles, that have prevented a more active role by SMEs in technology-transfer. These appear to be related to corporate limitations on one side and to host country's constraints on the other. The former includes lack of information, insufficient finance and a low-risk approach by management.

Despite the constraints, SMEs of developed countries have emerged in recent years as increasingly important suppliers of international investment capital and technology. Many factors have contributed to this, such as slower growth-rates and high-labour costs in developed countries, which have pushed SMEs to seek new markets. A major factor has probably been increased of home country government support to SMEs. Thus, during the 1970s, Development Finance Corporation was established in various countries with the aim of promoting private investment in developing countries by providing risk and long-term loan capital, which SMEs are seemingly taking advantage of. Some countries have also adopted credit programmes for facilitating foreign investment by national firms, which include special measures dedicated to projects of SMEs. Many mechanisms related to public-aid policies, are also instrumental in directly affecting the transfer of technology by SMEs to

developing countries like Pakistan.

5.2 Non-Commercial Sources: Technologies originating from public-fund, apply equally to bodies in developing countries and international organizations. The mechanism of commercialization and diffusion, appear to be even weaker in these cases. Particularly surprising, is the lack of information on the use made of results stemming from the multiple R&D programmes and projects financed by the United Nations. Indeed, many of the technologies and R&D results originating in connection with United Nations' programmes are very likely to be exploited by small and medium-sized enterprises, and thus, constitute an alternative source of technology for them. The "public" technologies may also offer a vast potential as alternative sources for developing countries.

The non- commercial sources of technology are mainly the international organizations and non-governmental organizations, financed by the developed countries. In the agricultural sector, the best example is of the R&D organizations working under the CGIAR system, which are mandated to transfer the technologies and skills free of cost to developing nations (11).

There are also organizations of technologically-advanced nations, which are inclined to transfer technology, which are, prima-facie free. However, the commercial interest of these organizations in terms of regular supply of equipment, including spare parts, consultancy and repair and maintenance services cannot be ruled out.

6. PROBLEMS RELEVANT TO THE ACQUISITION OF TECHNOLOGY

Potential technologies' acquirers in Pakistan, like other developing frequently face serious obstacles in their dealings with technology-holders in developed countries.

These obstacles are basically of three kinds: those which arise from the imperfection of the market for technology, those attributable to the relative lack of experience and skill for enterprises and institution in concluding adequate legal arrangements for the acquisition of technology, and those government procedures, legislative and administrative, in both developed and developing countries which influenced the implementation of national policies and plans designed to encourage the flow of technology to, and its acquisition by developing countries.

Following is the detail about some major problems faced by developing countries like Pakistan during the process of technology transfer from the developed countries:

6.1 Lack of Information and Expertise: The enterprises or institutions in developing countries, frequently lack information about sources of technology and opportunities for its exploitation, and do not possess the means to assess and make a choice among alternative technologies, to determine the appropriateness of the technology for their needs, and to negotiate fair and reasonable terms for its acquisition. As a consequence, prospective technology acquirers in developing countries may find that their bargaining position in their dealing with technology-holders in developed countries is relatively weak and as a result the latter may present the former with a technology "package" tied to commercial, financial, and other inputs.

Due to absence of national institutions in Pakistan to assist in carrying out the function of identifying evaluating and selecting technology, the local enterprises must often turn to international consultants, many of whom are already closely associated or have established relations with certain technology-holders in developed countries, thus, leading to a further state of external dependence.

For the adaptation and absorption of the technology, technical, engineering and managerial skills are among the basic prerequisite. Developing countries generally lack these skills. In the developing countries the skill formation should also be carried out through the training components of the technology-transfer transaction.

Similarly, while the basic national infrastructure of science and technology, in the developing countries can be strengthened and research and development programme expanded, with particular stress on applied research and the creation of indigenous technology, enterprises in developing countries must have access to advances in existing technology, as well as to

new product or process technologies, developed by technology-holders in developed countries.

The reluctance of technology-transferers to provide information on technological advancement and new technology, and to complement that information with adequate technological services and assistance is not only detrimental to the technology-transferee, but also works against the general interest of a developing country in as much as enterprises and institutions in developing countries, need to develop alternative technologies and to enhance their indigenous growth capabilities.

Consequently, it is incumbent upon technology transferees and government authorities administering laws governing the transfer of technology and responsible for overseeing the import of technology, to carefully examine the proposed terms and condition of the technology-transfer transaction, to ensure that the basic technology to be supplied is appropriately defined, that adequate guarantees of its effectiveness are included, that access to technological advances and new technology is facilitated and that the undue restrictions are not placed on the disclosure by the technology transferee, or the communication to and use by the third person of information, about such advances and technologies.

6.2 Technology-Holders: The willingness of the enterprises (technology-vendors) in developed countries, to allow others access to the technology or to permit its exploitation, is motivated by technological, commercial, economic and sometimes even political considerations. One of the more important of these, is an assessment of the advantages and disadvantages if the technology was to be exploited in the technology holder's country and the resulting product exported to the developing countries, rather than exploited in the developing countries with the resulting product sold in that and in other countries. These facts are among the policy considerations of the enterprises and institutions of the technology-buying countries.

6.3 Financial Implications of the Technology: A further obstacle to acquisition of appropriate technology by enterprises in developing countries, is that such countries have scarce financial resources to exchange for that technology.

For those enterprises and institutions in developing countries, which will not have the benefit of external financing, the acquisition of technology on international commercial terms, will impose a burden on the local economy unless the price of the technology can be brought within manageable limits.

As the value of technology varies from industry to industry, the process of determining the fair price for technology-importing firms, is very tricky. The situation is more difficult in developing countries, who lack the institutional support in this regard.

In addition, for a given technology-transfer transaction, there may not be a readily available measuring stick to determine the price of the technology to be transferred. Among the factors which will be taken into account, are the cost of the research and development activities of the technology transferer that are associated with the creation of the technology to be transferred, and with the possible future technological advances, as well as with new technology, the possibility of multiple sales of the same types of technology, the need to design the technology specially to meet the particular requirements of the technology transferee, and the extent to which the technology transferor is to receive the price in whole or in part from an allocated part of the technology transferee's return in exploiting that technology, a method of payment which may be intended, on the one hand, to reflect a credit facility by the technology transferor, or, on the other hand, its willingness to share with the technology transferee the risk of a business venture.

Further, the fact must not be overlooked that a technology-transferer may derive substantial indirect gains from the technology-transfer transaction, as a result of the supply by it or other inputs necessarily related to the technology transferred, such as plant or machinery, raw materials or intermediate goods or components required in the exploitation of the product or process technology. It is for this reason that tie in arrangements which link the sale of such

capital goods or inputs to the technology transferred must be scrutinized not only from the perspective of the added benefits to the technology transferer but also from the point of view, of their impact in narrowing the latitude of the technology transferee to explore alternative and more economical international sources of supply, as well as from their undesirable effect in discouraging participation by the potential local suppliers.

Similarly, technology transferers may stand to benefit from controlling the output of the technology exploited, such as by limiting the purpose for which the technology may be used, or by attempting to impose quantity or price restriction on the sale of the product or by efforts to confine the marketing of the product to the developing country where the manufacture takes place or to channel that production into the hands of the technology transferer or away from markets being serviced by it with its own production or with the production of other technology recipients. Here again, such restriction must be viewed from the perspective of the added gains to the technology transferer, the freedom of the technology transferer, and the impact on the economy of the developing country and its posture as an emerging trading power.

6.4 Inadequate Legal Framework for the Technology Transfer Transaction: An important prerequisite to the successful commercial transfer or acquisition of technology, is an adequate legal framework within which the parties to the transaction can fix their respective rights and obligations, and which permits an equitable balance to be struck between, on the one hand, the interests of these parties and, on the other, the interests of the state or the public.

A successful technology-transfer transaction (in legal perspective) involves technical, financial, and commercial matters and relevant stake-holders, under the existing legal framework, of the importing nation. The implementation rests on an adequate legal framework for commercial transactions - i.e. laws concerning contracts, business association, fair trade practices and industrial property - yet in many developing countries these laws need to be modernized and institutions for their administration need to be established or strengthened.

Furthermore, from the standpoint of the potential technology-acquirer, there is often a lack of information and skill to deal with many legal aspects of industrial property licenses and technology-transfer agreements - the two principal mechanisms through which the commercial transfer of technology takes place.

Both mechanisms sketch the legal, commercial, financial and technical parameters of the transaction, and set the operating procedures for the transfer of the technology, its application, absorption and exploitation.

6.5 Inadequate Government Controls and Lack of Understanding of the Commercial Aspects of Technology-Transfer: From the standpoint of the government in a developing country, there are many broader considerations than those at issue, between the potential technology transferer and the prospective technology, the effect on the balance of payments of the country, the need for parallel negotiations on final matters, foreign exchange transfers and foreign investment.

In some developing countries the technology-transfer transaction, itself may be the subject of scrutiny by a government authority charged with approving the terms and conditions of the legal arrangements, which the parties have concluded or intend to conclude.

In such countries the technology-transfer transaction must, thus be regarded in the light of not simply whether, as a commercial transaction, it strikes a fair balance between the interests of the transferer and transferee, but also whether its technical, financial, commercial and legal aspects are consistent with the objectives sought to be achieved by the government and, whether they will result in an inflow of technology that will appropriately promote the scientific technological and economic development of that country.

In developing countries, which set up or desire to set up machinery to control the commercial transfer of technology, difficulties have arisen however, in establishing the appropriate government policies, and in formulating the government procedure and criteria. Further, enhanced coordination of diverse government

sectoral policies plans and programmes, the clearer identification of the appropriate decision making authorities, the stabilization of the legal base for the commercial transfer of the technology and its control, greater flexibility in the approvable technical financial and commercial terms of the technology-transfer, transaction and continued improvement of the fiscal incentives for investment can lead to a more favorable climate for the transfer of technology from enterprises in developed countries and its acquisition by enterprises and institutions in developing countries(3).

7. INTELLECTUAL PROPERTY (IP) AND TECHNOLOGY-TRANSFER

The contemporary evidence suggests that, because developing countries are large net-importers of technology from the developed world, the globalization of IP protection will result in very substantial additional net-transfers from developing to developed countries. The benefits to developing countries from IP protection, would have to come from an offsetting dynamic stimulus to trade, the development of technology, investment, and growth. Moreover, the developed nations feel easier in transferring technology and investment in the nation, which have stronger intellectual property protection laws. In the recent past, the OECD countries made significant investment and transferred technologies to China in various sectors, after the proper promulgation and enforcement of intellectual property laws (12).

Worldwide, intellectual property is being more and more extensively protected through the implementation of Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement. Viewed in terms of welfare economics, neither constant stiffening of rules in industrialized countries, nor the international expansion of intellectual property rights, effected by the TRIPS agreement can qualify for unreserved endorsement. The impacts on technology-transfer to developing countries are mixed: advanced developing countries stand to benefit, while less developed countries are almost certain to lose (6). In view of the fact that knowledge is a crucial factor in reaching the Millennium Development Goals and setting an economic development process in motion, industrialized countries are called upon to promote technology-transfer to developing countries. Indeed, they have to this end a broad set of instruments extending from public-sector research financing and tax incentive to innovative fund solutions. Development cooperation, too, can provide an important contribution here, provided that, it is embedded in the education and research strategies of given partner countries.

In today's liberalized and competitive environment, companies in developing countries can no longer compete on the basis of importing "mature" technologies from developed countries and producing them behind tariff barriers. Companies are more wary of transferring technology in ways that may increase the competition they face. The problem is less about obtaining mature technologies on fair and balanced terms, but more about accessing the sophisticated technologies that are required to be competitive in today's global economy. TRIPS has strengthened the global protection offered to suppliers of technology, but without any counterbalancing and strengthening of competition policies globally. Therefore, it may be unwise to focus on TRIPS as a principal means of facilitating technology-transfer. A wider agenda needs to be pursued, as is currently being done in the WTO. Developed countries including Pakistan, need to give serious consideration to their policies for encouraging technology-transfer (7). In addition, they should promote more effective research and cooperation with and among developing countries to strengthen their scientific and technological capabilities.

8. INSTITUTIONAL ARRANGEMENTS IN PAKISTAN

In Pakistan a National Center for Technology Transfer (NCTT) was created in early eighties to deal with the technology-transfer related affairs. The government in 1993, due to certain administrative reasons, however, abolished this center. Since then no alternate arrangements have been made to tackle the problems related to foreign technology-transfer to the country. However, some of the following institutions are providing a limited assistance in terms of foreign technology-transfer.

- Pakistan Scientific and Technological Information Center (PASTIC) is mandated to provide the information about the latest technologies covering all important industrial sectors. In this regard PASTIC under its TIPS (Technology Information Promotion System) programme, disseminates information (through publications and internet) regularly.
- At the international level, technology

information services are also provided by the Asian and Pacific Center for Technology-Transfer (APCTT) through its publications and website.

- The Government of Pakistan established Pakistan Technology Board (PTB) (in 2000) which is, inter-alia, mandated to conduct technology assessment and forecasting studies. The Board is not operating its functions due to lack of manpower and funding. However, the board with the collaboration of UNIDO is conducting technology foresight studies.
- The Government of Pakistan recently (2005) established the Technology Up-gradation and Skill Development Company (TUSDEC). The scope of this company, however, is very limited in regards to technology-transfer related matters.

9. CONCLUSIONS AND PROPOSALS

From the above discussion, it becomes evident that the technology-transfer from the developed countries to the developing countries is not a straightforward mechanism and it is skewed towards the economic benefits of the technology-supplier countries. Keeping in view the importance of problems relevant to the technology transfer, many developing countries have established institutions for public support. In India, National Institute of Science and Technologies and Development Studies (NISTADS), Technology Information, and Forecasting and Assessment Council (TIFAC), are working on various aspects of technology-transfer (9). Unfortunately, in Pakistan the only center (NCTT) that was mandated to provide technical assistance in terms of technology transfer, was abolished.

The almost total lack of institutions facilitating technology-transfer in countries like Pakistan has created certain complexities for SMEs and even for major industrial enterprises. It is impeding the efforts of our local industry for being more competitive. The situation demands that the government of Pakistan establish institutions, with proper technical manpower to deal with the problems relevant to foreign technology-transfer. The institution(s) may facilitate the local industry and other technology-users in the following ways:

- Locating the proper information sources of foreign technologies.
- Making proper arrangements for assessment and evaluation of technology in terms of its effect on environment and society.
- Facilitating industrial sector in pricing the international technologies.
- Making arrangements for legal support in technology-contract negotiations.
- Establishing a complete coordination between technology venders and users through entering in all technology-transfer related proposals and agreements.
- Conducting research studies for technology transfer in various sectors.

Special attention is needed for undertaking technology-assessment, monitoring and forecasting studies. Through forecasting exercise, the country may be able to get information about the life cycle of imported technologies. For this purpose the capacity-building of Pakistan Technology Board (PTB), through manpower and funding is required on immediate basis.

Due to investment-friendly policy of the government, the volume of direct foreign investment is expanding with time, and more and more multinational companies are establishing their industrial unit in Pakistan in various sectors. The government of Pakistan may persuade the MNCs to transfer their technologies to Pakistan after milking profit from their enterprises. This step, however, needs a proper institutional assistance.

Finally, the assistance from international organizations like: UNIDO, APCTT, UNDP, and other relevant organizations, can be sought for developing effective technology-transfer measures in the country.

Need-assessment studies of potential foreign technologies importing enterprises may be conducted keeping in view their absorbing capacity of foreign technology.

On the basis of the above-mentioned discussions it is concluded that for any successful technology transfer there is an urgent need for the establishment of some institutions in Pakistan to deal with various aspects of technology-transfer.

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WATER FOR RURAL COMMUNITIES IN GHANA: AN OVERVIEW OF PROVISION OF BOREHOLES

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ABSTRACT

A rapidly growing interest in groundwater abstraction, for rural communities, is occurring throughout Ghana with much attention on the development of boreholes. The limited financial resources available and skilled-manpower required in large-scale projects, suggests that groundwater development can be costly and difficult without the proper understanding of hydrogeological principles and practice and the appreciation of the socio-cultural dimensions of the beneficiary communities. A general overview of borehole provision has been outlined in this paper supported with data derived from borehole development in poorly-permeable areas of the Ashanti Region. The importance of the use of geophysical techniques in well-siting is also emphasized as an invaluable tool in terrains where groundwater development could be difficult and complex.

INTRODUCTION

Ghana, in recent times, has focused much attention on the need to provide potable water and adequate sanitation facilities to rural communities, which constitute over sixty percent of the population (Ghana vision 2020). As a result of constraints on the availability of water-resources and finance and the need for technically simple and easily implemented water-supply schemes, underground water resources are being developed. This involves constructing dug and drilled wells and equipping them with simple manually operated hand-pumps. In pursuance of this objective, the government has directly and indirectly, through encouragement to Non-Governmental Organisations (NGOs) and of late through traditional authorities (on pilot basis), improved access to water supply in rural communities. In fact within a span of ten years, (1974-1984), about 6000 hand-operated boreholes had been drilled in the Northern, Central and Southern parts of Ghana, with assistance of bilateral donors, such as Canadian International Development Agency (CIDA), Japanese International Development Agency (JICA), Danish International Development Agency (DANIDA), etc. (GWSC, 1987). Most of the programmes are funded with direct disbursement and contractor/consultant execution.

There are, however, many technical and financial problems in constructing and maintaining these boreholes. The assumption that little attention needs to be given to the siting, design and construction of boreholes, as the yield requirements are small, are countered by the argument that the neglect of hydrogeological principles and practices, can result in much higher cost and the whole programme of meeting the needs of deprived communities could be in jeopardy. A new thinking is required if the limited financial and trained-manpower resources are to be used effectively in providing reasonably low-cost but adequate and reliable groundwater supplies to the deprived communities. In this paper, the technical processes for groundwater development are discussed, illustrated by results and experiences from deprived communities in Ashanti Region underlain by rocks of the Birimian System and the Voltaiain Formations, from which abstraction of groundwater is complex and difficult due to the presence of crystalline and sedimentary rocks. The need for hydrogeological principles in the design and construction of wells is also highlighted.

1.1 Historical Background to Groundwater Development in Ghana: Over much of Ghana and Sub-Sahara Africa in general, the existence of readily accessible water has always been a very important criterion for settlement. The seasonality of rainfall, its effect on the presence of water and pasture, has resulted in fixed settlement occurring only close to perennial surface water or shallow groundwater. Across most of the rural communities in Ghana, groundwater use was until more recently, restricted to abstraction from shallow hand-dug wells and open holes on river banks or in dry river beds.

Formal development of groundwater resources for domestic supply was commenced by colonial governments in about 1900 generally, on a small scale with very limited budgets and was often carried out in a piecemeal fashion. Water-well drilling programmes was mainly the responsibility of the Geological Survey Department (Bates, 1962). The geological input to the provision of groundwater supplies was often restricted to routine well-siting, commonly carried out by field-survey geologists with little or no formal training in hydrogeology. One of the important outcomes of this was an interest

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Table - 1: Comparison of Drilling Methods and Equipment

Items	Hand operated rig	Cable tool rig	Small – air flush rotary rig	Large multi purpose rotary rig
Capital Cost	very low	low- medium	medium	very high
Running cost	very low	low	medium	very high
Training needs for operation	low	low- medium	medium	very high
Repair skills	very low	low- medium	medium	very high
Back up support	low	low- medium	medium	very high
200mm holes to 15m in unconsolidated formation	fast	fast	feasible but difficult	very fast*
200mm holes to 50m in unconsolidated formation	very slow and difficult	fairly fast	feasible but difficult	very fast*
200mm holes to 15/50mm semi – consolidated formation	impossible	fairly fast	feasible but difficult	very fast*
100mm holes to 15/50m in consolidated (hard) formation.	impossible	very slow	fast	very fast*

in, but often uncritical use of geophysical techniques, especially resistivity for routine well siting, irrespective of hydrogeological conditions or water requirement with the neglect of other aspects of the provision of supplies.

One of the outcomes of increased interest in water supply at the national political level, is the strengthening of Government organisations responsible for water development. The establishment of Community Water and Sanitation Agency (CWSA) with the responsibility of co-ordinating national rural water and sanitation programmes, have provided the institutional framework for closer coordination between the various sectors engaged in rural water resources development across the country. During the past few years, there have been concerted efforts in Ghana to identify water resources development options that are suitable to serve widespread rural population, since large scale surface water development is often constrained by the need for expensive reticulation and treatment, and may be further affected by markedly seasonal nature of many surface water resources. Current thinking is tending to favour boreholes, which provide a primary protected source where people can collect clean water. The hand-pump is replacing the bucket, and with improved design, local community maintenance of its mechanism should be feasible.

1.2 Feasibility Studies and Master Planning: Groundwater resources are generally more difficult to quantify than surface water, particularly when dealing with geologically complex aquifers, and when account must be taken of potential advantages of widespread

Table - 2: Summary of Drilling Results Weathered/Crystalline Basement Aquifer

Project Identification/Location	Number of Boreholes Drilled (Dec, 2004)			Borehole Records			
PPTAP/Ashanti Region	Total	Successful	Dry	Aver. Drill Depth (m)	Aver. Depth of aquifer (m)	Aver. SWL (m)	Aver. Yield (L/min)
	38	34	4*	65	45	14.6	35

* Dry wells drilled in the Voltaian sandstones and shale beds of the Sekyere East and West Districts of Ashanti Region

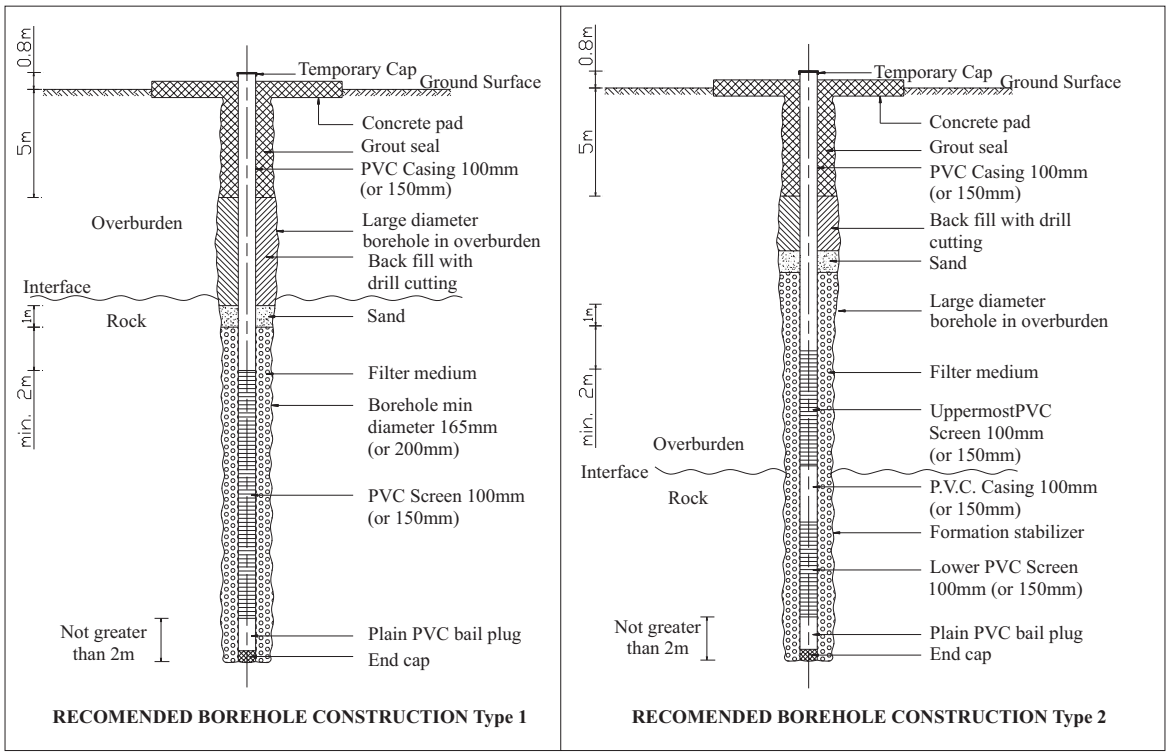

Figure - 1: Borehole design type "A" for sedimentary formation

Figure - 2: Borehole design type "B" for hard formation

occurrence, lower environment impact and cost effectiveness. An important component of a Master Plan, therefore, should be to identify the occurrence of available water sources, whether ground or surface water, and to provide cost-comparisons of development options. This could be carried out by a multi–disciplinary team, probably headed by a hydrogeologist or water engineer, who by nature of his training appreciates and comprehends the complexities of groundwater development. The teams' overall responsibility could be looking critically at accumulation of information, including well construction, water-quality and geophysical data. Additional information by investigative drilling, is necessary in an attempt to identify hydrogeological conditions on regional or national basis. Updating and modification of the Master plans, should frequently be carried out as the project implementation progresses, and should not be regarded as final statements. This is particularly true, where groundwater supply programmes elsewhere is increasing the available hydrogeological information.

Many factors must be balanced including water demand, the hydrogeological environment, water quality, optimum drilling and abstraction methods, the availability and suitability of local construction materials and the feasibility of community involvement.

In planning a project of groundwater abstraction with hand-pumps, decisions or information on the following design factors will be needed.

a. Per-capital water consumption and the maximum acceptable walking distance for collection
b. Total number of people to be served (by extrapolation to a planning horizon usually 5 – 10 years ahead) and their distribution, required numbers of water points can be calculated.
c. Types of water points, whether dug, or a drilled well in accordance with hydrogeological conditions.
d. Optimum pump-design for easy maintenance
e. Plan for maintenance, operational procedure and funding.
f. Recommended level of community involvement.

