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Pakistan – Role of Education For A Sustainable Future

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PAKISTAN-ROLE OF EDUCATION FOR A SUSTAINABLE FUTURE

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I. INTRODUCTION

1. I feel very privileged to have been asked to deliver this lecture. I would like to thank the Governor of the State Bank of Pakistan, Muhammad Yaqub, and the committee for the Zahid Husain Memorial Lectures for the privilege to speak to you and to expose my biases to your critical scrutiny.

The subject is the *Role of Education* in ensuring **sustainability** for our beloved Pakistan. I will talk about a future that all of us want and the children of today would need.

I am aware that talking about the "future" at this time may appear surreal when Pakistan is standing at a cross-road and undergoing political and economic turmoil. My hope is that the messages that I present would be relevant for our needs of today. All that we have is today.

2. **"Sustainability"** as a technical term entered our vocabulary in 1987 with the publication of the (Brundtland) Report of the World Commission on Environment and Development. The Commission defined "Sustainability" *as use of resources by the current generation in a way that it does not reduce the capability of future generations.*

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* Director, Learning and Leadership Center, World Bank. This paper relies heavily on work done in the World Bank, but only reflects the views of the author, and not of the World Bank or its affiliated Organizations.

All action or lack of it is thus with the current generation. Today's conditions, whatever they are, have, therefore, to be taken as the starting point for ensuring or failing to ensure **sustainability.**

The Human Development Report (HDR, 1993) defines sustainability as development:

- **of the people**
- **for the people**
- **by the people**

• The first means investment to improve human capabilities—education, health, employment experience—so they can be productive and creative;

• The **second** means ensuring that the economic growth that results is shared widely and equitably;

• The t**hird** means improving participative and consultative (i.e. democratic) process in ensuring the first and second above.

3. Both the Brundtland Commission and HDR definitions of **sustainability** highlight human capabilities as the ultimate source of growth. Other forms of capital[1]—natural and Physical—may play a complementary role in the growth process, but it is "**human capability or human capital**" and "**growth**" which are described as the fountains for **sustainability.**

Thus education for and maintenance of health of the citizens of a country are defined to be central for ensuring sustainability.

This is the thesis I will attempt to develop.

Within education I will argue that scientific and mathematical literacy is a specially important ingredient—actually a necessary component if there is to be sustainability for Pakistan in the 21st century.

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[1] It is to be noted that the Brundtland Commission's definition does not use the concept of "maintenance of capital" in defining the conditions for sustainability; it uses "human capability" as the operational concept.

This is not to imply that primary, secondary, vocational and non-science tertiary education are not important.

And given our low levels of adult literacy universal primary and secondary education are essential for national revival. The whole educational system is important. Balance in the education system would require actions on all components.

I have chosen to emphasize science and mathematics as specially important at this time in our history, because these would provide the **solutions** and the **resources** for the tasks ahead.

I will argue that serious "**inequality of opportunity for developing capability**" within nation states significantly reduces the prospects for sustainability.

4. I will thus talk about two relationships which bear strongly on achieving a sustainable future for Pakistan:

- Link between inequality and sustainable development;
- Role of science and technology in reducing inequality and for generating the resources for shared growth.

These translate into two related hypotheses: (1) significant "**capability**" inequality within and among nations (given **globalization**) is a binding constraint to achieving sustainability; and (2) education generally, but scientific education specifically is a sine qua non for reducing intra-and international "**capability**" inequality.

5. I have borrowed heavily from the work[2] of Dr. Abdus Salam—the scientific pride of Pakistan and our only Nobel Laureate (in Theoretical Physics). I have also borrowed from the literature[3] on Environmental and development issues produced by UN, World Bank, UNEP and the (U.S.) National Academy of Sciences.

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2 Abdus Salam, "*Notes on Science, Technology and Science Education in the Development of the South*". Published by the Third World Academy of Sciences for the 5th Meeting of the South Commision, 1989.

3 "*One Earth, One Future*". Publication of The National Academy of Sciences Washington, D.C., U.S.A. 1990.

II. LEVELS OF SUSTAINABILITY

6. Operationally, "sustainability" has been defined to have three levels—**weak, sensible** and **strong**—depending on how strictly one chooses to use the concept of maintenance of capital.