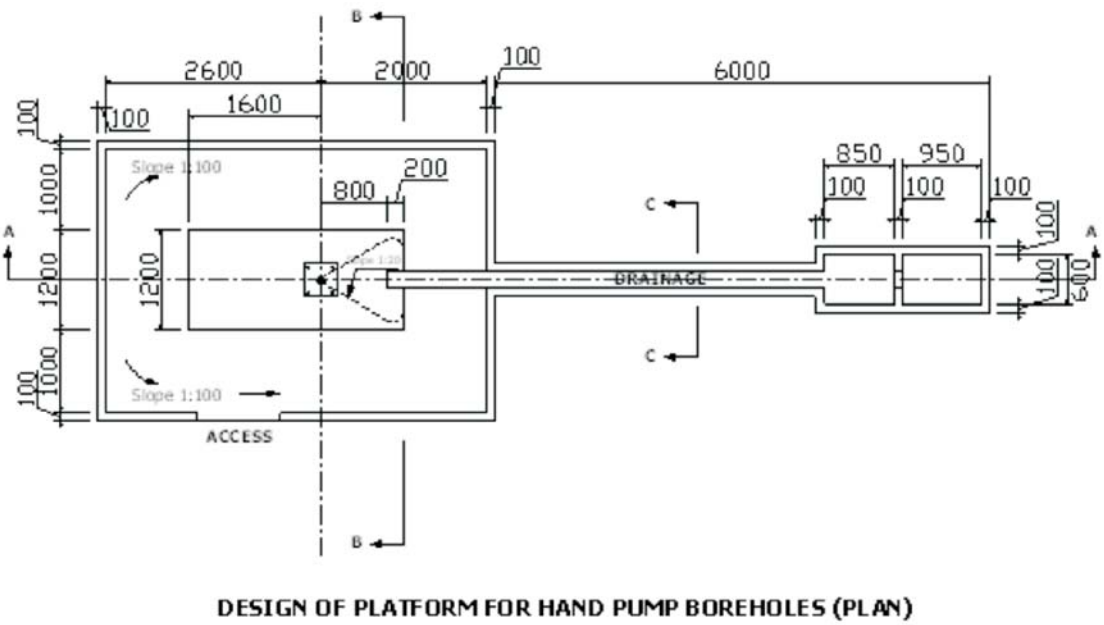

Figure - 3: Standard Design of Aprons and drain pit type A

Projects involve a wide range of activities from field survey to community organization, and in certain areas a small scale pilot project in advance of a major scheme may be merited.

1.3 Equipment: Drilling rigs currently used for groundwater exploration in Ghana range from small – air flush rigs, which can drill a few meters to large multi-purpose rotary rigs capable of drilling to more than 500m. Low-cost hand operated rigs and cable-tool rigs are less employed as drill-depth is to a few meters below ground surface, and are limited to servicing private homes. In Ghana deep groundwater generally available to boreholes occurs in three types of environments: (a) in zones of deep weathering in hard crystalline rocks; (b) in fractured and jointed fresh rocks of several kinds and (c) in porous stratified sedimentary rocks. Ideally a rig should, therefore, be fast and efficient, simple as possible and cheap to operate, robust and reliable, as well as easy to move and maintain. It should also be capable of drilling through any type of formation both unconsolidated and hard formations. Table-1 shows the relative merits of various types of drilling rigs.

Drilled-wells for hand-pump installation, require a minimum internal diameter of approximately 100mm to accommodate a hand pump cylinder. The wells will often not be less than 30m deep, but average around 60m deep and in some cases reach or exceed 80m (beyond which pumping by hand is not feasible). Borehole mechanization requires large diameter holes which could be 150m – 175mm. Rigs must be able to drill together both hard and soft rocks in the same hole. Direct circulation rotary rigs with mud facilities are commonly used in Ghana, but occasionally small rotary rigs without hammer facilities are employed for drilling unconsolidated formations in areas where accessibility for machinery is not possible.

Drilled formations will range from unconsolidated (and caving) sediments through semi-consolidated formations (such as weathered crystalline rocks) to hard consolidated rocks. If it is planned to screen unconsolidated to semi-consolidated formations, a 50 – 75mm thick gravel pack is desirable, requiring a hole diameter of 200 – 250mm. Open hole completion of 100mm diameter may be adequate in hard rocks.

Most suitable drilling methods will depend on local circumstances but as drilling technology improves, rigs could be produced which could

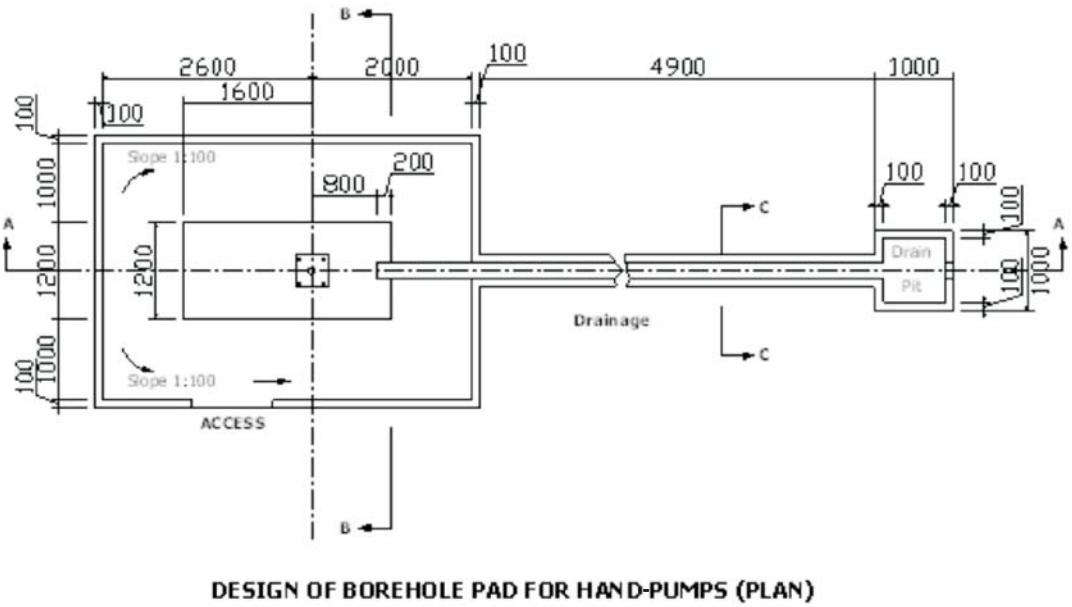

Figure - 4: Standard Design of Aprons and drain-pit type B

be suited for drilling wells in remote areas with semi skilled crews. Similar attention needs to be given to other items of rural water-supply hardware such as down the hole hammer bits, caisons, well screens (slotted and plain). Well-screen commonly in use in Ghana are the locally extruded and slotted PVC pipes. The advantages of using PVC pipes for well construction lie in the relatively low-cost, ease of installations and range of slot sizes, caisons for installation in unconsolidated upper formation to prevent cave in range from 200m – 250m. A maximum caison length of 40m is suitable for most drilling operations in Ashanti Region. The wide distribution of crystalline rocks in Ashanti Region also calls for the application of emerging technologies for obtaining maximum yields from low permeable rocks. Hydro fracturing has become an invaluable method in this regard, enabling marginal boreholes to be redeveloped to increase yield. This could be a back up support for drilling equipment mobilization on a project.

2. WELL-SITING

Hydrogeological conditions and user-convenience must both be considered in well-siting. A sense of community ownership is desirable and critical in the overall project success and may be achieved by allowing the community as much involvement as possible in the selection of the well-sites. The degree to which this is feasible will depend on the hydrogeological environment where the supply aquifer is within fractured bedrock, the need for detailed geophysical surveys will limit community site selection. Where aquifer occurs in extensive weathered formations at moderate depth the community's choice could be paramount, bearing in mind the need for protection from pollution and ensuring proper drainage at the well-site.

The well-site should be chosen so that an adequate and sustained yield of water of acceptable quality is to be anticipated. For a hand-pump, the minimum requirement as specified by CWSA should not be less than 13.5 l/min. The well should be situated so that it can serve a rural population of 500-1000 people within the design maximum walking distance, which is usually between 0.3 and 1.0 km. If the water level is shallow and the near surface formation is relatively soft, a dug well will probably be more economic, with deep water wells and hard formations, a drilled well is likely to be preferable.

The use of geophysical techniques, mainly the electrical resistivity method, is gaining acceptability as an invaluable tool for successful detection of potential aquifer zones, which would have been overlooked in groundwater exploration programme. Applications are more justified when determination of weathering thickness is a critical factor or in a

search for localized fracture zones in bedrock. Unsuccessful boreholes are expensive and the need to minimize the number is clear. The over 80% achievement of successful boreholes in Ashanti Region justifies its application in well-siting (Table 2). Improved correlation with hydrogeological conditions of lower-cost geophysical techniques such as electromagnetic and perhaps more effective use of satellite imagery in conjunction with air photographs would have obvious advantages in low–cost rural water supply programmes. A more extensive use of sophisticated geophysical techniques would in many cases be constrained by the general scarcity of equipment and trained geophysicists in the country.

3. WELL-DESIGN, CONSTRUCTION AND COMPLETION

A good well-design is fundamental to long-term project success, because of the greatly reduced need for hand-pump maintenance due to reduction in sand pumping. A series of standard designs shown in figures 1 and 2, may suffice but close supervision should ensure that the designs are correctly implemented. Close supervision of a drilling programme is likely to reduce costs. All too frequently, a well is drilled to 60m when an adequate yield would and lower draw down could be obtained from shallow well, screened in unconsolidated surface weathered layers than from a deeper hole in which it is cased out. A drilled well draws on storage in the aquifer, in order to ensure a reliable supply, the relationship between pumping regime, storage requirement and rate of inflow must be carefully understood so that a general design parameter of target depth of excavation below dry season static water-level can be established. Further the amplitude of seasonal and long-term water level fluctuations needs to be considered. Such neglect could put out of action several boreholes. An important requirement of well-construction is that it should ensure proper sanitary protection to reduce pollution risks. Current designs being implemented in most groundwater projects are given in figures. 3 and 4.

In practice any of the designs could be adopted to suit the topographic and terrain condition. Provision should be made by means of an apron and drain for removal of waste water from the wells' head. Recommended drains could, therefore, be modified to ensure that the well-site is clean. This is particularly important when the borehole is located close to residential areas with poor drainage facilities.

4. WATER-QUALITY

Boreholes drilled in Ghana are more often than not drilled to provide potable water for all-purpose use. It would be expected that the quality of water should meet WHO international standards. Chemical analyses are expected to provide results of iron, chloride, nitrate and other mineral logical contents of the water within acceptable limits. Bacteriological tests to determine the extent of contamination with pathogenic substances, are crucial to avoid users drilling contaminated water. The availability of chemicals on the market makes possible for the disinfection of contaminated boreholes to make usable without health hazards.

5. HAND-PUMPS

The critical issue in selecting a hand-pump, for installation at the community level, is its potential for sustainability. The hand-pump itself is still a weak link in development programmes, due to difficulties of maintenance. Village Level Operating Maintenance (VLOM) hand-pumps, are generally understood to possess attributes of robustness, high-discharge at relatively shallow depths, and ease of maintenance as well as cost-effectiveness.

Hand-pumps are designed to have most of the maintenance work to be done at the community level, and require few tools and interchangeable wearing parts. One of the major risks to the sustainability of hand-pumps is the availability of spare parts for the community to purchase locally. The chance of spare parts' availability is increased when there is standardization on a small number of hand-pumps throughout the community. This standardization makes it easier for the private sector, to procure hand-pumps and spare parts, as well as to set up retail networks. Hand-pumps' standardization also facilitates the training requirements for community-level caretakers and area mechanics.

Based on the national sector policies initiated in 1992, Ghana standardized on the use of the following VLOM hand-pumps at the national level:

- Afridev SKAT/HTN Specification Revision 3 –1998 (Suitable for 10 – 45m depths)
- Nira AF – 85 Direct – Action hand pump. (Suitable up to 15m depths)
- Vergnet HPV – 60 Vergnet pump (Suitable for 10 – 45 depths)
- IM2 Ghana modified India Mark II. (Suitable

above 10m depths)

Final selection of the pump may be modified after completion of the borehole, when the dynamic water-level is known. Experience in Ashanti Region indicated that hand-pump failure can most frequently be attributed to sand-pumping consequent upon poorly-designed gravel packs or incorrect well-screened slot size. Major savings are to be anticipated from improved borehole design in respect to this single issue.

6. COMMUNITY PARTICIPATION

The importance of community participation must be stressed. Projects which have not involved the local communities during the planning and implementation phase, often break down because of the lack of commitment by the villagers. Construction is only the beginning of the life of a water-supply point. Operations will hopefully continue for many years afterwards, but it is during construction that a sound basis of effective maintenance must be established. It is only in this way, that a sense of commitment and feeling of ownership by the community can be built up to allow a successful establishment of a maintenance system, in which the villagers themselves play a large part.

7. OPERATION AND MAINTENANCE

A major cause of failure of rural water-supply projects all over the world, is the inadequate attention to organisation and funding of maintenance. (Grey et.al. 1985). The experience of projects in Ghana, has shown that a centralized government maintenance organisation is rarely able to provide adequate service, because of high-costs of operation and bureaucracy. This can result in pumps being out of action for long periods of time. Villagers may become disillusioned with an improved, but unreliable supply and return to traditional, polluted sources. By their nature, rural water supplies are widely dispersed in remote areas and provide for poor in the community, in such circumstances, more effective maintenance may be possible in which responsibility is developed wholly or in part to the community using the well. If community responsibilities are to be extended to routine replacement of below-ground components these too must be simple and easily removed from the wells. Successive tiers of area mechanics and maintenance assistances leading up to district teams could provide the capability to carryout more difficult repairs, a supply of spare parts and supervise each tier below. Different solutions are possible. There is, therefore, the need for socio-cultural studies on an effective maintenance system which takes not only the technical factors into consideration but also the social and administrative structures, economic factors and the general degree of self reliance of the people in the deprived communities.

8. CONCLUSION AND RECOMMENDATIONS

Groundwater development can be difficult and costly without proper understanding of the hydrogeological principles and practice involved. The recent experience in Ashanti Region of Ghana, attests to the benefits that can follow from the appreciation of groundwater-abstraction from basement complex, in terms of the successful number of boreholes achieved and reduction in cost. It is clear that groundwater is likely to be the most preferred option of supplies to most deprived communities in Ghana for the future. Consequently there is need to occasionally review groundwater abstraction and exploitation techniques, in order to be better suited to the limited skills available and the large-scale of many programmes.

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A FRESH LOOK AT MUSLIM CONTRIBUTIONS TO S&T

*Sadrul Hassan Rizvi**

1. INTRODUCTION

The history of Muslim science - its epoch, stagnation, and decline - has been of much concern to the present-day Muslim Ummah. While it is of great concern to the Muslim Ummah, it has also been of considerable interest to the non-Muslim historians of science. However, this concern (or interest) has been rather a recent development. Toby E. Huff writes[1]: Until quite recently little attention had been given to the existence of Arabic Science and to the fact that it lies in a direct line leading to modern science'. The history of Muslim science cannot be studied in isolation; this is part of the history of mankind. One does witness a kind of continuity in human endeavours of all societies, the coming generation learning and borrowing from the earlier generations. Indeed, such borrowings have always been adapted to the philosophical and sociological value-system of the particular society.

While Europe was plunged into the Dark Ages, the Muslims took up the ancient European science – the Greek and the Hellenic heritage – in right earnest, without any inhibition of any kind. Before one talks about the ancient and prehistoric fund of knowledge which were acquired and then developed by the Muslims, one would like to discuss the philosophical and social structure of the Muslim society in the years of its political ascendancy. In particular, one would like to discuss them in the context of what have aroused the debate on issues such as :

i. Who were those people in the Muslim world who initiated this study?
ii. What was the urge behind these endeavours?
iii. How was this received in the society?
iv. What was the institutional framework in which such study gathered momentum for advancement?
v. How long was the Muslim preeminence in science and technology sustained?
vi. How, when, and why the Muslim epoch in science and technology started to retrograde and finally decline ? These and many other issues deserve the attention of modern scholarship in order to develop the future path-way to get it back on the rails again. In this respect, the human history is a great resource to learn from.

2. SOME NEW WAYS OF LOOKING AT HISTORY OF CIVILIZED MAN

The history of mankind has been written from two perspectives. Most histories are the accounts of the civilizations and cultures – their rise and fall. However, a recent work, Guns, Germs, and Steel by J. Diamond, traces the human history since 50,000 years back when, according to the author, the first leap forward took place in the evolution of mankind, but a suitable starting point from which to compare human historical developments on the different continents has been reckoned by him as 11,000 B.C. The theme is essentially an extension of the theory of evolution: if man came to being as a product of evolution from its animal ancestors, must not its history be also studied as the manifestation of the natural process of evolution that is largely determined by the natural environments – capricious as it has often been that forced the animal world to adapt itself in the changing environment it lived in. Diamond thus considers the human history as a science, much like other sciences and presents an agenda for future work to establish its status as a science: 'The challenge now is to develop human history as a science, on a par with acknowledged historical sciences such as astronomy, geology, and evolutionary biology'[2]. He is aware, however, of the difficulties in determining the parameters that delineate the trajectory of the human history. He has identified four major factors, but he invites further studies, for he states[3]:

"A historian who had lived at any time between 8500 B.C. and A.D. 1450, and who had tried then to predict future historical trajectories, would surely have labeled Europe eventual dominance as the least likely outcome, because Europe was the most backward of those three Old World regions for most of those 10,000 years. From 8,500 B.C. until the rise of Greece and then Italy after 500 B.C., almost all major innovations in western Eruasia – animal domestication, writing, metallurgy, wheels, and so on – arose in or near the Fertile Crescent."

Diamond's theme that the environmental factor, i.e. 'geographic determinism' , has had been the main player in determining the course of the history of mankind is a question mark even to Diamond himself, for he says[4]:

"But mention of these geographical differences

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invites among historians the label 'geographic determinism' which raises hackles. The label seems to have unpleasant connotations, such as that human creativity counts for nothing, or that we humans are passive robots helplessly programmed by climate, fauna, and flora. Of course these fears are misplaced. Without human inventiveness, all of us today would still be cutting our meat with stone tools and eating it raw, like our ancestors of a million years ago. All human societies contain inventive people. It's just that some environments provide more starting materials, and more favourable conditions for utilizing inventions, than do other environments."

Diamond's concluding words are, however, more relevant for the modern researchers who would still like to view the world history in the light of the endeavours of human societies to mould the course of history to their advantages, physical, moral, and spiritual. Thus, is not the human history different from the evolutionary history of the living beings prior to the coming of man! Diamond says[5] :

The histories of the Fertile crescent and China also hold a salutary lesson for the modern world: circumstances change, and past primacy is no guarantee of future primacy. One might even wonder whether the geographical reasoning employed throughout this book has at last become wholly irrelevant in the modern world, now that ideas diffuse every-where instantly on the Internet and cargo is routinely air freighted overnight between continents. It might seem that entirely new rules apply to competitions between the world's peoples, and that as a result new powers are emerging – such as Taiwan, Korea, Malaysia and especially Japan.

Based on his concept of 'geographical determinism', Diamond explains why the power (economic, political, and technological) shifted from its Fertile Crescent base to western Europe, the supremacy of which is predicted to be sustainable because of its climatic factors – plenty of rainfall sustaining agriculture and forest. Thus, while Diamond dismisses the racial or genetic factors as the plausible reason for supremacy, he nonetheless finds the geographical reasons for the West dominance. Quite a few modern writers assert that modern science has found its home in the Western because of its particular cultural ethos which promotes 'neutral spaces' for free-thinking, unfettered by any consideration of religious, social, and political prejudices, and they are of the opinion that the Muslims, Chinese, and Indian societies do not provide the 'neutral spaces' for free-thinking[6]. One would have thought that modern science should mean the current science of any particular time in any particular society. However, when these authors speak of modern science, they mean something else; they identify the distinguishing features of modern science as follows[7] :

The breakthrough that allowed freedom of scientific enquiry is undoubtedly one of the most powerful intellectual (and social) revolutions in the history of humankind. As the paradigmatic form of free enquiry, science has been given a roving commission to set all the domains of thought aright. Science is thus the natural enemy of all vested interests – social, political, and religious – including those of the scientific establishment itself. For the scientific mind refuses to let things stand as they are. The organized skepticism of the scientific ethos is ever present and always doubtful of the latest (and even the long-standing) intellectual consensus.

This concept of modern science vis-à-vis its supposedly incompatibility with the cultural ethos of the Muslim society deserves an in-depth study which would be attempted in the relevant chapters of this book. However, to turn to the main theme of this book, we would like to recount very broadly how the Muslims were drawn in to take up science seriously and how they fared since the beginning of the Muslims ascendancy to world power up to as late as the beginning of the scientific revolution of the West in the seventeenth century A.D., roughly a period of about a thousand years. To start with, it must be understood that the Muslim ascendancy to political domination was not for material gains as such. Some Western scholars of history try to regard this as a means to political dominance with the zest for riches and as a diversion to avoid internal conflict.

3. DISCUSSION OF TOYNBEE'S VIEWS

Toynbee says[8] :

"Even so, the combined power of Medina and Mecca might not have been strong enough to re-subdue the rest of Arabia if the dead Prophet's Khalifa (Caliph, successor), Abu Bakr , had not opened up for the insurgents an attractive alternative to rebellion."

Either on his own initiative or at the suggestion of the Islamic State's informal steering committee by which he had been elected, Abu Bakr invited the insurgents to turn their arms, under the Islamic state's leadership, against the two empires that adjoined Arabia on the north. Both empires had emerged exhausted from the deadly Romano – Persian war of 604-28; they would be an easy prey for an assault delivered by the united forces of the whole of Arabia; and, though both empires were now economically ruined in the eyes of their own subjects, they were still a rich prize in Arab eyes. Abu Bakr was here taking his cue from Muhammad himself. He was soliciting loyalty by rewarding it with opportunities for acquiring loot – for which the poverty-stricken Arabs had an insatiable appetite. This combination of allurement with coercion succeeded in deflecting the Arab insurgents from rebellion to foreign conquest.

All the same, Toynbee admits that 'the speed and range of the Islamic state's conquests are amazing'[9]. One would wonder if a community is not committed to loftier ideals, could it ever accomplish the feat which has been so amazing! Is there any earlier evidence of such feat in the history of the earlier Arabs? Could the poverty-stricken people with poor resources and organization, do what they accomplished?

Here one would like to very briefly recount the state of Arabian societies prior to Islam. The Arabs of the Arabian Peninsula were divided into two distinct regions, the south (Yemen) and the north (Hijaz and Najd). The south was well-developed and held a distinct political organization, culture, and language that for centuries helped it to dominate the region, while the north Arabia had mostly nomadic people, often getting subdued by the south Arabs, yet taking pride in their Arabic language. However, by 600 A.D. Yemen was fully taken over by Abysinian kings, thus leaving the Yemeni Arabs lost of all earlier prides. How demoralized the Arabs of the north were, can be gauged by the Abraha's invasion of Mecca in the same year (but prior to)the Prophet (SAW) was born: The Meccans offered no resistance to Abraha's army, and had it not been for the miraculous ruination of the elephant riding Abraha's army by the swarm of the tiny birds—Ababeel, the history of north Arabia would have been very different[10].

One would wonder whether Toynbee had not been aware of the Muslim rules of conduct in warfare – there is to be found no parallel of these rules in the history of mankind. One must not confuse the war booty of the Muslim conquests with the loot and plunder that has had been the order of the day of other peoples and communities, except of course the faithful followers of earlier prophets. Toynbee further on says that the 'Muslim Arab garrisons in the subject territories were not missionary minded': he says[11]:

"For the Islamic Empire's subjects, conversion to Islam was attractive financially as a possible means of acquiring the Muslim establishment's relatively favourable fiscal status: but, just because this status was less onerous, the Islamic Treasury opposed conversions and sought when conversion occurred to nullify their fiscal effect".

This perspective is just not tenable. Islamic conquests have been given the Islamic law's sanction only to carry the message of Islam : indeed, forcible conversion is forbidden in Islam. It must be understood that the Holy Quran and the Prophet's (SAW) traditions made it obligatory for every Muslim to carry the message of Islam. The people of the Books should not find it difficult to appreciate it in the light of the life and teachings of the prophets given in their own holy scriptures. Toynbee obliquely admits that the Arab conquests were motivated by the Prophet's guiding words in their conquest and management of the conquered lands: he writes: 'The Arab conquests were also facilitated by the directive, in the Quran, that people of the Books were to be tolerated and protected if they submitted to the Islamic government and agreed to pay surtax'[12] : he further writes, 'The Arabs left the collection of the taxes payable by their non-Muslim subjects in the hands of the existing native fiscal officers[13] ; '…but the native fiscal authorities, though now compelled to do their work in Arabic, were allowed to remain in office; they were not replaced by Arab's[14].

The strict discipline of the Arab soldiery, their proper management and control from the central command, their confinement to cantonments assuring minimal contact with the conquered people, their impeccable lifestyle attracting the non-Arab settlers show how cautious they were in carrying the message of Islam – coercion for conversion was strictly forbidden.

4. THE ADMINISTRATIVE AND TECHNOLOGICAL SYSTEM OF THE 2ND CALIPH, UMAR IBN AL KHATTAB

The above brief account of the Muslim conquests indicates the open-mindedness of the Muslims to face new challenges with vision and that they were receptive to new knowledge. Obviously they had no earlier experience of large-scale warfare and the management of conquered lands. Admittedly they developed competitive war machinery, their management and control, management of communication, use of geographical information, the logistics of the supply of food, establishment of civil administration and so forth. They may have learnt some of the skills from others, but their indigenous inputs in these arts and technologies were mostly original – Caliph Umar (RA) is reported to have been the pioneer in some three dozen areas of civil management, international relations, and pertinent technologies for the benefit of the then society and state. Here under are given some of these:

Administration:

i. Judiciary;
ii. Finance;
iii. Standing army and Defense;
iv. Population census;
V. Jail Administration;
vi. Police and intelligence department;
vii. Establishment of cantonments;
viii. Financial support to poor non-Muslims;
ix. Waqf institution;
x. Management of mosque.

Technologies:

i. Calendar;
ii. Survey of land;
iii. Irrigation
iv. Architecture and civil engineering;
v. Assessment of river resources;
vi. Breeding of quality horses;
vii. Teaching institution

It is surprising, nevertheless, to find some authors alleging the Muslims – at least the earliest Muslims – to be against scholarship and learning. Mehdi Nakosteen writes in his book 'History of Islamic Origins of Western Education'[15] :

The phrase, Muslim scholarship and learning, is misleading if it implies that the faith created the scholar and determined the depth or scope of his scholarship. Nor can we refer to the scholarship under Islam as Arabian unless we imply only that it used Arabic as its medium of expression, a medium which by the end of the eleventh century was effectively challenged by the new Persian language after its revival by Firdowsi. Actually, the first Muslim conquerors were in no way patrons of learning.

The Umayyads, the first Muslim dynasty, ruling during the first century of expansion were too preoccupied with the conquest, consolidation, and administration of a vast multi-national and multi-cultural empire to be concerned with the needs of the mind'.

Furtheron he says that:[16] 'they either burned or drowned many of the Hellenistic works in Alexandria and the Pahalvi works in Zoroastrian Persia': When Amr ibn al-Ass, after conquering Egypt, saw the voluminous library in Alexandria, he sought the advice of the Caliph Umar (RA) as to what he should do with it, to which the caliph replied:

"As to the books about which you are inquiring, if there is to be found in them information which is in agreement with the Book of God (the Quran), such information is already available to us, and if there is in them materials that are contrary to the Book of God, there would be no need for them. In any event, proceed with their destruction."

Based on Qifti's account, Nakosteen writes that 'the books were distributed to the bath houses of Alexandria which kept them heated for six months'. A similar account is given by him about the libraries in Persia – these books were drowned in water under the intructions of Caliph Umar (RA)[17].

Now returning to Nakosteen's statement, one would say that, in reporting such accounts, scholarship demands caution W. Dampier has to say the following in this context[18]:

"About the middle of the third century, the famous Museum, or the place dedicated to Muses, was founded in Alexandria. The four departments of literature, mathematics, Astronomy and medicine were in the nature of research institutes, as well as schools, and the needs of them all were served by the largest library of the world, containing some 400, 000 volumes or rolls. One section of the library was destroyed by the Christian Bishop Theophitus about

A.D.390, and, after the Muslim conquest in the year 640, the Mohammedans, whether accidentally or deliberately is uncertain, destroyed what the Christians left. History is replete with such sweeping statements such as Nakosteen's. Who would believe that the people who conquered the vast empires of the time and provided in the conquered lands the egalitarian system of governance – unknown in that time -- could not be 'concerned with the needs of mind'. The pioneering innovations of Caliph Umar (RA) speak volumes for his great vision. And how could he (the caliph) advise against the Prophet's teaching whose tradition say that 'it is obligatory for Muslims, men and women, to acquire knowledge', and furthermore another tradition says that 'what-ever new knowledge a Muslim comes across, he should take it as his lost heritage'. Notwithstanding these glorious instructions to Muslims, what do historical records say? Mehdi Nakosteen himself mention, on the authority of Nadeem's Al-Fihrist, that the Ummayyad rulers did have an interest in medical and alchemical works[19].

5. MUSLIM INTEREST AND COLLABORATIVE ATTITUDE IN THE DEVELOPMENT OF SCIENCE

Even earlier to this, there are evidences of Muslims' interest in promoting learning and technologies. Muawiyah (RA), the Governor of Syria during the days of Caliph Umar (RA), is reported 'to relax in book after his business of the day'. Nicholson says[20]: "He consecrated a third part of every night to the history of Arabs and their famous battles; the history of foreign peoples, their kings, and their government; the biography of monarchs, including their wars and strategies, and method of rule; and other matters connected with Ancient History". He also called Abid b.Sharya in his court and asked him to write the history of Arabs. This book was written up and entitled 'The Book of the Kings and the History of the Ancients'[21]. (It is said that the writer mixed fiction with facts, but this is besides the point). Muawiyah (RA) was also the first to organize Muslim Navy for warfare: In 669 Muawiyah (RA) built a fleet, and in 674 -8 he besieged Constant inople by both sea and land; but this seize turned into a disaster for the Arabs[22].

In another place Nakosteen himself says[23]: 'The old theory that the early Muslims were enemies of learning and science and that except in their own Quran and tradition they showed no toleration of the beliefs and intellectual treasures of other nations is without historical basis".

The point now is who these early Muslims were, and to differentiate between the Muslims of different geographical origins. Naive though this question may appear, many historians of science have tried to differentiate the Arab Muslim's science from the non-Arab Muslim's science, emphasizing that the great name in the Muslim science were non-Arabs, such as Avicenna, Al Haytham , Al Biruni and so on. While many authors speak of Arabic Islamic science (Nakosteen even speaks of politico-religious nationalistic identifications, such as Persian Islam, Hispania Islam, Egyptian Islam), it must be appreciated that Islam was a culture which integrated all people from different nationalities to form one nation – the Muslim nation. Brian Stock says[24]:

"Nor is it true, as some claim that the most distinctive contributions to science were made by outsiders. Of course, many of the leading scientists were not Arabs. Al-Biruni and Omar Khayyam were Persian, Al-Farabi a Turk, Avicenna from Bukhara, Jabir ibn Hayyam a Sabean, Masha'allah a Jew, and the Bakhtyisha family Nestorian Christian. Yet modern notion of nationality must not be misplaced. Islam extended into a new environment and a wider geographical framework, a principle well-known in the Roman Empire, namely, the conferring of citizenship upon men from different background who shared a common single cultural and political allegiance. What they added was religious unity. In patronizing science, Baghdad, Cairo, Cordova did nothing that Rome's Alexandria, and Perganum had not done. They just did it under a new banners and on a bigger scale."

Indeed, the first converts to Islam were Arabs, but even this earliest community of Muslims – the companions of the Prophet (SAW) – comprised people from Abyssinia (Bilal Habashi (RA), Emperor Najashi), Persia (Salman Farsi), Rome (Suhaib Roomi), and people converted from Judaism and Christianity. After embracing Islam, they had only one identification – Muslims. This fraternity was so all-embracing that, centuries after, the students from Spain would come to Baghdad for studies, and the scientists from Spain collaborated with the scientists of the eastern zone (Baghdad) in scientific projects – an outstanding example is in Astronomy. Ibn al-Haytham's rejection of Ptolemy's theory-- in the words of Ibn al-Haytham[25], 'the arrangements proposed for planetary motions in the Almagest

(are) 'false' (his own words) and that the true arrangements were yet to be discovered'-- led to what was the formulation of a proper 'scientific project' that was carried out by the great minds of Muslim astronomers both in the western (Spain) and eastern (Baghdad) centres of Islam. In Andalusia (Spain), a century after Ibn-al-Haytham, Arab thinkers independently led what has been called a revolt against Ptolemaic astronomy[26]. The Tusi couple was a great achievement, which 150 years later, reappeared in the works of Copernicus – the similarity between the two is amazing, to say the least.

How long did the preeminence of the Muslim Science continue? The earlier perception that it definitely declined after the eleventh century is no longer sustainable. There is ample evidence that it continued upto the seventeenth century. Huff says[27]: "considered altogether, in mathematics, astronomy, optics, physics, and medicine, Arabian science was the most advanced in the world. In different fields it lost the lead at different points in time. But it can be said that until the Copernican revolution of the sixteenth century, its astronomical models were the most advanced in the world". In the field of medicine, the works of Rhazis and Avicenna were still in use in the medical curriculum of Europe : 'They were still insisting upon and getting new translation of Muslim medical works … and Muslim pharmacology was respected in Europe until the nineteenth century[28]. Al-Batani's work on veterinary Sciences, and Ibn Khuldun's al Muqaddimah – a great work on sociology – also speak of the preeminence of Muslim scholarship up to as late as the 14th century. About Ibn Khuldun's Muqqaddimah, it will be pertinent to quote from Encyclopedia Britanica[29].

"But the greatest Arab historian and one of the most penetrating thinkers about histriology in any time or place was undoubtedly Ibn Khuldun."

The Introduction (al-Muqqaddimah) to his Kitab al-ibar, a universal history (began in 1375) is, in A.J. Toynbee judgement (1934), "the greatest work of its kind that has ever yet been created by any mind".

6. THE PERIOD OF DECLINE

Viewed against the above observations about the primacy of Muslim science and scholarship that continued much beyond the eleventh century, one finds a very strange observation about the possible reason for the retrogradation of Muslim science after the eleventh century. In a footnote, Huff makes the following observation[30].

"A likely explanation of it, however, is to be found in the pattern of conversion to Islam over the centuries. For the first several centuries of the Islamic empire, the percentage of subjects who were Muslims in many areas of the empire remained less than a majority. It was not until about the tenth century that the pre-existing communal structures of the non-Islamic peoples were weathered so that widespread conversion to Islam took place. Accordingly, the tenth century marks a turning point when rates of conversion soared, and with this new wave of conversion to Islam, the percentage of freethinkers who were not fearful of the corroding effects of the foreign sciences also dramatically declined, and this dynamic probably had negative consequences for the pursuit of the natural sciences and intellectual life in general. Although there will be those who will challenge this hypothesis, it has, I believe, the virtue of being consistent, not only with the fact just noted but also with the additional fact that even today there is no Islamic equivalent to a Hong Kong, a Singapore, a Taiwan, or, much less, a Japan among the Islamic countries of the world, despite the fact that at least six of them have enormous oil wealth, including the per capita richest, Brunei, which could be directed toward this goal were it considered desirable."

There are two aspects of these observations, first that the Muslim civilizational glory faded out just after the tenth century, and secondly that the Muslim society was intolerant to free-thinking and intellectual enterprise. Both these view points are contrary to facts. The political primacy of Muslims continued as far as the early twentieth century – the Ottoman Empire came to an end after the First World War. Toynbee writes:

"For a century and a half, 1555-1707, three great Islamic empires – the Ottoman, Safavi, and the Timurid Mughal – co-existed with each other and embraced, between them, the greater part of the Islamic world."

The Ottoman empire was the oldest of the three empires; it had suffered the onslaught of the Mangols, but then eventually recovered its place under Murad IV(623-40) by recapturing Baghdad from the Safavis in 1638, and 'in 1768 Ottoman Empire still held Bosnia and Belgrade and

exercised an effective suzerainty over the two Romanian principalities to the north of the lower course of the Danube. In fact, the Ottoman Empire emulated its predecessor, the East Roman Empire, in its ability to recuperate from disasters that had looked as if they were irretrievable' [31].

Even Andalusia survived until the late 15th century when it was finally run over by the Christian united Kingdom of Castile and Aragon. Cordova, Baghdad, Cairo, Damascus, Granada, Delhi, Agra, Basra and many other cities were known for centuries to be at the zenith of cultural and commercial glory. Hong Kong, Singapore, etc., emerged very late. It is too early to say how the presently rich Muslim states will fare in future – it is hardly 50 years since they became rich. Admittedly the Muslim political ascendancy started moving downhill since the seventeenth century – some six hundred years after the tenth century. And can it be that political ascendancy was achieved without any support of intellectual enterprises! This aspect, indeed, still needs to be investigated. The financial/monetary crises in the Ottoman empire, as against Europe's adventures on the seas discovering the new world – thus bringing riches – is a cogent factor for the decline of the Muslim political power. Obviously financial bankruptcy could not sustain intellectual activities, more on this we would talk in later chapters.

The other aspect of Huff's observation is more important for in- depth study. This, in fact, is related to the Muslim Scholasticism. One must, at the very outset, understand that Muslim scholasticism has been completely different from Christian Scholasticism. First, Jesus (AS) did not found the Christian state. The handful of the first followers of Christ had hard time in preserving their identity and the book containing the divine message given by Jesus (AS). The early Christian faith – the Judo-Christianity – was on the verge of extinction when 'Saint Paul saved Christianity from setting down as a Jewish Sect doomed to early extinction, and preached it as a world religion. When it grew and spread, it came in touch with Greek Philosophy, 'and the chief work of the early fathers of the church lay in combining that philosophy with Christian doctrines[32]. First, Origin (C. AD 185-C-254) tried to establish conformity of ancient science with the Christian faith. Origen's most fundamental tenet was the unchangeableness of God which involved the eternity both of the Logos and of the world: however, in his days the doctrine was fluid. The Council of Church condemned Origen's theology in 553. The history of the synthesis of knowledge, the Greek philosophy and Christian faith, is a long one. To quote Dampier,[33] 'Catholic doctrine was formulated by dispute and "showed why" our creeds are not only statement of belief, but peaens of triumph over defeated heretics and heathen'. The development of Canon law to regulate the killings under the cover of Inquisition was based on Roman Law. Surprisingly, many of the ideas of Greek philosophy – even those which had no empirical basis, and were simply hypothetical – were adopted as a matter of faith in Christianity, such as, the geocentric theory of the cosmos, or the concept that things cannot be created out of nothing. It is a long history of why and how many scientists were condemned and executed as heretics.

The Western civilization lauds about its world-view of modern science, which is, to quote Huff[34]: 'in addition to subscribing to the notion of laws of nature, modern science is a metaphysical system which asserts that man, unaided by spiritual agencies or divine guidance, is single-handedly capable of understanding and grasping the laws that govern man and the universe'. This is an expression of the audacities of man : ' whether or not is it true that God made man in his own image, it is certain that man makes gods in his'[35].

7. THE INTERACTION BETWEEN SCIENCE AND ISLAMIC THOUGHT

Let us now return to the Islamic Laws. The Prophet (SAW) himself founded the Islamic state; his companions numbered about a hundred twenty-five thousand; the Islamic state expanded at an unprecedented rate, and the Muslim ascendancy to political and intellectual power continued for more than a thousand years. As early as the first century Hijri, one finds a surge of academic activities to elaborate, compile and codify the Islamic laws to provide guidance for the benefit of individuals and the state. These laws were based on Quran and the Prophet's (SAW) traditions. The principles of (i) tafseer, making commentaries on Quran, (ii) hadith, compilation and interpretation of the Prophet's tradition and (iii) fiqh, enacting laws (jurisprudence) were developed. These activities were also supported by the state. There is a mistaken view that Ilm-e-Kalam was developed after the Muslim came across the Greek philosophy, in order to synthesize the Islamic laws with Greek knowledge and philosophy. In fact, Kalam began when

disputation arose in interpreting the 'mutashabihat' verses of the Quran. Ilm-e-Kalam provided the rational basis for their correct interpretation. Indeed, when the Muslims came across the Greek and Hellenic knowledge and philosophy as a result of the great translation work carried out in the time of Abbasi Caliphate, some Muslim minds were influenced by the Greek philosophy, particularly on metaphysical issues. The Greek philosophers had been trying to get to the 'Truth' through philosophical discourses. As far as the Muslims were concerned, the Truth was Allah, the Creator, and the belief in Him was part of faith. So this part of the Greek philosophy was of no relevance to Islam. Ilm-e-Kalam, however, was further developed to counteract philosophy, developing its own system of logic, and thus effectively contending what was diabolical from Islamic point of view. To quote Huff[36] : 'By the fourteenth century, however, the Islamic religious philosophers (mutakallimun) appear to have risen sufficiently to have fully defeated philosophy, thereby putting Kalam in the ascendancy in Sunni lands'. This is where Ashairi's work and later Ghazali's work are important*. The Mutakalamin (so-called Islamic philosophers in the sense of Western perception of philosophy) never tried to reconcile the Muslim faith with Greek philosophy. In fact, the metaphysical part of Greek Philosophy had no place in Islamic belief. Albeit, some Muslim natural philosophers, among them Avicenna was a scientist, Avervoes an astronomer –cum-Jurist), while maintaining that the knowledge and injunctions given in the Holy Quran need not be proved or disproved by dialectical methods (they are words of Allah), they did falter in some of their writings, for example, Averroes considers the world as eternal – 'ambiguitic and inconsistencies are not absent in Averroes statements'[37]. If Allah is the Creator – which of course He is – and has made human beings accountable for their deeds (the concept of reward and punishment is associated with this accountability), then indeed it is but logical that He should say what finds His approval or disapproval, and because He is All – Knowing we cannot say that His words in the Scriptures lost currency with the passage of time. This is what Islamic laws tell us and this has been the essence of all divine scriptures—fortunately (indeed by divine will) only the Holy Quran has survived the heavy hand of corruptibility at the hands of misguided humans. Never was any foreign precept, conjecture or belief adopted as a matter of faith in Islam. It is a fact that the kind of killings done in the Christian world are not known in the Muslim world. Generally the Muslim society was quite tolerant – for example, the doctrine of Motallazites that said that 'Quran was not the words of Creator, it rather was His creation', though professed by the Caliph, Mamun, and his court Ulama, was not implemented as a creed of the Muslim populace, and when a countryman appeared out of the blue to contend this doctrine (in the face of the State's law which made such a contender liable to death punishment, should he lose the debate with the court Ulama), he won the debate, and not only that his life was spared but the State's law in this respect was also abrogated.

Was there any urge in the Muslim society to take up philosophy and science ? Yes, indeed: one finds in the Holy Quran a number of verses inviting humans to look around and study the working of the nature, for indeed therein there are signs for those who believe. In surah Al-Jathiyah, for example, it says:

"Lo! in the heavens and the earth are portents for believers, and in your creation, and all the beasts that He scattereth in the earth, are portents for a folk whose faith is sure. And the difference of night and day and the provisions that Allah sendeth down from the sky and thereby quickeneth the earth after her death, and the ordering of the winds, are portents for a people who have sense".
(45:verses 3-5).

The first purpose for 'observing and pondering on the working of the nature' is that it strengthens one's belief in the Creator, i.e. Allah. The second reason is that all these have not been created 'in vain,' nor would one find 'disorder' in their working: the stars move on the set path; the day and night alternate; the life follows a pattern of birth and death; the nature provides all that is required for the sustenance of life, and so on. This aspect of the Quranic injunction has two dimensions, one that it reaffirms the belief in the Creator, and secondly that it invites men to find the order in the working of the nature so that one may harness them for use – another aspect to which many other Quranic verses also draw attention, namely that all the physical world, the heaven and the earth, have been made subservient to humankind. In Surah Al-Jathiyah it says:

* For a short History of Ilm-e-Kalam, See chapter VI—under 'Ilm-e-Kalam' and tasawwuf (spiritualism)' of Ibn-e-Khulduns (urdu translation by Mumtaz Raghib Rehman) Muqaddimah .

"Allah it is who hath made the sea of service unto you that the ships may run thereon by His command, and that you may seek of His bounty, and that haply ye be thankful; And hath made of service unto you whatsoever is in the heavens and whatsoever is in the earth; it is all from Him. Lo! Herein verily are portents for people who reflect" (45:verses 12-1). Thus a Muslim need not delve in finding the ultimate Truth, i.e. Allah – this is part of the belief of a Muslim. Indeed, a Muslim should look into the mystery of creation in order to strengthen one's faith and harness it for the benefit of the society (This is physical science). This would explain why the Muslim scholars advised against philosophy – in fact, the metaphysical part of philosophy is what has been discouraged in Islam. This does not mean that the study of philosophy, as such, has been discouraged; it is the stated purpose of it that 'it will lead to the Truth,' which is just a waste of time for the Muslims. Indeed, there have been quite a few notable philosophers amongst the Muslim community who are regarded as great minds of scholarship. In short, Muslims have an urge to study physical sciences and technology as a consequence of their belief. If this was not so, how could the Muslim society produce such great minds in science and make such great contributions in science and technology; a brief survey of this will be given in later chapter of this book. And now the question is how the Muslim society at large reacted to this widespread Muslim interest in science and technology? To quote Brian stock[38]. If one looks over the field of Muslim science as a whole, the most remarkable feature is not the frequently emphasized appearance of a handful of universal minds – Al-Kindi, Al-Khwarizmi, Al-Razi, Al-Farabi, Al-Biruni, Avicenna, Alhazen, and Avrroes – but, rather that science in one or another form was the part- time or full-time occupation of so large a number of intellectuals.

Thus, one can see that the Muslim community at large was quite receptive to, in fact enthusiastic about, science and technology. The institutions of learning that the Muslims established – the madrasahs, Bait-ul-Hikmat, Libraries, etc. – would be discussed later. Then the debate is whether the Muslim intellectuals had any preference for either science, or technology, or arts and crafts. The interest in arts and crafts has been present in all societies in all ages. We see people of the same profession forming guilds. We would not like to delve here in the debate on what some regard as the culture of secrecy in professional knowledge prevalent in the intellectual activities of the Muslims in the Middle Ages.

The debate whether science and technology went together, as Needham seems to suggest, particularly with reference to Chinese technology which, in his opinion, was the most developed upto the 15th century in comparison with the West, needs to be studied in the context of Muslim science and technology. Needtham holds the view[39] that 'no meaningful distinction can or should be made between science and technology in history'. Science as is known today is 'systematic and theoretical knowledge about how the world is and how it work's[40]. From this point of view, science and technology in the West became intimately connected towards the end of the nineteenth century. However, we do find science-based technologies developed by the Muslims in the Middle Ages. For example, great advances were made in metrology: accurate balance for specific gravity measurements and for making time-measuring devices; survey instruments for geodesic measurements; jet propulsion for making torpedoes; new versions of sails for ships; navigational instruments; fractionation of petroleum products, and so on. Indeed, the most outstanding works were in the fields of pure science, such as mechanics (laws of motion), mathematics, astronomy, optics; and most importantly in introducing the inductive method of scientific reasoning (observation, generalization, hypothesizing, enacting laws); Leonard de Vinci and Bacon came centuries later than Ibn Haytham who was the one who systemized inductive logic in Muslim science. To conclude, let us turn to the most important question: what prospects Muslims have for once again being in the frontline of science and technology. We purposely avoid calling it 'modern science and technology', because of our reservations about its precepts as advanced by its modern thinkers. The Western Science today is neither international nor intercivilizational in character, for its access to less-developed countries is being aggressively denied by the Western nations, and its secrecy is covetedly guarded – even the patent literatures are purposely made ambiguous in disclosing technical details. Thus the present Western science is neither international nor inter-civilizational.

8. SOME THOUGHTS ON THE FUTURE

Will the Muslims have to forgo their cultural

(religious) ethos to attain primacy in modern science? This issue will come up while discussing the factors of the decline of Muslim science. The first response to this question would, however, be that Muslims cannot afford to disown their cultural base. The God-consciousness of the Muslim society will never think this way. The seventeenth-century scientific revolution of the West had the stated purpose that any philosophical/scientific investigation need not be carried out under the larger domain of philosophy – a limited study of the part of the domain of knowledge was also important[41]. Thus natural philosophy dissociated itself from philosophy, and made great strides – the end-result is that physical science is now delving in philosophy, and in the words of Dampire, 'But, now or later, intelligible mechanism will fail, and we shall be left face to face with the awful mystery which is reality[42]."

How would a modern rationalist – frankly, an atheist – respond to Dampier? Professor Dawkins is a great exponent of atheism: in one of his lectures, delivered at an American university, he responded, with the impunity of an obsessed mind, to a questioner who was hurt by his curt reply to his questions and had complained that he (the speaker) was insulting him; to this he responded that he was not insulting him, he was insulting God. In a debate organized by the 'Time' magazine (Nov.5,2006 issue) between him and Professor Francis Collins, he wound up the debate as follows:

"My mind is not closed, as you have occasionally suggested Francis. My mind is open to the most wonderful range of future possibilities, which I cannot even dream about, nor can you, nor can anybody else. What I am skeptical about is the idea that whatever wonderful revelation does come in the science of the future, it will turn out to be one of the historical religion that people happen to have dreamed up. When we started out and we were talking about the origins of the universe and the physical constants, I provided what I thought were cogent arguments against a supernatural intelligent designer. But it does seem to me to be a worthy idea. Refutable – but nevertheless grand and big enough to be worthy of respect. I do not see the Olympian gods or Jesus coming down and dying on Cross as worthy of that grandeur. They strike me as parochial. If there is a God, its going to be a whole lot bigger and a whole lot more incomprehensible than anything that any theologian of any religion has ever proposed."

The response from Prof. Dawkins does say one thing for sure: even after some 2500 years of philosophical scholarship the 'Truth' has yet not been discovered, and that there may be a possibility of science revealing God, much more grand and bigger than any theologian of a religion has proposed so far. His scepticism is understandable, but his assertion that God revealed by future science would not be the One believed by any known religion of today is also a dogmatic thinking. The grandeur that beats all imagination can be found in the concept of Allah that the Muslims have – incomprehensible (a mystery but a reality), yet resplendent in the awe-inspiring but immensely enthralling vistas that unfold themselves, with increasingly greater grandeur, at every step taken by the penetrating minds engrossed in science and technology. He certainly is not in the image of man: this is the distinguishing feature of the Muslim faith. There is every hope, therefore, that the Muslims would rise again and attain primacy in science which hopefully would be truly international and responsive to the needs and aspirations of the humanity at large. Unfortunately, the present-day Modern Science is neither international nor inter-civilisational.

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DESIGNING OUT A MALIGNANT SUPPLY-CHAIN

*Ahmed F. Siddiqi**

ABSTRACT

Management of supply-chains is a pivotal success-factor for any organization in a knowledge-based economy. Efficiency of a typical supply-chain depends on an identically optimal performance of its each and every component, while any comparatively weak component may desolate the whole performance. One way out is intelligent application of already proved-efficient statistical experimental designs.

The present article is attempting to treat supply-chain management as a system of quantifiable components and then use designed experiments, not only to improve its performance but to guard against the malignant effects of any miscreant component. The article attempts to explain guiding principles involved in planning, executing, and analyzing designed experimentation in the domain of supply-chain management. Some specific statistical plans are also discussed for their comparative merits and demerits in the field of supply-chain management.

Keywords: Designed Experiments, Robust Designs; Supply-chian management.

1. INTRODUCTION

One of the most distinguishing characteristics of a knowledge-based economy is its efficient and exploratory use of existing resources. Some of the most spectacular business-success over the past two decades have come from exploring more effective ways to deliver products to consumers (Blackwell & Blackwell [1999]), but there too have been some major wrecks along the same road. It's a high-take game, and one does not have a lot of choices about playing, if your organization touches a physical product, it's part of a supply-chain (Thomas [1999]) and your success hangs, unfortunately, on the weakest link of that chain. In a knowledge-based economy, the nature of competition is shifting away from the classic struggle between the organizations. The new competition, as Cohen et. al [2000] puts it, is supply-chain vs. supply-chain.

Supply-chain management is the integration of resources, information, and financial flows in a network of companies, or organizations, that make a delivery of products & services from the source to the consumer. In little broader terms, as Marien [1998] puts it, "supply-chain management is providing earth-to-earth movement of products to ultimate consumers/users, including the sustainability of the environment." From this perspective, supply-chain management is all the activities that start with the exploration for and extraction of raw materials from the earth, through what happens to them in the environment when they are no longer of use.

Supply-chain management is a very important activity. Dealing wit the planning, and sourcing for the resources, your organizational needs, and the making & delivering of your products and services takes up the effects of well over half the people in any organization. Its goals are multi-dimensional and include cost-minimization, increased level of service, improved communication among supply-chain companies and increased flexibility in terms of delivery and response-time (see Lancioni et. al. [2000] for details). It is complicated and, yet, effectively managing your supply-chain offers great opportunities for lowering costs and enhancing customer-satisfaction and thus customer- retention.

Literature on supply-chain management is replete with numerous managerial techniques, personal experiences and theoretical gimmickries, in different domains of business-life, to manage a supply-chain in a prudent, comprehensive and efficient manner. The main point is not to spare the supply-chain management at the mercy of a few components that, if they go weak, can destroy the whole supply-chain management. Unfortunately, only a few serious attempts have been made so far to treat supply-chain management as a system of quantifiable components that can be statistically or atleast mathematically, analyzed. Statistical techniques have proved applicabilities in the domain of management (see for instance Witten[1994], Anderson et.al[1994], Schwartz Schwartz04b, among others). But its efficacy seems merely textbookish (Schwartz[2004]. A Proquest, Jstor (A paid research journals' archive at http://www.jstor.org), or Ebscohost (A paid research journals' archive at http:/www.ebschost.com) search for statistical applications in the field of management yields only a few references. In fields like supply-chain management, such literature is simply non-existent. Some sample surveys,

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however, have been conducted to objectively quantify collective experiences in the field. Cachon & Fisher [2000] numerically establishes the positive role of information-technology in this field. Carman & Conard [2000] discussed the measurement challenges in supply-chain management. Morell[1997] attempts to numerically appraise how well a supply-chain management is integrated toward optimal performance. Only recently, there are a few works appearing in literature to give quantitative techniques in this field. Malnyk et.al [2004] is a very recent example of measuring the performance in operation management. Schwartz[20] informs of some application of stochastic optimization to actually automate the decision-making process in supply-chain management. Grove [2004] discusses how to optimize a hospital supply-chain. Marketing, one facet of the supply-chain management, has huge repository of quantitative surveys but most of these surveys are lacking statistical rigor and are thus of suspicious validity.

The present article is an attempt in the above-noted direction

2. COMPONENTS OF A SUPPLY-CHAIN MANAGEMENT-SYSTEM

The evolution of supply-chain management over the years has been slow, but quite steady. Organizations, in different corners of the globe, pioneered, developed and refined individually different parts of their supply-chains to address their challenges (Bovet & Sheffi [1998]). Mostly, it is the transportation system that gives a debut to their supply-chain management-system which, at later stages, gives way to a bevy of other component systems like warehousing, inventory of both the raw materials & finished goods, material handling, packaging, customer service, purchasing, etc. Level of maturity in these systems depend mainly on need, indigenous expertise of the organization and maturity of knowledge-sharing culture in the society, in general.

Scharlacken [1998] collects an exhaustive list of important, almost omnipresent, complementary components of a typical supply-chain management-system. These components are listed here in Appendix A, for ready reference, believing, these are the only components that supply-chain management system can have by assuming that all others, if present, are of similar nature. As a matter of interest, all these components, and subsequent subcomponents, are quantifiable in the sense that numerically coded data can be gathered against all these components. An intelligent, practical code system is required for such quantification. Numerically coded data for such components, as Schwartz [2004] opines, seems illogical, but authors have been engaged in such activities for some high- profiled consultancies. Further, all these components may be categorized, like Taguchi & his school of thought (see Taguchi et.all [2000]), as either

- Easy-to-control components,

or

- Difficult-to-control components

for a given situation. Using this new vocabulary, defined earlier, supply-chain management system may be redefined as planning to reduce dependence on difficult-to-control components at the expense of easy-to-control ones. Main objective is to control the whole system in such a way that no weak component may destroy the whole system. Such a planning calls for exquisitely designed schemes, or more technically designed experiments.

3. DESIGNED EXPERIMENTS

The statistical literature defines a designed experiment as a test, or series of tests (Montgomery [2001]), in which purposeful changes are made to the system under investigation, composed of components, so that we may

- observe any change,
- identify the reason for that change
- optimize, in some predefined direction, the change

in the resultant response. Wu & Hamada [2006] opine that experimentation is used to understand and/or improve a system. The literature is replete with numerous types of designs including classical blocked, multicomponent factorial, continuous-component response surfaces, error-focused robust, pseudo-statistical parameter designs, just to name a few from a very long list. Texts like Montgomery [2001], or Wu & Hamada [2000] present excellent discussions for various types of designs for different situations along with comparative merits, or demerits, of each. Foremost objective of each of these designs is to optimize the resultant response by intelligently setting of the levels of different participating components.

4. DESIGNING SUPPLY-CHAIN MANAGEMENT-SYSTEM

Designing an experiment for supply-chain management-system is quite complex and technical. Knowledge of the system, locale & experimentation niceties, which are considered to be the only requisites for designing an experiment in any other discipline, is only one domain for experimentation in supply-chain management. The other, and more important, domain is the commitment on the part of management. It is essential that the management fully understand all of the benefits of the experimentation, and that the experimentation is in no way a threat to their position or to their importance to the organization. No matter, how good or less-efficient a program might be, it can be extremely difficult for those individuals at the lower end of the organization, if top & middle management are not committed to supporting it and making it work.

The following seven-step procedure summarizes the important steps that the experimenter must take.

i. State Objectives

The objectives of the experiment need to be clearly stated. These include the major and minor areas of decisions. Is it the whole supply-chain management system that is to be focused or only a mere sub-system which needs to be revamped. The whole supply-chain management system is focused to pinpoint miscreant components and usually it is not required. Once the miscreant is pointed out, more elaborate experimentation is done on that component only to control and/or improve its performance. Genichi Taguchi, Jeff Wu and their school of thought used to categorize the objectives as either larger-the-better, nominal-the-best, or smaller-the-better. In supply-chain management experimentation, we are more interested in the latter two types of objectives, rather than the former, which is rarely the objective here.

ii. Choose Response

The response is the experimental outcome or observation. Most often, in supply-chain management experimentation, the response is the reduction in time, and prices. But, these are not the only responses. For instance, in the customer-service component, the response may be better conversation or customer-satisfaction, etc. but all such responses are very difficult to quantify. It is always desirable to have numerical or quantifiable responses. Further, in supply-chain management experimentation, the response would always be continuous.

iii. Choose Participating Components & Levels

This is the most crucial part of supply-chain management experimentation. It includes, on one hand, the selection of important components that may affect the response (this is usually done either through screening experiment or fact-finding discussions with management). Then, on the other hand, the selection of two or more values for the other selected components. These values are referred to as levels or settings. A flow chart diagram, or a cause-and-effect (also called fishbone) diagram can be used to list and organize the potential components as well as their settings. Both of these selections are of utmost importance and demand sheer intelligence. Cost and practical constraints must be considered. One of the distinguishing feature of supply-chain management experimentation is the ubiquitely qualitative nature of the components and calls for an expert system of codification.

iv. Choose Experimental Plan; the Design

This is the second most crucial step in supply-chain management experimentation, after the selection of participating components and their respective levels (discussed in previous paragraph). A poor design may capture little information out of experimentation which no analysis can rescue. On the other hand, if the experiment is well-planned, the results may be obvious so that no sophisticated analysis is required. Statistical literature has numerous designs for different situations. These include classical blocked, multicomponent discrete factorial, continuous-component response surfaces, error-focused robust, pseudo statistical parameter designs, just to name a few from a very long list. Texts like Montgomery [2001], or Wu & Hamada [2000] present excellent discussions for different types of designs for different situations along with comparative merits, or demerits, of each. Robust design (pioneered by Box), or Parameter designs (pioneered by Taguchi) are best suited designs for supply-chain management experiments. Robust design stabilizes a system for some pre-diagnosed and pre-gauged malignancy. While, parameter designs improve the performance of a system by bifurcating selected components into Easy-to-control components, & Difficult-to-control components, Robust designs are mostly theoretical and have little use in industry.

v. Perform the Experiment

This is the mere execution of the experimental plan/design to have the actual data about the system. This is the phase where management-commitment plays a pivotal role. The accuracy and sanctity of the data lies on this commitment. The use of a planning matrix is recommended. This matrix describes the experimental plan in terms of the actual values or settings of the components. It is also worthwhile to perform a trial 'run to see if there will be difficulties in running the actual experiment. But this trial run is a merely option.

vi. Analyze the Data

An analysis appropriate for the design used to collect the data needs to be carried out. This includes model fitting & assessment of the model assumptions through an analysis of residuals. This also includes statistical analysis of variance, in case of robust designs, and pseudo SN ratio analysis, in case of parameter designs. Today, many statistical computing packages, like SAS, SPLus, SPSS, etc. are available to facilitate the analytical part. SAS & SPlus are quite proficient in dealing with experimental design data.

vii. Draw Conclusions & Make Recommendations

Based on the data analysis, conclusions are presented which include the important components and a model for the response in terms of important components. Recommended settings or levels for the important factors may also be given. The conclusion should refer back to the stated objectives of the experiments. Cabrera & McDougall [2001] present excellent discussions to shape a purposeful and directional conclusion. A confirmation experiment is worthwhile, although it is almost impossible to conduct even a part of supply-chain management experimentation a second time in some situations.

5. SOME EXPERIMENTAL PLANS, EXCLUSIVE FOR SUPPLY-CHAIN MANAGEMENT-SYSTEM

Statistical literature is replete with numerous experimental plans suitable for different theoretical and practical situations. Not many of these are suitable in supply-chain management experimentation environment. Traditional blocked designs are meant only for controlling a known source of error(s), instead of optimizing a process for that error(s). Supply-chain management experimentation, should, involve optimization in addition to controlling. On the other hand, designs that satisfy optimal design criteria will usually not be optimal when observations are missing, when outliers are present or when, contrary to the assumptions, the error of the observation arises from non-Gaussian distribution. George Box & Norman Draper and their schools of thought have pioneered and developed robust designs to protect above-stated efficiency-related characteristics of traditional response surfaces designs against some delinquencies including outliers, leverage points, model misbehaves, missing observations, etc., (see Box & Draper [1986] for details). Unfortunately, most of these designs could not go beyond textbooks or reference journals because of their sheer mathematical base and complex application procedures (see Montgomery [2001] for detailed critical discussions). Further, these designs are exclusive to situations and difficult to manualize. These designs are using quite complex but established mathematical and statistical principles for subsequent analysis. Genichi Taguchi, and his school of thought, presents parameter designs; an industrial adaptation of traditional statistical designs (see Siddiqi [2003] for details). They have taken the genesis of their designs from accepted mathematical plans, but the subsequent design nomenclature and the analysis are completely their own. The design nomenclature is quite complex but not situation-exclusive, while the analysis is quite simple. These designs are quite popular among the Japanese, and now, the Western industrialists too among for their easy application and result-oriented approach. Many softwares, including SAP, are available to carry out the experimentation right from A to Z. The author would recommend the use of Taguchi's approach in the domain of supply-chain management, too.

These are not the only applicable designed plans for supply-chain management experimentation. But, these are the plans readily available, statistically reliable, and proven practical in the business & industry environment. One can always think about developing new plans, more akin to the situation at hand. Literature is replete with numerous such examples, like Taguchi's, where plans are developed to cope with problems at hand. And, this is the facet in this domain that may welcome design statisticians.

6. CONCLUDING REMARKS & POSSIBLE FUTURE POSSIBILITIES

Supply-chain management has become one of the

most important pillars for any organization in today's knowledge-based economy. An efficient, optimal, vision-oriented and robust supply-chain management is the sheer requirement, but all these adjectives depend on the system that runs it. One way to achieve these cherished characteristics is to base supply-chain management-system on proved statistically-designed experiment. The present article is simply an attempt to open this dimension to analysts of supply-chain management. Statistics has many theoretical and practical designs, suitable for different situations. A serious and practical effort is required to pin-point the designs applicable in the domain of supply-chain management system, or to develop new designs like Genichi Taguchi's.

7. APPENDIX A: Almost Omnipresent Components of a Typical Supply-Chain Management -System

1. Purchase/Procurement Decision Areas

- EDI Programs with vendors
- On-line purchasing from vendor catalogs
- Communicating with vendors
- Negotiation with vendors
- Checking price quotations of vendors
- Arranging for returned/damaged products to vendors
- Dealing with warranty issues of vendors

2. Inventory Management

- EDI programs with vendors
- Coordination of IJT delivery programs
- Communication with customers on out-of-stocks, etc.
- Notification of delays in order ship dates to customers
- Communication with vendors on raw-material inventory levels
- Communication with customers on emergency situations affecting inventory levels
- Communication with vendors on finished goods inventory levels
- Communication with field warehouses and depots on field inventory levels
- Communication with field depots on out-of-stocks situations, emergencies, etc.

3. Transportation

- Scheduling pickups at regional distribution centers
- Scheduling drop-offs at regional distribution centers
- Monitoring on-time arrivals of carriers
- Managing claims' status & processing communication with carriers on overall pe

4. Order Processing

- Communication with customers on order status
- Communication with vendors on order efforts
- Communication with customers on out-of-stocks
- Check credit status of customers
- Check credit status of vendors
- Communication with customers on returned merchandise
- Providing total order cycle performance for customers
- Providing credit processing status to customers
- Obtaining price quotes from vendors
- Providing price quotes to customers

5. Customer Service

- Receipt of customer complaints
- Providing technical service
- Notifying customers of emergencies in the supply chains-strikes, firs, etc. . Use of Internet to sell to customers
- Manage the outsourcing of customer service functions

6. Production Scheduling

- Coordination of production schedules with vendors
- Coordination of production schedules with field depots
- Coordination of production schedules with JIT schedules of vendors
- Coordination of production schedules of multiple manufacturing sites at indigenous locations
- Coordination of production schedules of multiple manufacturing sites at international locations

7. Relations with Vendors

- Coordination of deliveries of vendors to field warehouses and depots
- Communication with vendors regarding raw-material stock levels at their plant sites

- Purchasing of items from vendors on-line catalogs-supply lists
- Receipt of information queries from vendors
- Provision of information regarding vendor queries
- Providing vendors with service ratings on their overall performance
- Processing of returned materials, damaged products to vendors
- Providing vendors with ratings of the on-time performance of their carriers

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MICROBIOLOGICAL STUDIES RELATED TO GENETIC POLYMORPHISM OF INTERLEUKIN -1(α AND β) IN EGYPTIANS WITH PERIODONTITIS

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ABSTRACT

Genetic polymorphism for cytokines has been investigated as potential genetic markers for periodontitis. The aim is to determine the distribution of genetic variation in IL-1 gene family IL-1α (+4845) and IL-1β (+3953) as potential genetic marker for periodontitis among normal Egyptian individuals taking into account the association between the periodontal status and periodontopathic organisms as an additional variable.

Thirty normal Egyptian volunteers (between the ages 17-35) constituted the sample of this study. Dental examination was performed for each individual, in order to determine periodontal status and record Gingival-Index(GI) scores. Samples were categorized according to their Gingival-Index(GI) scores (good GI and fair GI). For each subject, IL -1α and IL-1β loci were genotype by PCR amplification, followed by digestion with restriction enzymes and gel electrophoresis. Certain micro-organisms were identified using both selective media and API test to establish their DNA-capture on Whatman FTA cards using PCR.

In the first group (the Good GI score group; 14 individuals), 85.7% were healthy, 7.14% had initial periodontitis and 7.14% had moderate periodontitis. Genetic polymorphism of IL-1 showed that 25 % of them were genotyped positive for IL-1α (+4845) and 6.25% were positive for IL-1β (+ 3953).

The second group (the Fair GI score;16 individuals) showed initial periodontitis in 18.75%, moderate periodontitis in 31.25% and severe periodontitis in 50%. 35.72% of them were IL-1α genotype positive and 7.4% were genotype positive for IL-1β (+ 3953). The study clarified that the distribution of IL-1α (+4845) and IL-1β (+3953) composite-genotype among the total studied samples were 30% and 6.66%, respectively. Results revealed that the percentages of certain bacteria, present in the oral cavity of Good and fair GI score groups, were respectively as follow: Actinobacillus actinomycetemcomitans, 7.14% and 6.25%, Porphyrmonas gingivalis in 7.14% and 18.75% and Prevotella intermedia 0% and 6.25%. In addition DNA was stable and could be captured on FTA cards: The results of identifying these microorganisms using PCR (after collecting samples on FTA card (Flinders Technology Associates) was found similar to the ordinary microbiological techniques.

Data of the present study provided evidence that polymorphism in genes of IL-family are associated with those suffering from periodontitis, which brings into question the usefulness of detection of the composite genotyping of IL-1α (+4845) and IL-1 β (+3953) alleles, as a reliable method for determining the susceptibility of patients to periodontitis .It would also be of interest to evaluate the role of other potential candidate genes as contributors to periodontitis by studying more cases. Presence of different microorganisms may be a variable parameter in causing periodontitis. Our results recommended the use of FTA cards as it establishes a new surveillance tool for molecular techniques .It constitutes a significant improvement in the collection of samples and their transport (especially from remote areas of the world to centralized laboratories).

INTRODUCTION

Inflammatory and immune processes operate in the gingival tissues to give protection against local microbial attack, and prevent microorganisms from spreading or invading the tissues (Page, 1991). It has been shown that some individuals carry polymorphisms of host response genes, that code for hypersecretion of certain cytokines in response to noxious stimuli (Lynch et al., 1994).

The diagnosis of moderate to severe periodontitis is a simple clinical process. However ,there is currently no known mechanism for determining which patients with no or mild periodontitis will respond to bacterial plaque, with progression to a more severe periodontitis that demands more extensive therapy .The lack of reliable markers for

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patient susceptibility to severe periodontitis has prevented the early identification of those at most risk and has prevented delivery of therapy appropriate for the degree of the risk. Moreover, the development of new therapeutics has been hampered by clinical trials in which only a small number of enrolled subjects exhibit disease progression, and by lack of clarity as to which segments of the population would benefit from more complex therapies (Kornman ,et al.,1997).

As our understanding of human genetics increases, it is apparent that host response to microbial infection, inflammation, and tissue destruction and repair, are all mediated by a complex of gene-gene and gene-environment interactions. Genetic variance may be, thus, due to combined effect of multiple, normally existing, and functional polymorphisms of genes. Functional polymorphisms are genetic variants that exist at a relatively high frequency, in the general population (>1%) (Malo and Skamene, 1994) .These gene variants may slightly alter the function of the gene product. Such variants usually do not cause disease per se, but it is possible that specific combinations of functional polymorphisms at a number of different genes may significantly alter an individual risk to develop a certain disease phenotype. This may be particularly true for gene products that are important modulators of gene- environmental interactions (Malo and Skamene, 1994).

A functional polymorphism of interleukin family gene has been proposed to be a risk factor for periodontitis, where IL-1 plays a pivotal role in the inflammatory cascade of the immune response to microbial challenge, and it was showed that its level increases with periodontitis, (Walker et al., 2000).

Genetic polymorphisms of cytokines have been investigated as genetic markers for periodontitis (Lopez et al., 2005). Furthermore, Shapira et al., (2005) suggested that the production of inflammatory mediators by inflammatory cells could be affected by different genetic traits.

Lopez(2000) reported that Actinobacillus actinomycetemcomitans, Porphyromonas Gingivalis, and Prevotella intermitis were the major periodontal bacteria species in most forms of progressive periodontitis in his study .He added that the occurrence of periodontal pathogens appears to be different in subjects of different ethnic origins, and that geographical factors may influence the distribution of these species. Umeda et. al., (1998) and Darout et al., (2002) have emphasized detection of many pathogenic bacteria causing periodontitis from saliva.

Dried blood spots (DBS), on filter paper have been used worldwide for the neonatal screening of congenital disorders (Guthrie, R. 1992). Recently, FTA cards (Flinders Technology Associates) was introduced to detect bacterial DNA or viral RNA from different biological samples as blood, saliva, tissues (Burgoyne, 1996). It is a cotton-based cellulose paper, impregnated with anionic detergent and buffer, that provide chelating and free radical-trapping properties. FTA paper contains reagents designed to adapt the storage, transport and integrity of samples so as to kill or inhibit saprophytes, during drying or bouts of high humidity, (Burgoyne, 1996). Moreover, it contains lyophilized chemicals that lyses many types of bacteria and viruses. Most cell types are lysed during contact with FTA, including white blood cells (Devost and Choy, 2000) and bacteria (Lampel,etal.,2000).Viruses are also inactivated ,leaving the nucleic acids suitable for molecular identification(Katz 2002). Therefore, the aim of this study was to determine the distribution of genetic variation in IL-1 gene family [(IL-1 α (+4845) and IL-1β (+3953)] as potential genetic markers for periodontitis among Egyptian individuals, taking into account the association between genetic variability and the periodontal status and periodontopathic organisms as an additional variable

2. METHODOLOGY AND SAMPLING

2.1 Subjects

Thirty normal Egyptian volunteers represented the sample of this study; their ages being between 17-35 years. They were subjected to a full mouth examination, to detect periodontal status and were submitted to gingival evaluation using Gingival Index according to Löe and Silness (1963).

They were divided into two groups according to Gingival Index scores (good GI scores group and fair GI scores group). Scoring of Gingival Index was done according to the following criteria:
0 = Normal gingiva
1 = Mild inflammation – slight change in color, slight edema. No bleeding on probing.
2 = Soft debris covering more than one third but not more than two third of the exposed tooth surface

3 = Soft debris covering more than two thirds of the exposed tooth surface.

N.B. The surface area covered by debris is estimated by running the side of the tip of an explorer across the teeth surface. The following examinations of individuals in this study were conducted:

i. Periodontal examination: Probing pocket depth, bleeding on probing, clinical attachment loss and gingival recession (A North Carolina probe was used in the examination).
ii. Clinical attachment levels were measured with a manual probe on six locations around each tooth, through investigation and evaluation of bleeding disorders and family history of cardiovascular disease or diabetes mellitus was done.
iii. The routine professional tooth-cleaning procedures were identified

2.2 Samples

From each case, the following samples were studied:

2.2.1. Saliva samples

a. 2ml of saliva was collected in 2ml transport media for detection of certain species of periodontopathic bacteria (A. actinomycetemcomitans, P.gingivalis and Prevotella intermedia) and identification using standard techniques.
b. Aliquots of samples (0.5ml) were blotted onto Whatmann FTA cards (1 cm in diameter) and allowed to air dry at (20 to 25°C). Samples after being dried were ready to be subjected to PCR reaction, or stored at an ambient temperature in envelopes with silica gel desiccant till use.

2.2.2. Blood samples

5ml Venus blood was collected from each case in order to detect IL -1 polymorphism using PCR technique.

2.3 Methods

2.3.1. Analysis of Interleukine (IL- 1 α and IL-1β) genetic polymorphism

This was done through PCR technique, followed by use of restriction enzymes for genotyping. The following steps were obeyed:

DNA extraction: DNA was extracted according to the instructions in the kit used (QIA amp DNA Mini kit QIA En, Ltd, UK " (genomic DNA purification kit)

Genotyping technique: 2-IL-1α(+4845): The primers used were:

Oligonucleotide primers 5' ATG GTT TTA GAA ATC ATC AAG AAT AGG GCA-3';5'-AAT GAA AGG AGG GGA GGA TGA CAG AAA TGT -3' (Cited after Walker,etal.,2000).

The technique:
PCR using Taq polymerase was carried out in 50µl reaction mixture containing 0.4Mµ primers under the standard buffer conditions. Cycling was performed as follows: 94°C, 1 minute;35 cycles 94°C, 1 minute; 56°C 1 minute; 72°C 2 minutes; one cycle 72°C 5 minutes. After the cycling period 23 µl of amplicon was digested with 2-5U Fnu 4HI yielding 2 fragments of 124 bp and 29 bp in subjects homozygous for allele "1", and one fragment of 153 bp in subjects homozygous for allele "2" . Individual bands were visualized by electrophoresis through 3.5 % agarose and ethidium bromide staining.
IL -1ß (+3953):

The primers used were:

Oligonucleotide primers 5'-CTC AGG TGG TGT CCT CGT AGAAAT CAA A-3'; 5'GCT TTT TTG CTG TGA GTC CCG -3' (Cited after Walker, et. al.,2000).

The technique:
PCR using Taq polymerase was carried out in 50µl reaction mixture containing 0.4Mµ primers under the standard buffer conditions. Cycling was performed as follows: 95°C, 2 minutes; 35 cycles 94°C, 1 minute; 53°C, 1 minute; 72°C, 1minute. After cycling period 23µl of amplicon was digested with 2-5U Taq 1 restriction endonuclease at 65°C for 2 hours yielding 2 fragments of 97bp and 85bp. Individual bands were visualized by electrophoresis through 3.5% agarose and ethidium bromide staining.

2.3.2 Microbiological Study:

Bacterial culturing technique:

The following media were used as instructed:
(ETSA)Trypticase soy agar, (TSBV) Tryptic soy

serum agar with bacitracin(75µg/ml)-vancomycin(5µg/ml) for isolation of A. actinomycetemcomitans and KVLB-2 (Kanamycin 75µg/ml, vancomycin 2µg/ml-laked blood agar) for isolation of Polphyromonas Gingiralis spp. and Prevotella intermedia spp

Procedure:
Samples were diluted in tenfold steps with repeated homogenization on vortex mixer at a maximal setting for 10 seconds between successive dilutions. Aliquots of 0.1 ml of the dilution were spread on each of freshly prepared plates of the last mentioned media. TSBV plates were incubated in 5% CO_2 incubator for five days at 37° C.ETSA and KVLB-2 plates were incubated at 37°C for 5-7 days in an anaerobic chamber (5% CO_2+10% H2+ 85% N2); black pigmented colonies were suspected to be isolated .Representative colonies of these types were subcultured on ESTA and incubated for 4-7 days.

Characterization and Identification:

Gram stain reaction, phase contrast microscopy for registration of motility, biochemical reactions agar fermentation pattern, and fluorescence in long-wave ultra violet light, as well as characterization and identification based on colony and cellular morphology.

Confirmation had taken place by using API system (La Balme Les Grottes 38390, Montalieu, Vercieu,France), which is fermentative 29. Biochemical standardized enzymatic reactions depend on the biochemical properties of the tested anaerobic microorganisms.

Polymerase chain reaction (PCR) for identifying certain bacterial strains:

1- Oligonucleotide primers used :
For analysis of A. actinomycetemcomitans , the following sequences of the forward and reverse primers were LKT2 (5- GGA ATT CCT AGG TAT TGC GAA ACA ATT TGATC -3) and LKT3 (5- GGA ATT CCT GAA ATT AAG CTG GTA ATC -3) .

Primers used for P.gingivalis analysis were FIM1 (5- ATA ATG GAG AAC AGC AGG AA -3) AND FIM2 (5- TCT TGC CAA CCA GTT CCA TTGC -3).

PCR using the last mentioned primers were described by Riggeno et al (1996). They were determined by a distinct band on 1.5 % agarose at 262 bp in size for A. actinomycetemcomitans and 131 bp for Polphyromonas Gingiralis. Primers used for Prevotella intermedia were (5- CCT AAT ACC CGA TGT TGT CCA CA -3) Pi -1 and (5- AAG GAG TCA ACA TCT CTG TAT CC-3) Pi2.These primers were described by Riggeno et al., (1998), which were determined by a distinct band on 1.5% agarose at 855 bp in size

DNA extraction and PCR procedure:

Samples on filter paper were air dried. 3 disks were punched and washed with FTA purification reagent twice. Used reagents were discarded after each wash. The samples were washed again with TE buffer (10 mM tris, 0.1 mM EDTA, PH 8), and the used buffer was discarded after each wash. Discs were dried and directly subject to PCR step. For detection of Actinobacillus actinomycetemcomitans and Polphyromonas Gingiralis, PCR amplification was carried out in a reaction volume of 100 µl contained 50 p mol of forward and reverse primers, 0.2 mM each of 4 deoxynucleoside triphosphatases, 2 units of the thermophilic DNA polymerase,1x buffer (10 mM tris-HCL PH 8.8 ,50 mM KCL, 0.1 % Triton x-100 and, 2.5 mM of MgCl2 (in reaction for A. actinomycetemcomitans and 1.5 mM in reaction with Polphyromonas Gingiralis and 2 units of Dynazyme Taq polymerase. PCR was carried out at 95°C for 5 min for one cycle, followed by subsequent 33 cycles of denaturation at 95°C for 1min, annealing at 55°C for 1 min and extension at 72°C for 1 min. The final extension was carried out at 72°C for 10 mins. For Prevotella intermedia, PCR amplification was carried out by the same composition of the last mentioned reaction mixture, but it was carried out at 94°C for 5min for one cycle, followed by subsequent 35 cycles of denaturation at 94°C for 1 min, annealing at 60°C for 1min, and extension at 72°C for 1.5 min. The final extension was carried out at 72°C for 10 min .

2.4 Results

Results are recorded in tables 1,2 and 3, to illustrate the relation between the periodontal status and IL-1 polymorphism genotype composite, as well as, the periodontal status and the distribution of certain periodonto-pathic micro-organisms.

Table 1, shows that among the examined individuals; group 1 (with good GI score; composed of 14 individuals) 85.72% were healthy, 7.14% had

Table - 1: Distribution of the samples according to mean gingival index scores and disease categories

Disease categories*	Gingival index score - groups		Total (n= 30)
	Good	Fair	
Healthy	12/14(85.72%)	0/16 (0%)	12/30(40 %)
Initial periodontitis	1/14(7.14%)	3/16(18.75 %)	4/30(13.33 %)
Moderate periodontitis	1/14 (7.14%)	5/16 (31.25%)	6/30(20 %)
Severe periodontitis	0/14 (0%)	8/16(50 %)	8/30(26.66 %)

*According to periodontal examination mentioned

initial periodontitis, 7.14% had moderate periodontitis, and none of them suffered from severe periodontitis. On the other hand, the group 2 (with fair GI score; were16 individuals) showed that none of them were healthy, 18.75% had initial periodontitis, 31.25% were moderate and 50 % had severe periodontitis

Table 2 reveals that only 11 out of the 30 subjects (36.66 %) carried the composite IL -1 genotype consisting of both IL-1α(+4845) and IL-1 β(+3953); 31.25% from group 1 individuals (those with good GI score) & 42.86% from group 2 individuals (those with fair GI score).

IL -1 α (+4845) polymorphism was carried by 30 % (9/30) of all subjects tested; where 25% of them were carried by group 1 and 35.72% from group 2 .

IL-1β(+3953) polymorphism was less; only 6.66 % (2/30) of all subjects carried this marker. One individual from each group (1&2) carried IL-1β(+3953) polymorphism, representing a percentage of 6.25% & 7.14% respectively. According to the distribution of the cases in table 2: IL -1 a (+4845) polymorphism was found to be most frequent in the studied subjects than IL-1β(+ 3953) . Composite IL -1 genotype, was also more frequent among individuals with fair GI score than those with good GI score, which may be considered a risk factor for severe periodontitis.

Table 3 presents the percentage of certain bacterial colonization in the oral cavity of the tested subjects. Actinobacillus actinomycetemcomitans percentage was nearly similar among good and fair score groups (7.14 % and 6.25%), whereas, Porphyrmonas gingivalis showed different percentages (7.14% in good and 18.75%in fair GI score groups). Prevotella intermedia were not isolated from good GI score group (0%) and could be isolated from one subject (6.25%) of all individuals with the fair GI score group.

In addition, microorganisms isolated using ordinary culture technique, were readily identified from FTA cards using PCR i.e. bacterial DNA was stable in the dried condition and could be recovered from the FTA cards.

2.5 Discussion & Conclusions

Microbial complexes colonizing the subgingival area, can provide a spectrum of correlations with the host, ranging from beneficial effect, in which the organisms prevent disease, to harmful effect where the organisms cause disease. At the pathogenic end of the spectrum, it is conceivable that different

Table - 2: Distribution of IL-1α (+4845) and IL-1 β(+ 3953) composite genotype among the studied subjects

Studied groups	IL-1 genotype		Total +ve IL -1 Genotype	Total -ve IL -1 Genotype
	IL-1α	IL-1β		
Good(GI)gp. group (1)	4/16(25%)	1/16(6.25%)	5/16(31.25%)	11/16(68.75%)
Fair (GI)gp. Group (2)	5 /14(35.72%)	1/14(7.14%)	6/14(42.86%)	8/14(57.14%)
Total studied sample	9/30 (30%)	2/30 (6.66 %)	11/30(36.66%)	19/30(63.33%)

Table 3: Distribution of bacterial species in the two studied groups (good and fair gingival index scores groups)

Bacterial species	Good GI score group Group (1)	Fair GI score group Group (2)
G-ve facultative rods *A. actinomycetemcomitans*	1/14(7.14%)	1/16(6.25%)
G –ve anaerobes: *Performonas gingivalis* *Prevotella intermedia*	1/14(7.14%)	3/16(18.75%)
	0/14 (0%)	1/16(6.25%)

correlations exist between pathogens. Pathogenicity could be enhanced in either an additive or a synergistic fashion, (Simonson et al., 1992).

The different members of the bacterial species possess a large number of virulence factors with a wide range of activities. These variable activities enable the organisms to colonize the oral cavity, invade periodontal tissues, evade host defenses, initiate connective tissue destruction and interfere with tissue repair, (Wilson and Henderson, 1995). Zambon (1996) added that they produce collagenase, an array of proteases (including those that destroy immunoglobulines) endotoxins, fatty acids, ammonia, and hydrogen sulphite and /or indole. These virulent enzymes induce inflammation, or form an immune reaction to waste products or to the lipopolysaccharide outer membrane component of Gram-negative organisms. This reaction leads to the change from a clinically healthy situation to a clinically inflamed state (gingivitis or periodontitis), as reported by Haffajee and Socransky(1994) and Takeuchi,et al., (2001). It is known that the nature of the host-response is affected primarily by genetic and environmental factors. The host response is essentially protective in nature, but both the under-activity (hypo-responsiveness) and the over-activity (hyper-responsiveness) aspects of the host response, can result in enhanced tissue destruction (Preshaw, et. al., 2004).

In this regard, our results showed that (36.66 %) carried the composite IL -1 genotype consisting of both IL-1α(+4845)and IL-1β(+3953). In addition, IL -1α(+4845) polymorphism was carried by 30 %, and IL-1β(+3953) polymorphism was carried by 6.66 % of our study population i.e. IL-1α (+4845) polymorphism was most frequent in our sample than IL-1β(+3953).This finding was in accordance to the finding of Gary et al., (2000) that IL-1β(+ 3953) polymorphism was much rare with only 3.3 % (10/300) in their study on Chinese population. Whereas the findings of walker et al., (2000) suggested that IL-1β(+3953) polymorphism was the most prevalent allele in the general African-American population in Western North Carolina, in a study of 37 individuals .

The prevalence of IL-1genotype positive subjects in other ethnic populations, has been reported around 30%among North European Caucasians (Engebretson et al., 1999 & Lang et al., 2000). It was 26% in a Hispanic Mexican population (Caffesse et.al., 2002). A higher percentage (38.9%) was observed by Mary et al., (2001) in European heritage. A high percentage of their presence was moderately high in our results (table 2).

Prevalence of the total IL-1 (IL- 1α and IL-1β) polymorphism in subjects of our results with fair GI score (42.86%) was more than in those with good GI (31.25%), which indicated that there is an evidence of a linkage between severity of periodontal disease and IL-1 gene expression. These results coincide with the findings reported by Di Giovine et al.,(1996) ,Salvi et al., (1998), Mary et al., (2001) and Laine et. Al., (2002).They agreed that individuals carrying this allele polymorphism are at greater risk for developing severe periodontitis.

In our study, there was no relation between the presence of A. actinomycetemcomitans and disease, since the percentage of its level was nearly the same among those groups, with fair and good GI scores groups. Albander et al., (1998) reported the same conclusion, and Ooshima etal., (2003) also reported that they considered A. actinomycetemcomitans a common member in children. In addition, the low level of isolating Porphyrmonas gingivalis and Prevotella intermedia from the studied subjects in both groups, showed that their presence was not related to the periodontal status. Schroeder and Lisgarten (1997) suggested that the continuous presence of such

large numbers of bacteria probably account for varied host-defense mechanisms against bacterial invasion and growth that can be found in the gingival tissues. Marsh and Martin (1999), supposed that the variations may exist due to many parameters influencing bacterial colonization and survival. These parameters greatly differ in the concentration of O_2, nutrients, PH, and metabolic products that cause local environmental heterogeneity. Laine etal., (2001), found that there is no relation between presence of A. actinomycetemcomitans and Porphyrmonas gingivalis in subjects with the genotype positive IL-1, Agerbaek et. al.,(2006) also stated that IL-1 gene negative subjects had a higher total bacterial load. On the other hand, Socransky et al.,(2000) concluded that the proportion of IL -1 genotype positive subjects that exhibited mean counts of specific subgingival species above selected thresholds was significantly higher than the proportion of genotype negative subjects. These findings cannot be exactly noted with our samples due to small percentage of microbial profile isolated from subjects who may be regarded as transient organisms. Saliva was used by different authors in order to isolate periodontopathic bacteria Darout et. al., (2002) and Umeda, et. al., (2004) .Some workers reported that the variations in some parameters presented in saliva, and PH may aid or suppress periodontal diseases [Maglis, et. al.,(1989), Sculley and Langley–Evans (2002) and Diab-Ladki,et al., (2003)].

Bacterial DNA was stable upon using FTA cards in the dried condition and could be analyzed by PCR. Elizabeth et. al., (2006) stated that FTA cards are a robust DNA collection method and generally produce DNA suitable for PCR, more reliably than buccal smear, as well as, analysis by nucleic acid amplification techniques, even when freezing conditions are not available.

3. CONCLUSIONS

Data of the present study provided evidence that polymorphism in genes of IL-family are associated with those suffering from periodontitis, which bring into question the usefulness of detection of the composite genotyping IL-1α (+4845) and IL-1β(+ 3953) alleles as a reliable method for determining the susceptibility of patients to periodontitis. It would also be of interest to evaluate the role of other potential candidate genes as contributors to periodontitis by studying more cases. Presence of different microorganisms may be a variable parameter in causing periodontitis. Our results recommended the use of FTA cards as it establishes a new surveillance tool for molecular techniques .It constitutes a significant improvement in the collection of samples and their transport (especially from remote areas of the world to centralized laboratories).

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RATE OF SPREAD OR DISSEMINATION OF SOME TECHNOLOGIES — PART II: A COMPARISON OF THE POSTULATED GENERALIZED CURVE WITH THE CASE OF NUCLEAR-PROLIFERATION

*M.M. Qurashi**

ABSTRACT

Transfer of technology has become a subject of great interest. The rate of spread or dissemination of technologies, is one interesting aspect of this subject, which was examined briefly in Part-I of this paper, published 20 years ago, in which examination of three typical technologies of the 19th & 20th centuries showed broadly similar patterns of dissemination, with an initial fast-dissemination (one country every five years), followed by a slowing down of dissemination, thereafter. Taken together with a Technology Development Capability Index proposed in 1974, it should, thus, be possible to predict when next another country will attain nuclear capability. This is studied here in the case of 3 countries that have gone nuclear since 1986, and it is found that the results generally support the view that dissemination here, also follows the same pattern, with only a delay of 5-8 years as a result of the hue and cry regarding nuclear-proliferation. Thus, the operation of normal market forces can be seen to be operative, in this case, of this particular technology also. Moreover, the spread of a particular technology can be predicted fairly reliably by using the concept of Technology Development Index, proposed in 1974 by Qurashi.

1. INTRODUCTION

The study of technology-dissemination is of great interest. U.K. and France were leaders from 1750 to 1850 A.D., but U.S.A. and U.S.S.R. have gradually forged ahead of Europe. In an earlier paper on this topic[1], published over 20 years ago, it was shown by examining the cases of 3 relatively modern technologies that the data showed a broad and generally similar pattern of dissemination, viz:

i. A relatively fast initial-dissemination, at the rate of one country every 5 years, among the 5 or 6 countries that are technologically most advanced, spread over a decade or two, followed by
ii. A relatively slow diffusion among the next level of technologically less-advanced countries, which may be spread over a century or more.

Some graphs for the cases of (a) aircraft manufacture and (b) nuclear explosion, are reproduced here as Figure 1(a) and Figure 1(b) In an effort to produce a more generally applicable curve, the mean graph of Figures. 1(a) and (b), was postulated as a useful model for future prediction (see Figure-1a). It was hoped to follow up part I with another part, but this was delayed by 20 years.

2. THE CONCEPT OF DISSEMINATION

From the data presented in Part I, it appeared to follow that the process of dissemination of technologies has a more or less constant or fixed pattern. This pattern was presumed to be that depicted in Figure-2. The passage of events over the last 20 years, provides us with an opportunity to study and test the above presumption, particularly in the case of the so-called "nuclear-proliferation". It is worth-noting that, in this case, "the process of "dissemination of technology" has been replaced by the epithet "proliferation".

The relative positions of various countries in the growth or dissemination of technologies of relatively recent origin are shown in Table-1, reproduced from Part I of this paper. Those at the top in a column, belong to or come from the previous Epoch; four more are now added to the second column, to bring the first column up-to-date. These countries are, in reverse order:

- North Korea[2] in 2006
- Pakistan[3] in 1998
- Israel/South Africa: probably in or ~ 1985
- India in 1974

While the dates of the first two and the fourth listed above, are more or less well-known[3], the third one i.e. Israel/South Africa, can only be inferred from the various media-reports and other circumstantial evidence, that points towards the development & successful collaboration in the nuclear field between these two countries with similar world-histories. For example, there was a newspaper report[4] that as early as 1956, France had agreed to provide Israel with a "nuclear-capability", as part of secret negotiations ahead of the invasion of Egypt, and …

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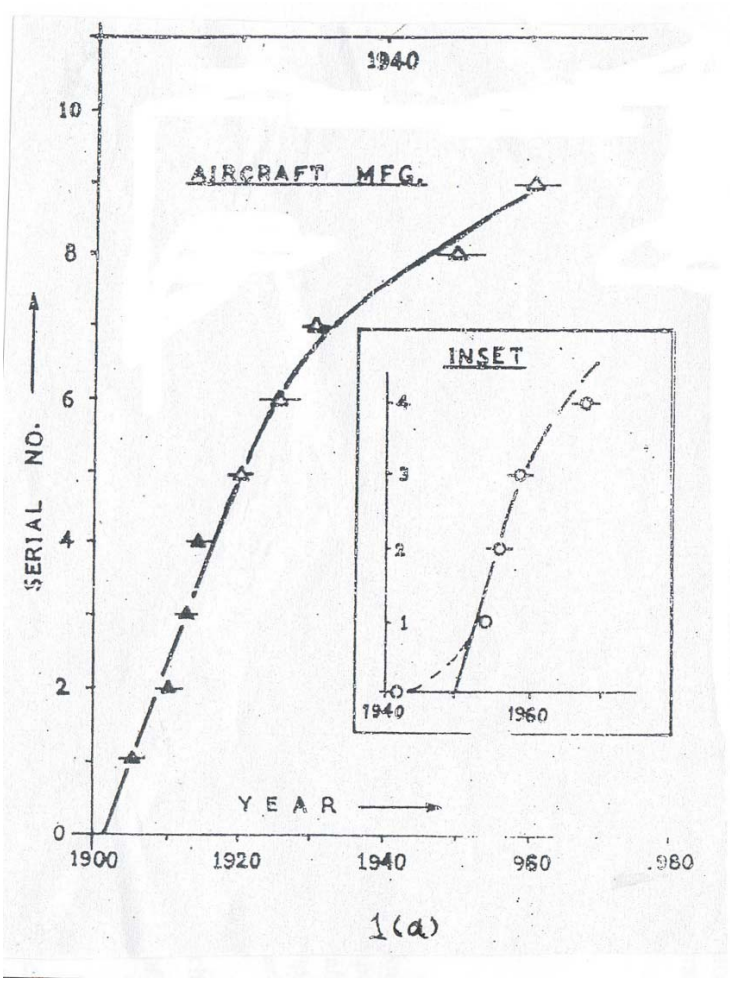

Figure-1(a): Plot of year of starting aircraft manufacture, for the first nine countries to do this, versus the year, showing an initial fast rate of dissemination. Inset: Inset showing the corresponding plot for rocketry (I.R.B.M.).

Table-1: Comparative Chart Showing the First Five Countries to Take up Various Recent Technologies

S.No.	Nuclear Explosion	Nuclear Power	Aircraft Manufacture	Steam Railway	Steam Engine
	1944-64	**(As in 1981)**	**1905-1920**	**1804-1850**	**Steam Engine**
1.	U.S.A. (1944)	U.S.A.	U.S.A.	U.K.	U.K.
2.	U.S.S.R. (1953)	U.S.S.R.	Germany	France	Czeck
3.	U.K. (1957)	U.K.	U.K.	U.S.A.	Belgium
4.	France (1960)	France	France	Germany	France
5.	China (1964)	Japan	Italy	Switzerland	

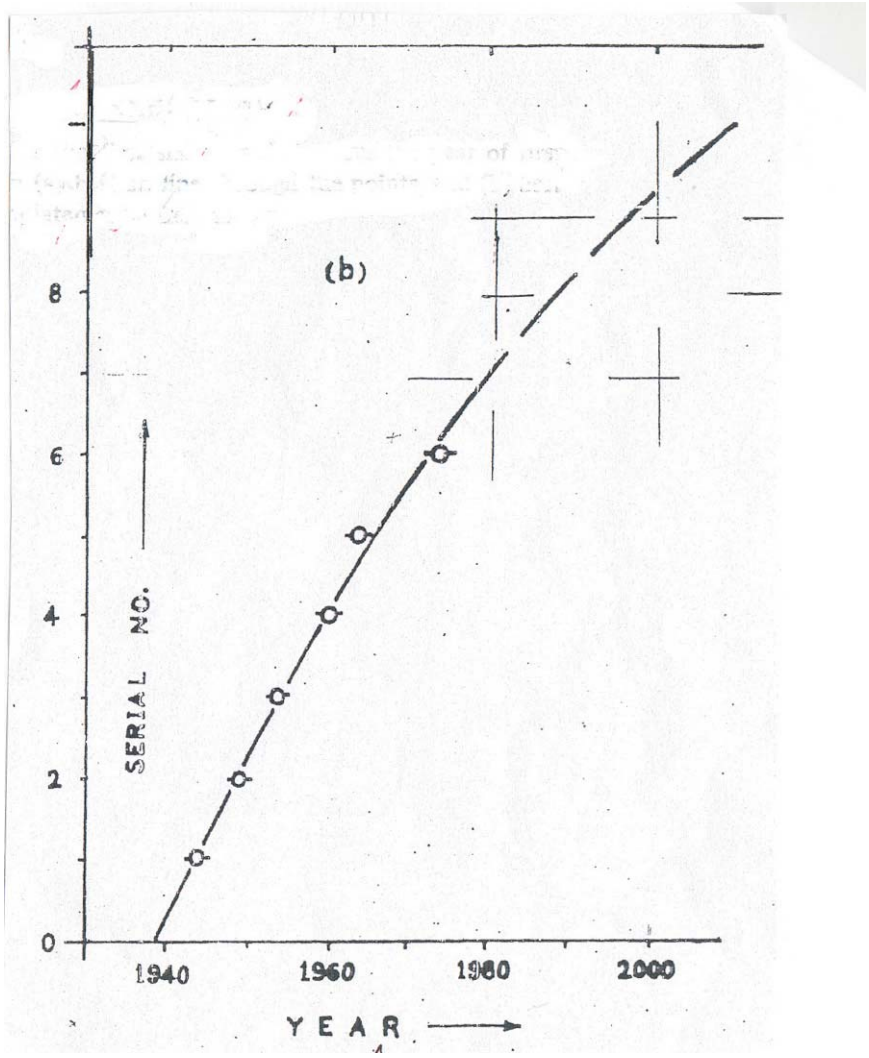

Figure-1(b): Plot of year of "going-nuclear" for the first six countries versus the year of first making an atomic explosion, with best curve-fitting the points and extrapolated as broken-line.

3. DISCUSSION OF THE DISSEMINATION/ PROLIFERATION OF NUCLEAR-WEAPON TECHNOLOGY

Here, it is important to note that the successful transfer or dissemination of any particular technology, requires at least two pre-requisites:

a. The minimum appropriate S&T capability in the recipient, and
b. A channel & arrangements (sale, donation or indirect), regarding transfer of the basic technology. This second requisite is of course governed by market-forces and the "felt-need" for the technology in the recipient country.

We can now replot the graph of Figure 2 and extend it with the help of the three additional points just noted. This replot is shown in Figure 3, where the solid-line has been continued as a chain-dotted line through the additional plotted points, while the broken line shows the extrapolation based on the best guess/estimate made two decades ago.

Comparison of the broken-line with the solid-line continued as chain-dotted beyond 1985, is instructive in two ways. First, it shows that proliferation or dissemination of nuclear-weapon technology has continued unabated, although at a

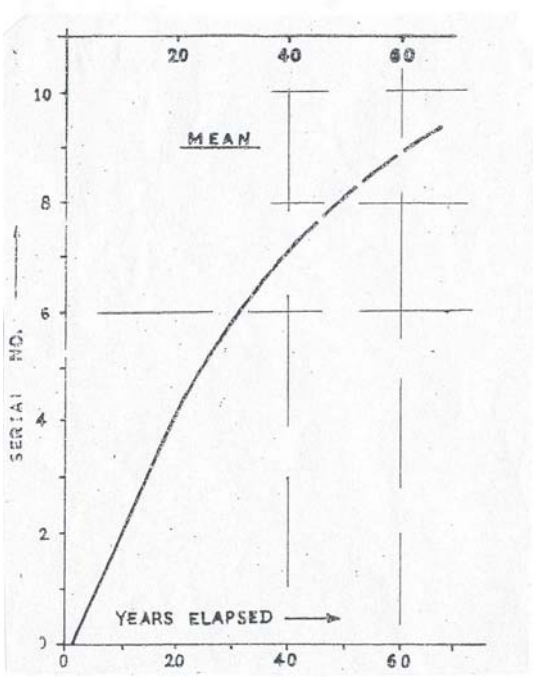

Figure 2(a): Mean of the two curves from Fig. 1(a) and Figure 1(b), giving the most likely curve for rates of dissemination to the first ten countries or so. Compared with the actual dissemination after 1975 [Figure 2(b)].

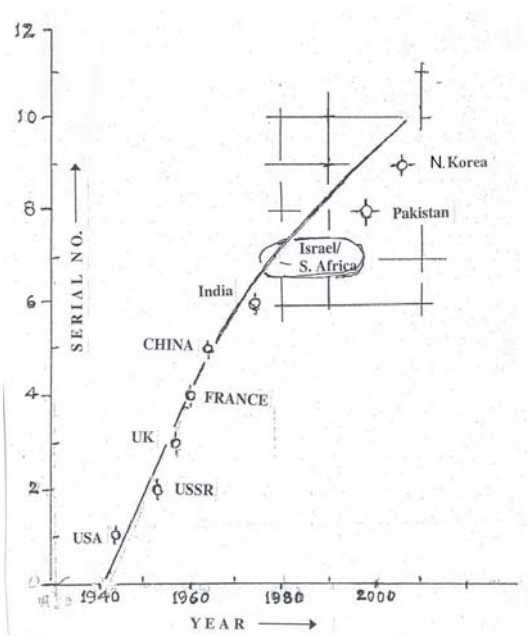

Figure 2(b): Plot of year of "going-nuclear" with best extrapolated curves (as in Figure 1(b), together with circles with crosses through them, for S. Korea and Pakistan, with ellipse as estimated for Israel and S. Africa. The portion beyond 1985 shows the delay of 5-8 years as against the predicted curve.

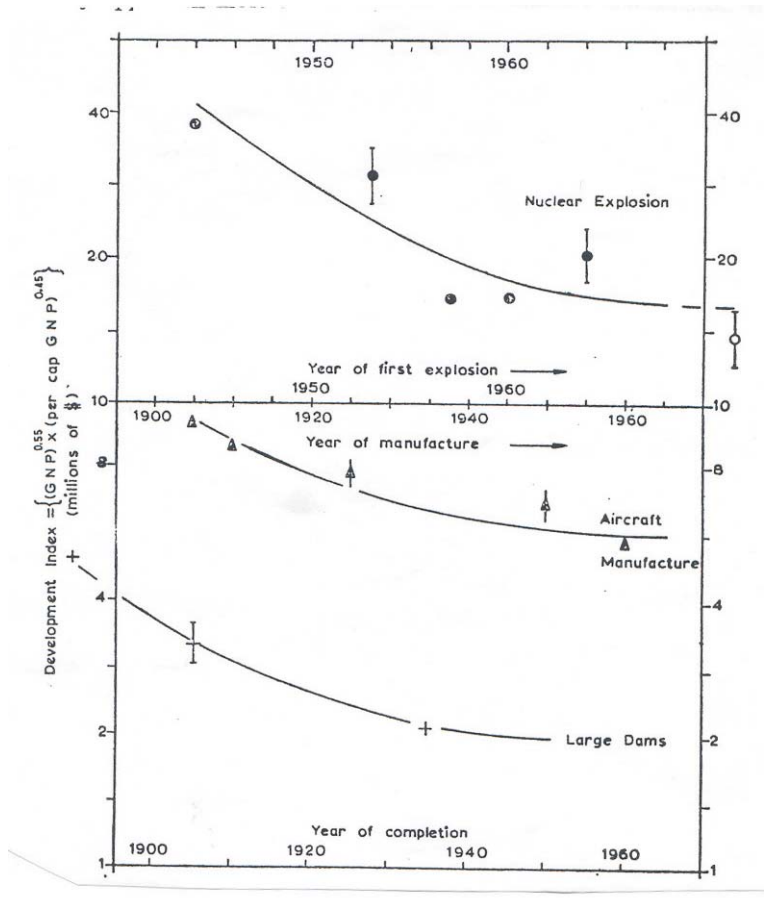

Figure - 3: Semi-logarithmic plots of the variation of the "Development Index" with δ = 0.05, {i.e. $(G.N.P.)^{0.55}$ (per cap. $G.N.P.)^{0.45}$}, with successive repetition of a project by various countries, for three categories of project, viz. nuclear explosion (top), aircraft manufacture (middle), and large dam construction (bottom). The limiting minimum value is in each case about half the initial value of the index

slightly slower rate than that estimated by extrapolation from the first six countries to go nuclear.

Secondly, it is seen that all the overt and covert efforts of the developed countries to prevent the so-called "nuclear-proliferation", have only succeeded in delaying the technology-transfer by five years in case of Pakistan, and 8 years in case of North Korea (See Figure 2(b)).

4. CONCLUSION & DISCUSSION

From the above analysis, it can be concluded that the case of nuclear-proliferation is also governed essentially by the market forces, which include the basically important factors of demand & supply and the capability to work up the technology indigenously. Reference may be made in this context to a much earlier (1974) paper[5] by the author, entitled "Formulation and Testing of a Technical Development Capability Index for use in Technology-Transfer". Starting from some general considerations of research and technological capability, an index was developed in the form:

Development Index = $(G.N.P.)^{0.55}$ (per cap. $G.N.P.)^{0.45}$.

It was found for three different technologies, that the values of this index lie on a smooth curve, showing a rapid initial drop for each succeeding repetition, followed by an asymptotic approach to a limiting-minimum, that is about half the starting value (for the first country in the field). The index value was (then) estimated to be reliable within 20%; accordingly, it was presumed that the index could be used to predict what technology a country can develop, and when.

Several conclusions follow from this, e.g.:

a. Transfer of technology from one country to another does follow certain general laws;
b. These laws are broadly the same for highly sophisticated technologies, as for the less sophisticated ones;
c. Also the likelihood of any technology being transferred to and developed by a particular country, is determined mainly by the Development Index of the recipient country.

As a corollary to the above statements, we may, on the basis of the present analysis of the spread of nuclear weapon technology, add that the international pressures of various sorts have played only a marginal role. This is seen in delaying the acquisition of nuclear explosion by a few years, viz. 9 years in case of Pakistan, and 8 years in case of North Korea. This is a fact that should be accepted by all concerned.

Another interesting fact is that, excluding USSR and China, this Nuclear-Weapon Technology has reached Asian countries about 36 5 years after Europe.

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SOME NEW EXACT SOLUTIONS OF EQUATIONS OF MOTION OF A COMPRESSIBLE FLUID OF CONSTANT VISCOSITY, VIA ONE-PARAMETER GROUP

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ABSTRACT

Some new exact solutions for the equations of motion of a compressible fluid of constant viscosity are determined employing one parameter group of transformations for an arbitrary state equation. All the exact solutions contain arbitrary functions/ function and this arbitrariness of functions/ function enables us to construct a large number of solutions to flow equations. The streamline patterns for some solutions are also given.

Keywords: One parameter group; Navier-Stroke's equations; Viscous compressible fluid; Steady plane flows; Rotational flows.

NOMENCLATURE

u, v	=	Velocity Components
p	=	Pressure
ρ	=	Density of fluid
μ	=	Viscosity of fluid
k	=	Coefficient of thermal conductivity
T	=	Temperature
e	=	Internal energy
Ψ	=	The streamfunction
x, y	=	Cartesian co-ordinates
Φ_j	=	set of functions
x_i	=	Independent variables
y_j	=	Dependent variables
$X, H, R, f_i, A, B, C, D, J,$	=	functions
G	=	Universal gas constant
C_v	=	Specific heat at constant volume
Superscript $'$ $''$ $'''$	=	Differentiation w.r.t. argument
Subscript x, y	=	Differentiation w.r.t. Cartesian co-ordinates

1. INTRODUCTION

The objective of this paper is to indicate some new exact solutions of equations governing the motion of a compressible thermally conducting fluid of constant viscosity using one parameter group of transformations for an arbitrary state equation. The paper is organised in the following fashion: In section 2, we consider the flow equations and transform them into a new system of equations using one parameter group of transformations. In section 3, we determine some exact solutions of new system of equations for an arbitrary state equation.

2. BASIC EQUATIONS

The steady plane flow of a compressible fluid of constant viscosity is governed by the system of four partial differential equations:

$$(\rho u)_x + (\rho v)_y = 0$$
$$\rho u u_x + \rho v u_y = -p_x + \mu \nabla^2 u$$
$$\rho u v_x + \rho v v_y = -p_y + \mu \nabla^2 v \qquad (1)$$
$$2\mu\,[u^2{}_x + v^2{}_y + 1/2\, u^2{}_y + u_y v_x + 1/2\, v^2{}_x]$$

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$$-2\mu/3\,[u^2_x + 2u_x v_y + v^2_y] + K\,[T_{xx} + T_{y\,y}] = ue_x + v\,e_y + p(u_x + v_y)$$

where u, v are the velocity components, p the pressure, ρ the density, μ the viscosity, K the constant coefficient of thermal conductivity, T the temperature and e the internal energy.
On introducing

$$\rho u = \psi_y$$
$$\rho v = \psi_x \qquad (2)$$

the system (1) is replaced by the following system:

$$\psi_y R\psi_{xy} + \psi^2_y R_x - R\psi_x\psi_{yy} - \psi_x\psi_y R_y = -\,p^*_x + \mu(R\psi_x)_{xy} + \mu(R\psi_y)_{yy}$$
$$-R\psi_y\psi_{xx} - R_x\psi_y\psi_x + \psi^2_x R_y + R\psi_x\psi_{xy} = -\,p^*_y - \mu(R\psi_x)_{xx} - \mu\,(R\psi_y)_{xy}$$
$$4\mu/3\,\{(R\psi_y)_x\}^2 + 4\mu/3\,\{(R\psi_x)_y\}^2 + \mu\{(R\psi_y)_y\}^2 \qquad (3)$$
$$-2\mu(R\psi_y)_y\,(R\psi_x)_x + \mu\{R\psi_x)_x\}^2 + 4\mu/3\,(R\psi_y)_x(R\psi_x)_y + K(T_{xx}+T_{yy})$$
$$= \psi_y e_x - \psi_x e_y + p\{(R\psi_y)_x - (R\psi_x)_y\}$$

of three equations in five unknown functions ψ, p, R, T, e as functions of x and y. In above, ψ is the stream function and the functions R and p* are given by

$$R = 1/\rho$$
$$p^* = p - \frac{4\mu}{3}\left\{\left(R\psi_y\right)_x - \left(R\psi_x\right)_y\right\} \qquad (4)$$

Once a solution of system of equations (3) is determined, the density ρ is determined from equation (4).

We now transform the system of partial differential equations (3) into a new system of ordinary differential equations using one-parameter group of transformations. We give here only one parameter group Γ_1 and its invariants that are utilised to obtain exact solutions of system (3). For details of one parameter group theory reader is referred to Ibragimov (1983), oliver (1986). Ovsiannikov (1982), Naeem (1994).

If Γ_1 is a group consisting of a set of transformations defined by

$$\bar{x} = a^n x, \qquad \bar{y} = a^m y, \qquad \bar{\psi} = a^j \psi \qquad \bar{p} = a^p p$$
$$\bar{R} = a^r R, \qquad \bar{T} = a^t T \qquad \bar{e} = a^j e$$

with parameter $a \neq 0$, Then the invariants for Γ_1 for system (3) are

$$\Psi = A(\theta) \qquad R = x^{\alpha_1}B(\theta) \qquad p = x^{\alpha_2}C(\theta)$$
$$T = x^{\alpha_3}D(\theta) \qquad e = x^{\alpha_4}E(\theta) \qquad \theta = y/x$$

wherein

$$\alpha_1 = r/n,\ \alpha_2 = \alpha_1 - 2 = p/n,\ \alpha_3 = t/n = 2\alpha_1 - 2,\ \alpha_4 = j/n = 2\alpha_1 - 2 \qquad (6)$$

The invariants (5) of Γ_1 transform system (3) into the following system of ordinary differential equations:

$$(\alpha_1 - 1)B\acute{A}^2 = -\alpha_2 C + \theta C' + \mu[(1-\alpha_1)H' + (\theta H')' + (B\acute{A})''] \qquad 7.1$$
$$(\alpha_1 - 1)\theta B\acute{A}^2 = -C' - \mu[(1-\alpha_1)\,(\alpha_1 - 2)H + (2\alpha_1 - 3)\theta H' - \theta(\theta H')']$$
$$-\mu[(\alpha_1 - 2)\,(B\acute{A})' - \theta(B\acute{A})''] \qquad 7.2$$
$$4\mu/3\,[(\alpha_1 - 1)\,B\,\acute{A} - \theta(B\acute{A})']^2 + 4\mu/3\,[H']^2 + \mu[B\acute{A})']^2$$
$$-2\mu\,(B\acute{A})'[1-\alpha_1)H + \theta H'] + \mu[1-\alpha_1)H + \theta H']^2$$

$$+ 4\mu/3\ H'[(1-\alpha_1)BA' + \theta(B\acute{A})'] + K[\alpha_3(\alpha_3 - 1)D - (2\alpha_3 - 2)\ \theta D' + \theta^2 D'' + D''] = \alpha_1 B\acute{A}M + \alpha_4 E\acute{A} \qquad 7.3$$

for the five unknown functions A, B, C, D, E of θ. In system (7)

$$H = \theta B\acute{A}$$

and

$$C = M - 4\mu/3\ \alpha_1 B\acute{A}$$

3. SOLUTIONS

In this section, we determine the solutions of the system (7).
When $\alpha_1 \neq 1$, equations (7.1–7.2) give:

$$\begin{aligned}(\alpha_1 - 1)\acute{A}\ J = &-\alpha_2 C + (1-\alpha_1)\theta^2 \acute{A}\ J + \mu[(1+\theta^2)J'' + (4-\alpha_1)\theta J' \\ &+ (2-\alpha_1)J + (\alpha_1^2 - 5\alpha_1 + 6)\theta^2 J \\ &+ \{(6-2\alpha_1)\theta^3 + (2-\alpha_1)\theta\}J' + \theta^2(1-\theta^2)J''] \end{aligned} \qquad (8)$$

wherein

$$J = B\acute{A}$$

Equations (7.2) and (8) imply that:

$$\begin{aligned}(1-\alpha_1)J\{u+\theta^2)A'' + (4-\alpha_1)\theta\acute{A}\} + (1-\alpha_1)(1+\theta^2)\acute{A}J' \\ = [\mu(\alpha_1 - 2)(\alpha_1 - 3) + (\alpha_1 - 4)\theta]J \\ -[\mu(\alpha_1 - 4)(\alpha_1 - 3) + 3\mu(\alpha_1 - 3)(\alpha_1 - 4)\theta^2]J' \\ -[\mu(1+\theta^2)^2 J''' - 3\mu(4-\alpha_1)\theta(1+\theta^2)J'' \end{aligned} \qquad (9)$$

The solution of equation (9), for given J, is:

$$A = \int \frac{(1+\theta^2)^{\frac{\alpha_1 - 4}{2}}}{J} L(\theta)\, d\theta + a_2 \qquad (10)$$

wherein

$$L(\theta) = \int \left[\frac{1}{(1-\alpha_1)} (1+\theta^2)^{\frac{2-\alpha_1}{2}} \text{ R.H.S. of eq. (9) } d\theta \right] + a_1$$

and a_1, a_2 are constants of integration.

The functions $B(\theta)$ and $C(\theta)$ are obtained from:

$$B = J/\acute{A} \qquad (11)$$

$$\begin{aligned}C = 1/\alpha_2[&(1-\alpha_1)\acute{A}J + (1-\alpha_1)\theta^2\acute{A}J + \mu\{(1+\theta^2)J'' + (4-\alpha_1)\theta J' \\ &+ (2-\alpha_1)J + (\alpha_1^2 - 5\alpha_1 + 6)\theta^2 J + [(6-2\alpha_1)\theta^3 + (2-\alpha_1)\theta]J' \\ &+ \theta^2(1+\theta^2)J''\}] \end{aligned} \qquad (12)$$

The equation (7.3) gives

$$E = 1/\alpha_4 \acute{A}\ [-\alpha_1 JC + \text{L.H.S. of (7.3)}] \qquad (13)$$

In the solution given by equation (10 -13) of system (7), the functions $J(\theta)$ and $D(\theta)$ are arbitrary. This arbitrariness of functions J and D enables us to construct a large number of solutions to the flow equations in system (1) for an arbitrary state equation.

In above solution, the arbitrary function $D(\theta)$, however, can be determined if the state equation is known. For example, when the state equation is, $p = \rho GT$, we find

$$D(\theta) = B(\theta)\, M(\theta)/G$$

where G is the universal gas constant

II. When $\alpha_1=1$, the system (7) becomes

$$C + \theta C' + \mu[(\theta H')' + J''] = 0 \qquad (14.1)$$

$$-C' + \mu[(\theta^2 H')' + (\theta J')'] = 0 \qquad (14.2)$$

$$-2/3\ \mu\theta J' H' + \mu(4/3+\theta^2)H'^2 + \mu(4/3\ \theta^2 + 1)J'^2 + K[(1+\theta^2)D']' = MJ \qquad (14.3)$$

The solution of system (14) is

$$C = \mu[\theta^2 H' + \theta J'] + a_3$$

$$J = \frac{a_3 + a_4 \mu\theta}{1+\theta^2} + \frac{a_5}{\left(1+\theta^2\right)^{1/2}}$$

$$D = \int x_2(\theta)d\theta + m_1 \tan^{-1}\theta + m_2$$

wherein

$$x_1(\theta) = \frac{1}{K}\left\{JM + \frac{2}{3}\mu\theta J'H' - \mu\left(\frac{4}{3}+\theta^2\right)H'' - \mu\left(\frac{4}{3}\theta^2+1\right)J''\right\} \qquad (16)$$

$$x_2(\theta) = \frac{1}{1+\theta^2}\int x_1(\theta)\,d\theta \qquad (17)$$

and m_1 , m_2, are arbitrary constants

We note that when $\alpha_1=1$, $\alpha_4=0$ and therefore the term $\alpha_4 E\acute{A}$ in equation (7.3) disappears and hence the function $E(\theta)$ becomes arbitrary.

In the above solution

$$B\acute{A} = a_3 + a_4\mu\theta/1+\theta^2 + a_5/(1+\theta^2)^{1/2} \qquad (18)$$

which means that one of the functions B or Á is arbitrary.

The solution (15) is for an arbitrary state equation and contains arbitrary functions $B(\theta)$ (or A'), $E(\theta)$ and this enables us to generate a large number of solutions to the flow equations. For ideal gases, the function $B(\theta)$ can be easily determined from $B(\theta) = GD(\theta)/M(\theta)$. However, the function $E(\theta)$still remains arbitrary. For polytropic gases the function $E(\theta)$ is given by $E(\theta) = C_v\, D(\theta)$,where C_v is the specific heat at constant volume.

III. When $\alpha_1=2$, the system (7) gives

$$J\acute{A} = \theta C' + \mu[(1+\theta^2)J']' \qquad (19)$$

$$\theta J\acute{A} = -C' + \mu[\theta^2(\theta J)'' + \theta J''] \qquad (20)$$

$$4\mu J^2/3 + \mu(1+\theta^2)^2 J'^2 + K[(1+\theta^2)D'' - 2\theta D' + 2D] = 2JC + E\acute{A} \qquad (21)$$

The equations (19–20), on eliminating C', yield

$$\mu\,(1+\theta^2)J'' + 2\theta\mu J' - \acute{A}J = 0 \qquad (22)$$

The integration of equation (20) yields

$$C = \int[-\theta J\acute{A} + \mu\{\theta^2\,(\theta J)'' + \theta J'\}']d\theta + \lambda^*$$

wherein λ^* is a constant of integration

The solution of equation (21) is

$$D = \theta\int(1+\theta^2)/\theta^2\;\; X(\theta)\; d\theta + \lambda_1{}^*\theta$$

wherein

$$X(\theta) = \int \theta^2/K(1+\theta^2)\;[2JC + 2E\acute{A} - 4\mu/3\; J^2 - \mu(1+\theta^2)^2 J'^2]\; d\theta + \lambda_2{}^*$$

and λ_1, $\lambda_2{}^*$ are constants and the function $E(\theta)$ is an arbitrary function. The solution of equation (22) is determined as follows:

We know from the theory of ordinary differential equations that equation

$$\Phi''(\theta) + a_1(\theta)\Phi'(\theta) + a_2(\theta)\Phi = 0$$

can be put in the normal form

$$\Phi^{*''} + (a_2(\theta) - 1/2\; a_1'(\theta) - 1/4\; a_1{}^2\,(\theta))\Phi^* = 0 \qquad (23)$$

by substituting $\Phi(\theta) = \Phi^*(\theta)\; e^{-1/2\int a_1(\theta)\, d\theta}$ (24)

The equation (22), on utilising equations (23-24), yields

$$\Phi^{*''} + (-\,\acute{A}/\mu(1+\theta^2) - 1/(1+\theta^2)^2)\Phi^* = 0 \qquad (25)$$

wherein

$$J = \Phi^*(1+\theta^2)^{-1/2} \qquad (26)$$

The solution of equation (25) can easily be determined by appropriately choosing the coefficient of Φ^* i.e.,

$$-\,\acute{A}/\mu(1+\theta^2) - 1/(1+\theta^2)^2 \qquad (27)$$

Let us now consider some of the choices for which the solution of equation (25)can easily be determined

(i) If we take

$$-\,\acute{A}/\mu(1+\theta^2) - 1/(1+\theta^2)^2 = \lambda/\theta^2 \qquad (28)$$

then

$$A = -\mu\tan^{-1}\theta + \lambda\mu/\theta - \lambda\mu\theta + d_1 \qquad (29)$$

and

$$\Phi^* = \begin{cases} d_2\theta\;\dfrac{1+\sqrt{1-4\lambda}}{2} + d_3\theta\;\dfrac{1-\sqrt{1-4\lambda}}{2}\;, & 4\lambda < 1 \\ \theta^{1/2}\left(d_4\,\mathrm{Cos}\sqrt{4\lambda-1}\;\ln\theta + d_5\mathrm{Sin}\sqrt{4\lambda-1}\;\ln\theta\right), & 4\lambda > 1 \\ (d_6 + d_7\ln\theta)\theta^{1/2}\;, & 4\lambda = 1 \end{cases} \qquad (30)$$

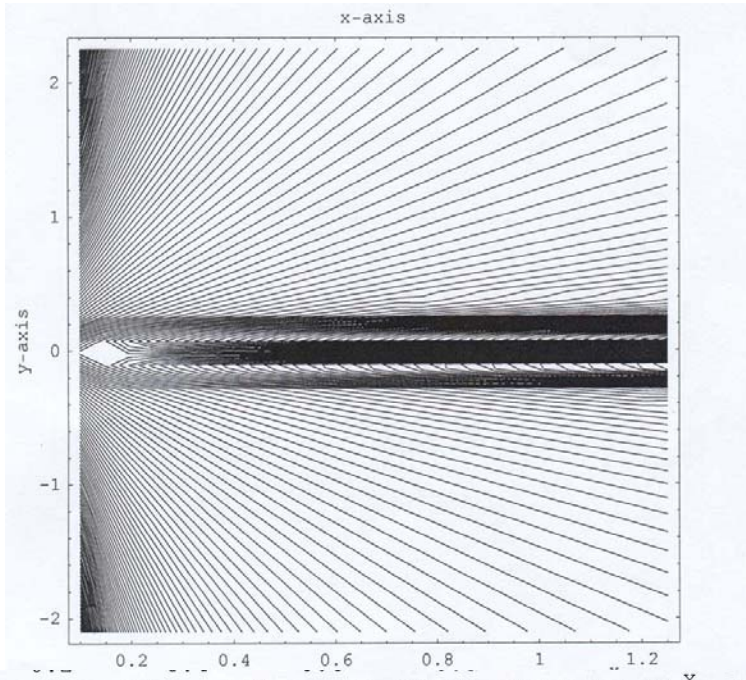

Figure-1: Streamlines pattren for $12+12\text{ArcTan}[y/x]-6(\frac{x}{y})+6(y/x)=0$

where $\lambda \neq 0$, d_1, d_2, d_3, d_4, d_5, d_6, d_7 are all non-zero constants. The stream function is $\psi = A(\theta) = A(y/x) = -\mu\tan^{-1}(y/x) + \lambda\mu(x/y) - \lambda\mu(y/x) + d_1$. The streamlines pattern is given in Figure 1.

Equation (26), on using equation (30), gives

$$J = \begin{cases} (1+\theta^2)^{-1/2}\left(d_2\theta \dfrac{1+\sqrt{1-4\lambda}}{2} + d_3\theta \dfrac{1-\sqrt{1-4\lambda}}{2}\right), & 4\lambda < 1 \\ \theta^{1/2}(1+\theta^2)^{-1/2}\left(d_4 \operatorname{Cos}\sqrt{4\lambda-1}\ \ln\theta + d_5 \operatorname{Sin}\sqrt{4\lambda-1}\ \ln\theta\right), & 4\lambda > 1 \\ \theta^{1/2}(1+\theta^2)^{-1/2}\ (d_6 + d_7 \ln\theta), & 4\lambda = 1 \end{cases}$$

(ii)For

$$\acute{A}/\mu(1+\theta^2) - 1/(1+\theta^2)^2 = \lambda_1 \ (\neq 0)$$

we find

$$A = -\lambda_1\mu(\theta+\theta^3/3) - \mu \tan^{-1}\theta + \lambda_2$$

$$J = (1+\theta^2)^{-1/2}\left(\lambda_3 \operatorname{Cos}\sqrt{\lambda_1}\ \theta + \lambda_4 \operatorname{Sin}\sqrt{\lambda_1}\ \theta\right)$$

When $\lambda_1=0$, we find

$A = \mu \tan^{-1}\theta + \lambda_5$

$J=(1+\theta^2)^{-1/2}(\lambda_6+\lambda_7\theta)$

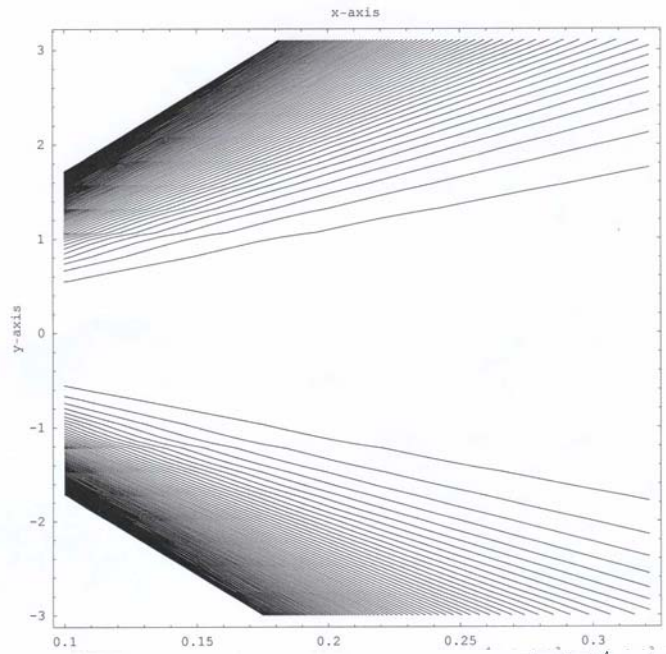

Figure-2: Streamlines pattren for $8+12\mathrm{ArcTan}[y/x]+6[\frac{(y/x)^4}{4}+\frac{(y/x)^2}{2}]+6[\frac{(y/x)^2-1}{(y/x)}]=0$

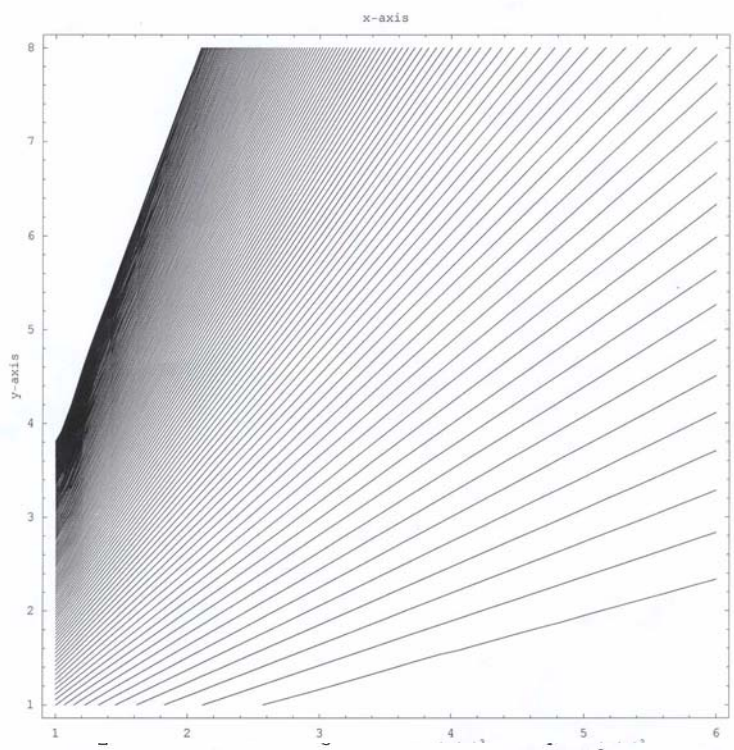

Figure-3:Streamlines pattren for $12+12\mathrm{ArcTan}[y/x]+6(\frac{y}{x}+\frac{(y/x)^3}{3})+4(\mathrm{Log}[y/x]+\frac{(y/x)^2}{2})-2((y/x)-\frac{x}{y})=0$

In above λ_2, ..., λ_7 are constants

(iii) Solution in terms of Bessel functions

If we assume

$$-\frac{A'}{\mu(1+\theta^2)} - \frac{1}{(1+\theta^2)^2} = \beta^2\gamma^2\theta^{2\gamma-1} - \frac{4p^2\gamma^2-1}{4\theta^2}$$

then Stanley [7]

$$J = \theta^{1/2}(1+\theta^2)^{-1/2} Zp\,(\beta\theta)$$

$$A = -\mu \tan^{-1}\theta - \mu\beta^2\gamma^2\left[\frac{\theta^{2\gamma}}{2\gamma} + \frac{\theta^{2\gamma+2}}{2\gamma+2}\right]$$

$$+ \frac{\mu(4p^2\gamma^2-1)}{4}\left[\frac{\theta^2-1}{\theta}\right] + D_1$$

wherein β,γ,p,D_1 are constants and Zp is Bessel function of order p*. The streamlines pattern for this solution is given in Figure 2.

iv) If we let

$$-\frac{A'}{\mu(1+\theta^2)} - \frac{1}{(1+\theta^2)^2} = b\,\theta^m$$

then

$$J = \theta^{1/2}(1+\theta^2)^{-1/2} Z_1/(m+2)\left(\frac{2\sqrt{b}\,\theta}{m+2}\right)$$

$$A = -\mu b\left(\frac{\theta^{m+1}}{m+1} + \frac{\theta^{m+3}}{m+3}\right) - \mu \tan^{-1}\theta + D_2$$

wherein b, m, D_2 are constants.

v) Solution in terms of Hermite function

On substituting

$-A'/\mu(1+\theta^2) - 1/(1+\theta^2)^2 = a_1 - \theta^2$

the equation (25) becomes

$\Phi^{*''} + (a^*_1 - \theta^2)\Phi^* = 0$

whose solution is

$\Phi^* = e^{-\theta^2/2} H_n(\theta)$

wherein $n = (a^*_1 - 1)/2$ and $H_n(\theta)$ is the Hermite –polynomial of degree n. The functions J and A, therefore, are given by

$J = (1+\theta^2)^{-1/2} e^{-\theta 2/2} H_n(\theta)$

$A = -\mu \tan^{-1}\theta + (\mu - a^*_1)\,\theta^3/3 - \mu a^*_1\theta + \mu\theta^5/5 + a^*_2$

wherein $a^*_1(>0)$, a^*_2 are constants.

(vi) Solution in terms of Whittakers confluent Hypergeometric function.

By putting

$$-\frac{A'}{\mu(1+\theta^2)} - \frac{1}{(1+\theta^2)^2} = -\frac{1}{4} + \frac{K}{\theta} + \frac{1/4 - m^2}{\theta^2}$$

in equation (25), we get

$$\Phi_*'' + \left(-\frac{1}{4} + \frac{K}{\theta} + \frac{1/4 - m^2}{\theta^2}\right)\Phi^* = 0$$

which is Whittaker equation and its solution is

$$\Phi^* = \{ a_3^{m+1/2}\, e^{-\theta/2}\, F(1/2 - K + m;\ 1+2m;\ \theta)$$
$$+ a_4\, \theta^{m-1/2}\, e^{-\theta/2}\, F(1/2 - K - m;\ 1-2m;\ \theta)\}$$

wherein K, m, a_3, a_4 are arbitrary constants

The function A is given by

$$A = -\mu \tan^{-1}\theta + \mu/4\,(\theta + \theta^3/3) - K\mu(\ln\theta + \theta^2/2)$$
$$+ (m^2 - 1/4)\mu(\theta - 1/\theta) + a_5$$

wherein a_5 is an arbitrary constant. The streamlines pattern for this solution is depicted in Figure 3.

(vii) If we assume that θ^m is an integral in the complementary function of equation (22), then

$$A = \frac{-\mu m(m-1)}{\theta} + \mu m(m+1)\ \theta + \alpha_1$$

$$J = \alpha_1 \theta^m \int \frac{d\theta}{\theta^m(1+\theta^2)} + \alpha_2 \theta^m$$

wherein α_1, α_2 are constants. In the expression for J, the indefinite integral can easily be evaluated from the tables of indefinite integrals Bois (1961) for given m.

The equation (22) can be transformed into an integrable form from Sharma and Gupta (1984) by introducing the new independent variable Z through $Z = \tan^{-1}\theta$ and choosing $\acute{A}(Z) = -\mu\alpha_3/Z^2$

the equation (22), on using these, yields

$Z^2 J''(Z) + \alpha_3 J(Z) = 0$

whose solution is

$$J=\begin{cases}(\alpha_4+\alpha_5 \ln\tan^{-1}\theta)\,(\tan^{-1}\theta)^{1/2}, & \alpha_3=1/4\\[2ex] \alpha_5(\tan^{-1}\theta)^{\frac{1+\sqrt{1-4\alpha_3}}{2}}+\alpha_7(\tan^{-1}\theta)^{\frac{1+\sqrt{1-4\alpha_3}}{2}}, & \alpha_3<1/4\\[2ex] (\tan^{-1}\theta)^{1/2}\left[\alpha_8\operatorname{Cos}\frac{\sqrt{4\alpha_3-1}}{2}\ln\tan^{-1}\theta+\alpha_9\operatorname{Sin}\frac{\sqrt{4\alpha_3-1}}{3}\ln\tan^{-1}\theta\right] & \alpha_3>1/4\end{cases}$$

where in α_3, —, α_9 are constants.

The function A is given by

$A = \mu\alpha_3/\tan^{-1}\theta + \alpha_{10}$

wherein α_{10} is an arbitrary constant. In this case the flow pattern is given in Figure 4.

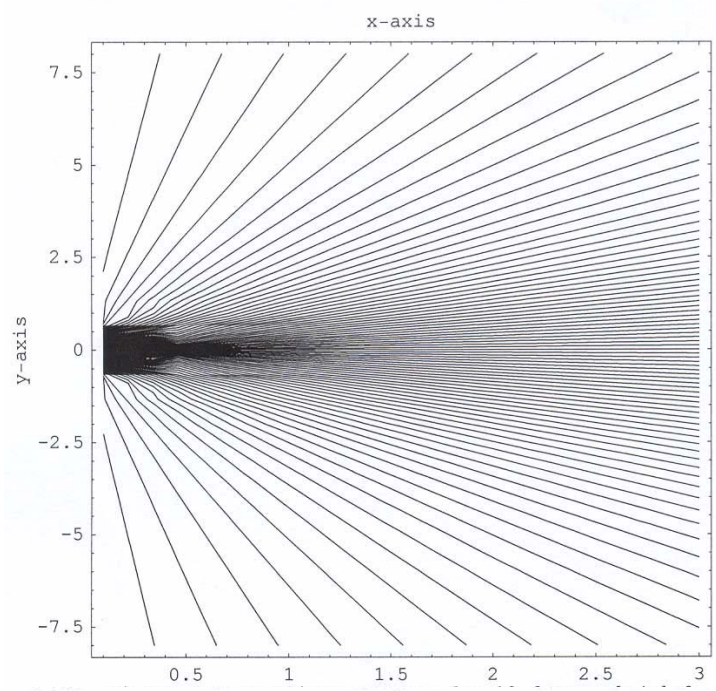

Figure-4:Streamlines pattren for 10-6ArcTan[y/x]=0

4. CONCLUSIONS

Using one parameter group of transformations, the invariants for the Navier-Stroke's equation describing the motion of a compressible fluid of constant viscosity are determined for an arbitrary state equation. These invariants are used to transform the flow equations into a new system of ordinary differential equations whose some exact solutions are determined employing some of the known methods / techniques for the determination of solutions of ordinary differential equations. All the exact solutions involve arbitrary functions or function and this arbitrariness of functions/ function enables us to construct a large number of solutions for the flow equations which are not obtainable through other methods/

techniques. It is indicated that all the exact solutions also hold for the flow of ideal and polytropic gases. For some solutions streamline patterns are also presented.

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ON PLANE FLOWS OF AN INCOMPRESSIBLE FLUID OF VARIABLE VISCOSITY

*Rana Khalid Naeem**

ABSTRACT

In this paper ,we indicate that the equations governing the motion of an incompressible fluid of variable viscosity for an arbitrary state equation possess an infinite set of solutions for the flows characterized by the equation $y = R(x) + C_1\Psi + C_2$ where Ψ is the streamfunction and R(x) the arbitrary function. The streamline patterns for the flows in unbounded and bounded domains are also presented for some forms of the function R(x).

Key words: Incompressible fluid of variable viscosity, plane flows , a class of plane flows, ,plane flows using von-Mises coordinates.

1. INTRODUCTION

The objective of this paper is to indicate that the equations describing the motion of an incompressible fluid of variable viscosity possess an infinite set of solutions for the flows characterized by the equation $y = R(x) + C_1 \Psi + C_2$ where Ψ is the streamfunction, R(x) is the arbitrary function, and C_1 ($\neq 0$) and C_2 are arbitrary constants .To achieve our objective, we treat x and Ψ as the independent variables and recast the flow equations in the von-Mises coordinates system (x , Ψ). von-Mises coordinates are used by many researchers [1-4] to obtain the numerical solutions of the flow equations for inviscid fluids.The paper is organized in the following fashion:In section (2), we transform the flow equations in the von-Mises system (x, Ψ).In section (3), we determine the exact solutions of the flow equations using the method of differentiation and integration [5,6] and present flow patterns for some forms of the function R(x) in unbounded domains and boundary value problems.

2. BASIC FLOW EQUATIONS

The non-dimensional equations describing the steady plane motion of an incompressible of fluid of variable viscosity μ and constant thermal conductivity κ are [7]

$$u_x + v_y = 0 \qquad (1)$$

$$u u_x + v u_y = -p_x + [(2 \mu u_x)_x + (\mu \{ u_y + v_x\})_y] /Re \qquad (2)$$

$$u v_x + v v_y = - p_y + [(2 \mu v_y)_y + (\mu \{ u_y + v_x\})_x] /Re \qquad (3)$$

$$u T_x + v T_y = [T_{xx} + T_{yy}] / Re\, Pr + Ec\, [2\mu (u_x^2 + v_y^2) + \mu(v_x + u_y)^2] / Re \qquad (4)$$

The meaning of various symbols used here are given in nomenclature. On introducing the vorticity ω and the total energy function L defined by:

$$\omega = v_x - u_y \qquad (5)$$

$$L = p + (u^2 + v^2) /2 - 2 \mu u_x / Re \qquad (6)$$

the equations (1-4)can be rewritten as:

$$u_x + v_y = 0 \qquad (7)$$

$$- v \omega = - L_x + [\mu \{ u_y + v_x\}]_y /Re \qquad (8)$$

$$u \omega = - L_y + [- (4 \mu u_x)_y + (\mu \{ u_y + v_x\})_x] /Re \qquad (9)$$

$$u T_x + v T_y = [T_{xx} + T_{yy}] / Re\, Pr + Ec\, [2\mu (u_x^2 + v_y^2) + \mu(v_x + u_y)^2] / Re \qquad (10)$$

In von-Mises coordinates (x , Ψ) , the velocity components u ,v and partial derivatives $(\bullet)_x$, $(\bullet)_y$ are given by

$$u = 1/ y_\psi \quad , \quad v = y_x / y_\psi \qquad (11)$$

$$(\bullet)_x = (\bullet)_x + (y_x / y_\psi) (\bullet)_\psi$$
$$(\bullet)_y = (1/ y_\psi) (\bullet)_\psi \qquad (12)$$

where in above " • " denotes any function. Equations (7-10) ,using Eqs. (11),(12) ,and $y = R(x) + C_1 \Psi + C_2$,are replaced by

$$R'' = - C_1 L_\psi - R' R'' \mu_\psi / Re + C_1 (\mu R'')_x / Re \qquad (13)$$

$$- C_1 L_x + R' (\mu R'')_x / Re + (1 + R'^2) R'' \mu_\psi / C_1 Re = 0 \qquad (14)$$

$$T_{xx} - R'' T_\psi / C_1 - 2 R' T_{x\psi} / C_1 + (1+ R'^2) T_{\psi\psi} / C_1^2 - Re\, Pr\, T_x / C_1 = - Ec\, Pr\, \mu R''^2 / C_1^2 \qquad (15)$$

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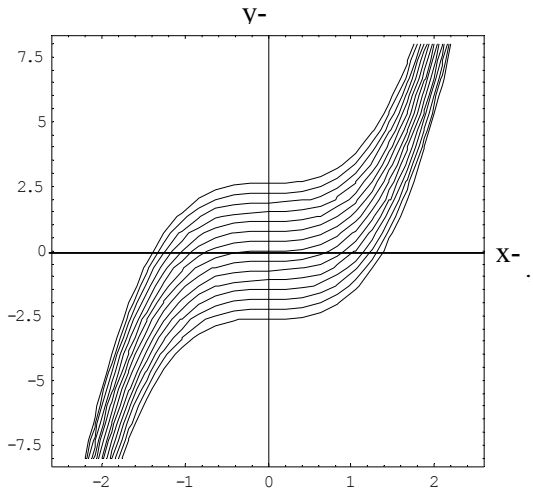

Figure – 1: Streamline pattern for y-x^3=constant (unbounded domain)

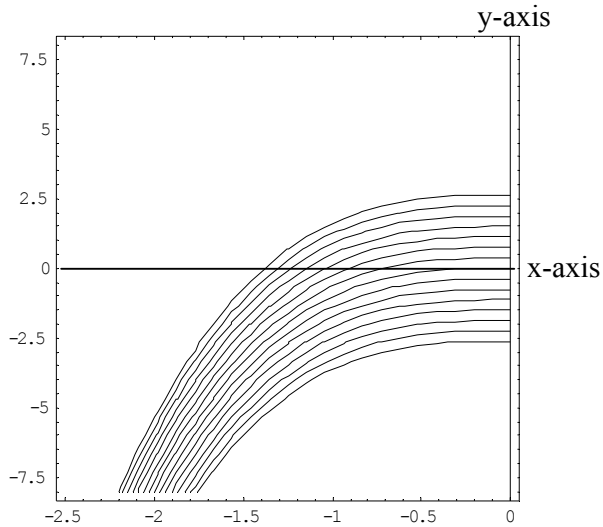

Figure – 2: Streamline pattern for y-x^3=constant for boundary value problem

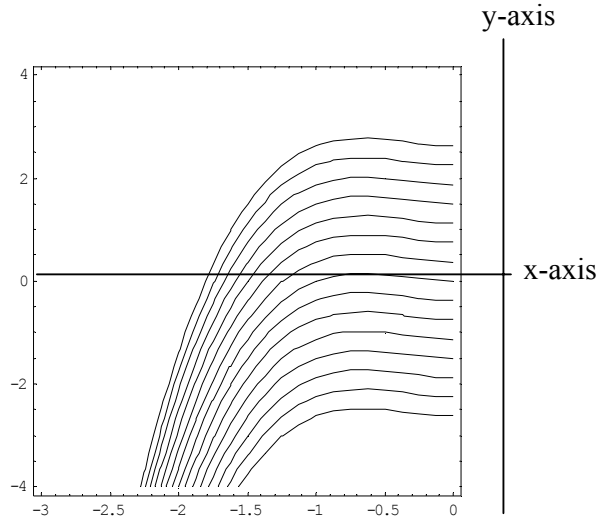

Figure-3: Streamlines pattern for y-x^3-x^2 = constant (unbounded domain)

3. SOLUTIONS

In this section we determine some solutions of the system of equations (13-15).

Equations (13) and (14), on using the integrability condition
$L_{xy} = L_{yx}$, yield

$$R'' \mu_{xx} - 2 R' R'' \mu_{x\psi} / C_1 + 2 R''' \mu_x - [(R' R'')_x + R' R'''] \mu_\psi / C_1 - R'' (1 + R'^2) \mu_{\psi\psi} / C_1^2 + R^{IV} \mu = Re R''' / C_1 \quad (16)$$

Equation(16) is the equation which the function R(x) and viscosity μ must satisfy for the flows characterized by Eq.(11). Once a solution of this is determined, the function L and temperature T are determined from Eqs.(13–15). If we treat Eq.(16) as a partial differential equation in μ the coefficients suggests to assume μ of the form

$$\mu = M(x) + M_1(x) \nu \quad (17)$$

Equation (16), on utilizing Eq.(17), becomes

$$R'' [M'' + M_1'' \nu (\Psi)] - 2 R' R'' M_1' + 2 R''' [M' + M_1' \nu (\Psi)] - [(R' R'')_x + R' R'''] M_1 / C_1 + R^{IV} (M + M_1 \nu (\Psi)) = Re R''' / C_1 \quad (18)$$

where

$$\nu(\Psi) = C_1 \Psi + C_2$$

Since x and Ψ are independent variables, therefore, Eq.(18) holds for all x and Ψ provided:

$$R'' M_1'' + 2 R''' M_1' + R^{IV} M_1 = 0 \quad (19)$$

and

$$R'' M'' - 2 R' R'' M_1' + 2R''' M' - [(R' R'')_x + R' R'''] M_1 / C_1 + R^{IV} M = Re R''' / C_1 \quad (20)$$

The solution of Eq.(19), for $R'' \neq 0$, is

$$M_1 = (C_3 x + C_4) / R'' \quad (21)$$

where C_3 (≠ 0) and C_4 are arbitrary constants .

Substituting Eq.(21) in Eq.(20) and integrating twice the resulting equation, we obtain:

$$M(x) = (\int [\int N(x)\, dx + C_5]\, dx + C_6) / R'' \quad (22)$$

where

$$N(x) = Re R''' / C_1 + 2 R' R'' M_1' + [(R' R'')_x + R' R'''] M_1 / C_1 \quad (23)$$

and C_5 , C_6 are arbitrary constants. Since in Eqs.(21) and (22), the function R(x) is arbitrary, we can generate a large number of expressions for viscosity μ .

The temperature Eq.(15), for viscosity μ defined in Eq.(17), becomes

$$T_{xx} - Re Pr T_x / C_1 - 2 R' T_{x\psi} / C_1 - R'' T_\psi / C_1 + (1 + R'^2) T_{\psi\psi} / C_1^2 = - Ec Pr R''^2 (M + M_1 \nu) C_1^2 \quad (24)$$

We seek a solution of Eq. (24) of the form

$$T = T_1 (x) + T_2 (x) \nu + T_3 (x) \nu^2 + \zeta (\nu) \quad (25)$$

Eq.(15) , on using Eq.(25). , yields

$$N_1(x) + N_2 (x) \nu + N_3 (x) \nu^2 + (1 + R'^2) \zeta'' - R'' \zeta' = 0 \quad (26)$$

where the functions N_1 (x), N_2 (x), N_3 (x) are given in appendix A.

Differentiating Eq.(26) w. r .t ‘ν ‘ , we get:

$$N_2 + 2 N_3 \nu + (1 + R'^2) \zeta''' - R'' \zeta'' = 0 \quad (27)$$

Differentiating Eq.(27) w. r .t ‘ ν ‘ , we get:

$$2 N_3 + (1 + R'^2) \zeta^{IV} - R'' \zeta''' = 0 \quad (28)$$

Differentiating Eq.(28) w. r .t ‘ ν ‘ , we obtain:

$$(1 + R'^2) \zeta^V / R'' - \zeta^{IV} = 0 \quad (29)$$

On differentiating Eq.(29) w. r .t ‘ x ‘ , we get:

$$[(1 + R'^2) / R'']' \zeta^V = 0 \quad (30)$$

This holds for all x and ν (Ψ) provided:

$$(i) \zeta^V = 0 , [(1 + R'^2) / R'']' \neq 0 .$$

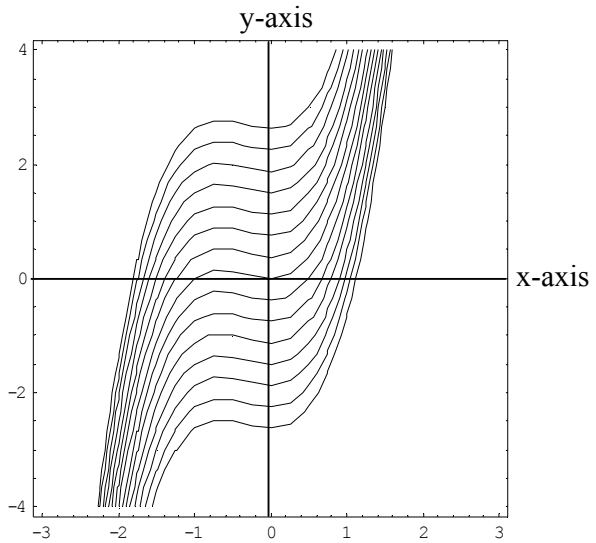

Figure-4: Streamlines pattern for $y-x^3-x^2$ = constant for boundary value problem

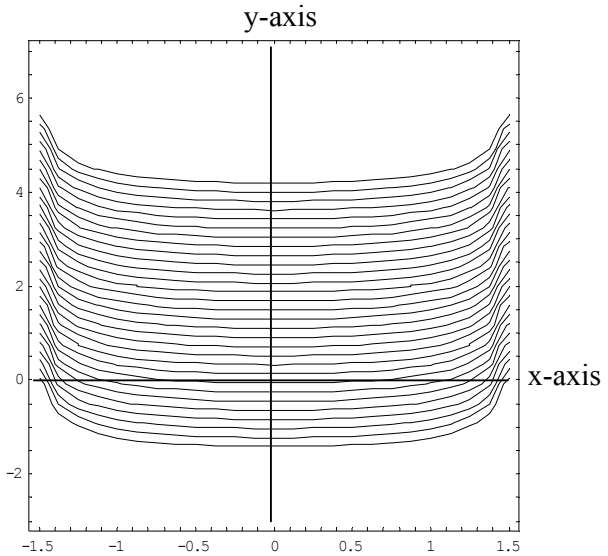

Figure-5: Streamlines pattern for y – log[Secx + 3] = constant for unbounded domain

(ii) $[(1 + R'^2) / R'']' = 0 , \zeta^V \neq 0 .$

We consider these two cases separately.

Case (i) When $\zeta^V = 0$, we get

$$\zeta (v) = C_7 v^4 / 24 + C_8 v^3 / 6 + C_9 v^2 / 2 + C_{10} v + C_{11} \quad (31)$$

where C7 ,C8, C9, C10 ,C11 are constants . Substituting Eq. (31) in Eq.(29), we get

$$C_7 = 0 \quad (32)$$

Equations (32) and (28) , yield

$$2 N_3 - R'' C_8 = 0 \quad (33)$$

The solution of Eq (33), utilizing the expression for N_3 (x) , is

$$T_3 = [\int (C_8 R' / 2 + C_{12}) \exp(- Re Pr x / C_1) dx + C_{13}] \exp(Re Pr x / C_1) \quad (34)$$

where C12, C13, are non-zero arbitrary constants.

Equation (27), on using Eqs. (31-33), yields

$$N_2 = C_9 R'' - C_8 (1 + R'^2) \quad (35)$$

On substituting expression for $N_2(x)$ in Eq. (35) and integrating twice the resulting differential equation , we get

$$T_2 = \int \exp (Re Pr x / C_1) [\int \exp(- Re Pr x / C_1) N_4 (x) dx + C_{14}] dx + C_{15} \quad (36)$$

where

$$N_4(x) = C_9 R'' - C_8 (1 + R'^2) + 2 R'' T_3 + 4 R' T_{3x} - Ec Pr R''^2 M_1 / C_1^2 \quad (37)$$

Finally, utilizing the above results in Eq.(26) and the expression for $N_1(x)$, we obtain

$$T_1 = \int \exp (Re Pr x / C_1) [\int N_5 \exp (- Re Pr x / C_1) dx + C_{16}] dx + C_{17} \quad (38)$$

where

$$N_5 = C_{10} R'' - C_9 (1 + R'^2) + R'' T_2 / C_1 + 2 R' T_{2x} - 2 (1 + R'^2) T_3 - Ec Pr R''^2 M / C_1^2 \quad (39)$$

We note that the function R(x) is still arbitrary and, therefore, we can construct a large number of solutions to the flow equations. In Eqs.(36-38) , C_{14} ,C_{15} , C_{16} ,C_{17} are all non-zero arbitrary constants.

Case (ii) When $[(1 + R'^2) / R'']' = 0$, then

$$R = [\ln \sec (x / C_{18} + C_{19})] / C_{18} + C_{20} \quad (40)$$

where C_{18} ($\neq 0$) , C_{19} , C_{20} are arbitrary constants .

The expression for the function R must satisfy the Eq. (29) and therefore we get:

$$C_{18} \zeta^V - \zeta^{IV} = 0 \quad (41)$$

The solution of Eq.(41) is:

$$\zeta = \exp (v / C_{18}) \{ \int [C_{21} v^3 / 6 + C_{22} v^2 / 2 + C_{23} v + C_{24}] \exp (- v / C_{18}) d v + C_{25} \} \quad (42)$$

where C_{21} ,C_{22} , C_{23} ,C_{24} ,C_{25} are all non-zero constants.

Equation (28) , utilizing Eqs.(40) and (41), yields

$$N_3 = - C_{21} C_{18} R'' / 2 \quad (43)$$

Equation (27),employing Eqs.(40-43) , yields

$$N_2 = - C_{22} C_{18} R'' \quad (44)$$

Substituting the expressions of $\zeta (\Psi)$, N_2 , N_3 in Eq.(26), we get:

$$N_1 = - C_{18} C_{23} R'' \quad (45)$$

On using the definitions of N_1 , N_2 , N_3 from appendix A and after integration , we obtain

$$T_1 = Z_3 [\int Z_3^{-1} \{\int Z_2 dx + C_{31} \} dx] + C_{32} Z_3 \quad (46)$$

$$T_2 = Z_3 [\int Z_3^{-1} \{ \int Z_1 dx + C_{29} \} dx + C_{30}] \quad (47)$$

$$T_3 = - C_{21} C_{18} [\int Z_3 \{ \int R' Z_3^{-1} dx \} dx] / 2 - C_1^2 C_{26} Z_3 / Re^2 Pr^2 + C_1 C_{27} Z_3 / Re Pr + C_{28} \quad (48)$$

In Eqs.(46 –47) ,

$$Z_1 = - C_{18} C_{22} R'' + 2 R'' T_3 + 4 R' T_{3x}$$

$$- Ec\, Pr\, R'' M_1(x) / C_1^2 \qquad (49)$$

$$Z_2 = - C_{18} C_{23} R'' + R'' T_2 / C_1 + 2 R' T_{2x} - 2(1 + R'^2) T_3 - Ec\, Pr\, R''^2 M(x) / C_1^2 \qquad (50)$$

$$Z_3 = \exp(Re\, Pr\, x / C_1) \qquad (51)$$

The solution of Eq.(16) can further be extended by assuming:

$$\mu = M(x) + M_1(x)\nu + M_2(x)\nu^2 \qquad (52)$$

Substituting Eq.(52) in Eq.(16) , we get:

$$X_1(x) + X_2(x)\nu + X_3(x)\nu^2 = 0 \qquad (53)$$

where the functions $X_1(x)$,$X_2(x)$, $X_3(x)$, are given in appendix A.

The solution of Eq.(53), following the same procedure as that of Eq.(18), is given by:

$$M_2 = (a_1 x + a_2) / R'' \quad , R'' \neq 0 \qquad (54)$$

$$M_1 = \{\int [\int L_1(x)\, dx + a_3]\, dx + a_4\} / R'' \qquad (55)$$

$$M = \{\int [\int L_2(x)\, dx + a_3]\, dx + a_5\} / R'' \qquad (56)$$

where

$$L_1(x) = 4 R' R'' M_2' + 2[(R' R'')_x + (R' R''')] M_2' \qquad (57)$$

$$L_2(x) = 2 R' R'' M_1' + [(R' R'')_x + R' R'''] M_1' + 2 R''(1 + R'^2) M_2' + Re\, R''' / C_1 \qquad (58)$$

and a_1 ,a_2 ,a_3 ,a_4 ,a_5 are all non-zero arbitrary constants. We note that the function R(x) in Eq.(54– 56) is arbitrary and therefore we can construct a large number of expressions for viscosity μ and the velocity components u , v .

The form for μ in Eq. (52), suggests to seek a solution of Eq.(15) in the form:

$$T = T_1(x) + T_2(x)\nu + T_3(x)\nu^2 + T_4(x)\nu^3 + \zeta(\nu) \qquad (59)$$

This, on substituting in Eq.(15), we obtain:

$$N_6(x) + N_7(x)\nu + N_8(x)\nu^2 + N_9(x)\nu^3 + (1 + R'^2)\zeta'' - R''\zeta' = 0 \qquad (60)$$

where $N_6(x)$, $N_7(x)$, $N_8(x)$, $N_9(x)$ are given in appendix B.

The solution of Eq.(60) can easily be determined in the same manner as that of Eq.(26) . We mention that the function R(x) in the solution of Eq.(60) also remains arbitrary, and, therefore, we can construct a large number of solutions to the flow equations.

Finally, for the sake of completeness, we consider some forms of the function R(x) and the boundary value problems .When $R(x) = x^3$, the flow pattern in unbounded domain is sketched in Figure 1. The Figure 2 represents the flow pattern for the fluid impinge on a porous wall
x = 0 , satisfying boundary conditions u(0,y) = 1 , v(0, y) = 0. For $R(x) = x^3 + x^2$, the streamline pattern in unbounded domain and for the boundary value problem same as for $R(x) = x^3$ are given in figures (3) and (4) ,respectively. The streamline pattern for the function R(x) defined by Eq.(40) for some values of C_{18} (≠ 0), C_{19}, C_{20} is sketched in figure (5).

4. CONCLUSIONS

It is indicated that the equations governing the steady plane motion of an incompressible fluid of variable viscosity for an arbitrary state equation admit an infinite set of solutions for a class of flows characterized by $y = R(x) + C_1\Psi + C_2$ .Some flow patterns for some forms of the arbitrary function R(x) are also presented in unbounded and bounded domains.

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NOMENCLATURE

u , v	–	velocity components.
x , y	–	cartesian coordinates.
p	–	pressure of fluid.
μ	–	viscosity coefficient.
T	–	temperature
Re	–	Reynolds number.
Pr	–	Prandtl number.
Ec	–	Eckert number.
Ψ	–	streamfunction.
E, F, G	–	coefficients of the fundamental elements.
W, J	–	Jacobin of transformation.
q	–	speed of the fluid
ω	–	vorticity
L	–	energy function.
α	–	angle of inclination.
Γ_{11}^2, Γ_{12}^2	–	christopher symbols.
A , M ,R , M_1, ζ , N , N_1 , N_2 , N_3 , N_4 ,N_5 ,N_6 ,N_7 , T_1,T_2 ,T_3 ,T_4 , Z_1 , Z_2 , Z_3, X_1, X_2 , X_3	–	functions

superscripts

$'$,$''$,$'''$,V, 1V	–	differentiation w .r .t. argument.

subscripts

x, y	–	differentiation w .r .t. cartesian coordinates.
Ψ	–	differentiation w.r.t Ψ coordinate.

APPENDIX - A

$$N_1(x) = T_{1xx} - R'' T_2 / C_1 - 2 R' T_{2x} + 2 (1 + R'^2) T_3 - Re\, Pr\, T_{1x} / C_1 + Ec\, Pr\, R''^2 M / C_1^2$$

$$N_2(x) = T_{2xx} - 2 R'' T_3 - Re\, Pr\, T_{2x} / C_1 + Ec\, Pr\, R''^2 M_1 / C_1^2$$

$$N_3(x) = T_{3xx} - Re\, Pr\, T_{3x} / C_1$$

$$X_1(x) = R'' M'' - 2 R' R'' M_1' + 2 R''' M' - [(R' R'')_x + R' R'''] M_1'$$

$$X_2(x) = R'' M_1'' - 4 R' R'' M_2' + 2 R''' M_1' - 2 [(R' R'')_x + R' R'''] M_2' + R^{1V} M_1$$

$$X_3(x) = R'' M_2'' + 2 R''' M_2' + R^{1V} M_2$$

APPENDIX - B

$$N_6(x) = T_{1xx} - Re\, Pr\, T_{1x} / C_1 - 2 R' T_{2x} - R'' T_{2x} + 2 (1 + R'^2) T_{3x} + Ec\, Pr\, R''^2 / C_1^2$$

$$N_7(x) = T_{2xx} - Re\, Pr\, T_{2x} / C_1 - 4 R' T_{3x} - 2 R'' T_{3x} + 6 (1 + R'^2) T_{4x} + Ec\, Pr\, R''^2 M_1 / C_1^2$$

$$N_8(x) = T_{3xx} - Re\, Pr\, T_{3x} / C_1 - 6 R' T_{4x} - 3 R'' T_{4x} + Ec\, Pr\, R''^2 M_2 / C_1^2$$

$$N_9(x) = T_{4xx} - Re\, Pr\, T_{4x} / C_1$$

THE IMPORTANCE OF TRADITIONAL KNOWLEDGE AND ITS INFORMATION-SYSTEM FOR PAKISTAN

Tariq Mahmood and Sobia Sarwar**

ABSTRACT

Traditional knowledge (TK) refers to the knowledge, innovations and practices of indigenous and local communities around the world. Traditional knowledge is mainly of a practical nature, particularly in fields such as agriculture, fisheries, health, horticulture and forestry. With the coming into force of the Convention on Biological Diversity (CBD), the need for the protection of traditional knowledge has received increased attention. One mechanism with much potential to protect traditional knowledge is its documentation in databases and registers. The rights of TK holding communities are also of considerable importance and are well-protected in some countries like India and China. Pakistan has a rich cultural and traditional background. There must be a database in the form of a Digital Library and legislation for proper preservation and protection of TK to use it as a developmental tool for sustainable socio-economic progress.

This paper highlights the importance of TK for Pakistan, as well as policy issues to document and protect the rights of TK-holding communities.

1. INTRODUCTION

The study of human knowledge is as old as history of human beings itself. It has been central to the subject matter of philosophy and epistemology since the Greek period. Knowledge has also begun to gain a new wave of attention in recent years. Human- knowledge systems are classified into two kinds: formal scientific knowledge (SK) system and traditional knowledge (TK) system. The main difference between these two kinds of knowledge-systems is their format. The SK system is essentially in explicit format that can be articulated in formal language including grammatical statements, mathematical expressions, specifications, manuals, and so forth. This kind of knowledge, thus, can be transmitted across individuals formally and easily. This has been the dominant mode of knowledge according to the (western) scientific philosophy. However, the format of TK system is mostly tacit that is hard to articulate with formal language. This knowledge is embedded in the experiences of indigenous or local people and involves intangible factors, including their beliefs, perspectives, and value-systems[8].

Traditional knowledge may be denoted mainly as a tacit type of knowledge that has evolved within the local (grass root) community and has been passed on from one generation to another; it encompasses not only local or indigenous knowledge, but also scientific and other knowledge gained from outsides.

For countries that are rich in traditional knowledge like Pakistan, the protection, promotion, and development of such knowledge can add to their competitive advantage. The long-term sustainable development of indigenous and local communities depends, at least to some degree, on the communities' abilities to harness their traditional and local technologies[4].

1.1 Background: A number of cases relating to traditional knowledge have attracted international attention. As a result, the issue of traditional knowledge has been brought to the fore of the general debate surrounding intellectual property. These cases involve what is often referred to as "biopiracy". The examples of turmeric, neem and ayahuasca illustrate the issues that can arise when patent protection is granted to inventions relating to traditional knowledge that is already in the public domain. In these cases, invalid patents were issued because the patent examiners were not aware of the relevant traditional knowledge. In another example, a patent was granted on a plant specie called Hoodia. Here, the issue was not whether the patent should or should not have been granted, but rather on whether the local people known as San, who had nurtured the traditional knowledge underpinning the 'Invention' were entitled to receive a fair share of any benefit arising from commercialization.

Partly as a result of these well-known cases, many developing countries, holders of traditional knowledge, and campaigning organizations are pressing in a multitude to protect traditional knowledge in a better way. Such pressure has led, for example, to the creation of an inter-governmental committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore in World Intellectual Property Organization (WIPO). The protection of traditional knowledge and folklore is also being discussed within the framework of the Convention on Biological Diversity (CBD) and in other international organizations such

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as United Nations Conference on Trade and Development (UNCTAD); World Health Organization (WHO); Food and Agriculture Organization (FAO), and United Nations Educational, Scientific and Cultural Organization (UNESCO)[11]. In addition, the Doha WTO Ministerial Declaration highlighted the need for further work in the TRIPS Council on protecting traditional knowledge[6].

2. THE IMPORTANCE OF TRADITIONAL KNOWLEDGE

Traditional knowledge as national asset is an important source of income, food, and healthcare for large parts of populations, particularly in developing countries[4].

Traditional Medicine (TM) serves the health needs of a vast majority of people in the world. According to the World Health Organization (WHO), up to 80 percent of the world's population depends upon traditional medicine for its primary health-needs[4]. For instance, the per-capita consumption of TM-products is, in Malaysia, more than double as compared to modern pharmaceuticals. TM is also significant in more advanced developing countries, such as South Korea, where the per-capita consumption of TM-products is about 36% more than modern drugs. It is often the only affordable treatment available to poor people and to people in remote communities[1]. In India, for example, there are 600,000 licensed medical practitioners of classical traditional health systems and over one million community-based traditional health-workers[4].

TM also plays a significant role in developed countries, where the demand for herbal medicines has grown in recent years. The world market for herbal medicines has reached, according to one estimate, US$43 billion, with annual growth rates of between 5 and 15%. For China, the leading country in this field, WHO estimates TM-generated income of about $5billon in 1999 from the international and $ 1 billion from the domestic market. The European market in 1999 was calculated to be $ 11.9 billion (where Germany had 38%, France 21% and United Kingdom 12%). Moreover, many pharmaceutical products are based on, or consist of, biological materials[10].

Studies of local communities also provide evidence that the conservation and the use of traditional knowledge can provide significant environmental benefits[4]. The use and continuous improvement of farmers' varieties (landraces) is essential in many agricultural systems. In many countries, seed supply fundamentally relies on the "informal" system of seed-production, which operates on the basis of the diffusion of the best seed available within a community[10].

Furthermore, TK is the origin of a great variety of artistic expressions, including musical works and handicrafts which are important parts of a community's heritage, and cultural patrimony can act as a source input into other markets, such as entertainment, art, tourism, architecture, and fashion[4].

The importance of TK for its creators and for the world community at large, and the need to foster, preserve and protect such knowledge, has gained growing recognition in the international fora. Thus, in 1981 a WIPO-UNESCO Model Law on Folklore was adopted; in 1989 the concept of "Farmers Rights" was introduced in the FAO International Undertaking on Plant Genetic Resources; in 1992 the Convention on Biological Diversity (CBD) specifically addressed the issue [(article 8(j)]. In 2000, an Inter-governmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore was established by the World Intellectual Property Organization (WIPO) and it first met in April 2001[1].

For Pakistan where 66.5% of the population lives in rural areas and 38.5% of population lives below poverty line the importance of TK greatly increased for sustainable development[10].

3. PROTECTING TRADITIONAL KNOWLEDGE

In Article 8(j), the CBD requires Parties to "respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity" and promotes the "wider application" of traditional knowledge with the approval and involvement of the holders of traditional knowledge. Article 10(c) similarly provides that CBD Parties "shall...protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements." The TRIPS Agreement and other international

agreements on intellectual property rights, by contrast, fail to recognize the value of traditional knowledge as a source of innovation. These instruments were designed mostly to protect "western" forms of innovation and do not provide adequate mechanisms that address the special nature of traditional knowledge.

Current trends show an increasing number of national laws providing direct or indirect protection for traditional knowledge. Establishing mechanisms exclusively designed for protecting traditional knowledge, including sui generis systems, provides direct protection. Indirect protection occurs as a consequence of more general laws oriented towards the protection of indigenous rights or laws regulating access to genetic resources. These particular trends should be supported by the international community because they favor a bottom-up approach when providing protection and permit more direct participation of indigenous and local communities in their national context[12].

3.1 Pakistan's Status: Pakistan is a signatory of many international agreements like Paris Convention (2004), Berne Convention (1948) and TRIPS Agreement (1995). It was after GIs came under WTO agreement on TRIPS that Pakistan started its efforts to develop a legislative framework for the registration and protection of products and traditional skills originated within Pakistan.

At present Pakistan Trade Mark Ordinance 2001 (promulgated but has not come into force yet) is the sole document for the protection of geographical indicators and other indigenous products. To improve its Intellectual Property Rights Regime, Geographical Indications of Goods (Registration and Protection) Ordinance, was drafted in 2001. In July 2006, a two day national workshop on GIs was organized by EU, IPO and WIPO to propose amendments to upgrade it as per the international requirement[9].

Apart from treaties and emerging international norms, which imply both legal and moral imperatives for protecting traditional knowledge, there are a number of reasons why developing countries like Pakistan may feel motivated to protect TK. These are set out below:

- To improve the livelihoods of TK-holders and communities
- To benefit national economies
- To conserve the environment
- To prevent biopiracy

There are ample reasons for the government to take steps to legally protect traditional knowledge (Table 1). However, it cannot be emphasized enough that protection of TK cannot satisfactorily be dealt with in isolation from the more fundamental needs, interests and rights of the holders of traditional knowledge, innovations, practices and technologies and their communities[2].

4. THE INFORMATION SYSTEM

The nature of traditional knowledge is such that more of it is transmitted orally rather than in written form. This poses particular problems when parties not authorized by the holder of that knowledge seek to obtain IPRs over it. In the absence of any accessible written record, a patent examiner in another country is unable to access documentation that would challenge the novelty or inventiveness of an application based on traditional knowledge.

Table - 1: Reasons to protect TK

REASONS		
Moral	**Legal**	**Utilitarian**
To fulfill moral obligations towards indigenous/local Communities	To comply with international treaties and emerging norms e.g. CBD,Universal Declaration of Human Rights(UDHR), International Undertaking on Plant Genetic Resources(IUPGR)	For local economic, welfare (health and food security) and subsistence benefits
To prevent biopiracy		For national economic and welfare benefits
		For global economic and welfare benefits
		For improved sustainable management of biodiversity and conservation

The use of Information System as an instrument can provide a solution. There is a need for developing digital databases of prior art related to herbs, which is already under public domain. It is assumed that if the materials / knowledge is documented; it can be made available to patent examiners the world over. It is also hoped that such documentation would facilitate tracing of indigenous communities with whom benefits of commercialization of such materials/knowledge has to be shared. A good example of the use of information system is The Museum of the Word and Image described by Santiago, the founder, as "a museum without walls". The museum is actually a mobile exhibition and website (www.museo.com.sv) aimed at Salvadorians abroad, documenting the history and culture of people of El Salvador. The first exhibition was set up in an international consumer fair organized by the American Embassy in San Salvador, and showed traditional dances and rituals, arts and crafts and oral histories next to stalls with the latest technology and consumer goods. Santiago comments: "By being a mobile museum we can go to places where no cultural activities normally take place. We also encourage people to document their own local histories, to construct a real, rather than distorted memory, and a sense of identity and belonging – a sense of self and of society, which is not blinded by attempts to ape the US… It is based on a firm belief that if you lose your memory you lose your social vision"[3].

Pakistan is endowed with immense traditional knowledge, which is either undocumented or available in ancient classical and other literature, often inaccessible to the Information Managers and Patent Examiners. Documentation of this existing knowledge, available in the public domain, on various traditional systems of medicine has become imperative to safeguard its sovereignty and protect it from being misused in patenting of non-original inventions.

5. TRADITIONAL KNOWLEDGE DIGITAL LIBRARY

Recent efforts have been made to develop a TK classification and to create a Traditional Knowledge Digital Library (TKDL) with the goal of enhancing the quality of patent examination and allowing patent examiners access to pertinent information concerning prior art in the form of TK in an appropriately classified form. These issues were taken up at WIPO during 1998 and 1999[4].

An initiative was spearheaded by the Department of Indian Systems of Medicine & Homeopathy (ISMH). It set up an inter-disciplinary task force, known as the TKDL Task Force, drawing on experts from the Central Council of Research of Ayurveda and Siddha, Benares Hindu University, the National Informatics Center, the Council of Scientific & Industrial Research and the Controller General of Patents and Trade Marks. The Task Force evolved a Traditional Resource Classification (TKRC), which would enable retrieval of certain information on traditional knowledge in a systematic manner[4].

The WIPO Member States have set up a Traditional Knowledge Task Force consisting of China, the European Union, Japan, India and the United Sates of America. The Indian proposal on creating a TKRC was presented to it[4].

Documentation, however, will not ensure benefit sharing with the holders of such knowledge. It may even foreclose that possibility, to the extent that the documented knowledge is deemed part of the prior art[4].

In case of Pakistan there is no such digital database or library. There is a need of TK documenting surveys and databases. One step in this direction is the creation of TKDL for SAARC countries.

5.1 Creation of TKDL for SAARC Countries: Keeping in view the importance of documentation of TK in the region SAARC Documentation Center arranged a two-day workshop on 'creation of TKDL for SAARC countries' in December 2004 in New Delhi. The workshop was attended by delegates from all member countries except Pakistan. The key issues that were discussed include creation of draft Legal and Policy Frameworks for TK protection in SAARC Countries and developing a Technical Framework for Creation of TKDL for SAARC Countries that have emerged as the major recommendations of the workshop[7].

6. POLICY RECOMMENDATIONS

Future action in this field may thus include:

- To protect TK, national legislation is needed. This should be followed by negotiations at the international level for an international agreement to protect TK and the rights of local communities.
- Disclosure, informed consent and equitable

benefit sharing in accordance with CBD, should be mandatory for any commercial use of TK and genetic resources. Concrete and specific methods of sharing benefits should be worked out in the event of commercialization.

- Develop an interface between community, industry and national authority to work out these modalities.
- There is need for a greater investment in research in TK by both the government and the private sector.
- To create awareness in society about the value of TK, a system of rewards and recognition for creators and holders of TK should be developed.
- We can promote intellectual and cultural exchange, community development and legitimate trade, by safeguarding our traditional cultures and cultural diversity.

7. SUMMARY & CONCLUSION

Traditional Knowledge (TK) is a valuable and sophisticated knowledge-system developed over generations by local communities in various parts of the world. TK has been developed in many fields and is still evolving. It is a technology or know-how capable of providing sustainable solutions to many present-day problems. This fact should be acknowledged and the commercial use of TK should be handled in the same way as the other technologies.

The importance and protection of Traditional Knowledge for a developing country like Pakistan raises a number of policy issues. Such issues are extremely complex, since there are broad differences about the definition of the subject-matter, the rationale for protection, and the means for achieving its purposes. The issues relating to TK should be addressed in a holistic manner, including ethical, environmental and socio-economic concerns of the use of such knowledge[5].

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