Weak sustainability is maintaining total capital intact without regard to its composition (natural, man-made, or human).

Sensible sustainability requires that the composition of total capital be balanced in some defensible way. Thus oil may be depleted as long as the receipts are invested in, for example, human capital. Judgment on balanced composition requires definition of critical levels of each type of capital, beyond which concerns about substitutability could arise. This assumes that man-made and natural capital are to some extent substitutable.

Strong sustainability requires maintaining the three kinds of capital separately intact. This assumes that in most production functions natural and man-made capital would be complements not substitutes. A saw-mill (man-made capital) is worthless without the complementary natural capital of a forest and the human capital invested in mill operators with forest management personnel.

Our knowledge about the relationship between human activity and maintenance of "capital" is fragmentary. We need to make greater scientific efforts to understand these connections in order to create more favourable environmental outcomes and thus improve the prospects for sustainability.

A key question that we may ask for Pakistan is;

What should we seek: weak, sensible or strong sustainability?

I would submit that at the end of 1996 a point between **sensible and strong** would be appropriately ambitious for us to aim as we prepare to enter the next millennium. The reason is simple: it will be irresponsible to take risks with respect to the next generation and those not yet born.

III. WHAT IS THE WORLD'S ENVIRONMENTAL STATUS TODAY?

7. Humans have not trodden softly on planet earth. The effect of human activity is pervasive and is transforming the surface of the earth such that in many places its original state is lost forever. It is ironical that this wholesale mutation has been caused by both increasing poverty (i.e. land degradation) as well as by increasing affluence (air pollution, ozone layer hole). By now the effect is global so that most peaple from the developed countries realize that their world, and their children's futures, may be jeopardized by unchecked deterioration of the environment. The poor of the world do not fully comprehend the extent of the danger that they and their children face as they struggle to survive every day. This scale of change is unequalled in human history.

In just one generation (i.e., since 1970) the world has lost nearly 200 million hectares of tree cover, an area roughly the size of the United States east of the Mississippi. Thousands of plant and animal species no longer exist. And the world farmers lost an estimated 480 billion tons of topsoil, roughly equivalent to the amount of India's cropland. Air pollution has reached health threatening levels in hundreds of cities. The amount of carbon dioxide, the principal greenhouse gas in the atmosphere, is rising 0.4% per year from fossil fuel burning and deforestation. While no one can be precise about timing, we know that climate change will occur unless national energy policies are modified. National accounting systems do not display the environmental debts being incurred by this generation. Will we continue to behave as the "dictator-generation" with respect to "all future generations", i.e., unconcerned about "their needs and claims" on the resources of planet earth? As Herman Daly put it succinctly "There is something fundamentally wrong in treating the earth as if it were a business in liquidation".

8. Two types of transformations of the earth have affected the global environment: changes in how humans use the land, most notably for agriculture, and changes in industrial capabilities. During the past three centuries, as the area of land under agriculture expanded, humans increasingly adapted land to suit their own purposes. The land area devoted to cropland has expanded by over 400 per cent in the past 300

years, amounting to a world increase of about 12.5 million square kilometers (i.e. 25% larger than the area of China or Canada). The net loss of forests due to human action amounts to approximately 8 million square kilometers (or about the area of Brazil). Over this period, the population of the 40 largest urban areas increased 25-fold and urban uses of land increased even faster. These changes drastically altered the earth's surface, the energy balance, the hydrologic cycle, the emissions of biologically produced gases to the atmosphere, and the vegetation.

9. Similarly, growth of industry and expanded use of fossil fuels had a noticeable effect on a global scale through pollutants introduced into the troposphere and even the stratosphere. The most well known effect of this pollution is the destruction of ozone in the stratosphere through chlorofluorocarbons (CFCs) which were invented in 1930 and were hailed as safe alternatives to ammonia. At that time scientists could not imagine that "safe and stable" CFCs would punch a hole in the ozone layer which has provided a natural shield from solar ultraviolet radiation, or that CFCs would contribute to global warming.

10. Global warming is feedback from the earth's ecological system. So are the ozone hole, acid rain in Europe and eastern North America, soil degradation in the world, deforestation and species loss in the tropical forest zone. These are the faces of global change but none of these would have been even noticed if world class scientists had not been studying and observing the ecological system. To demonstrate the importance of the scientist let me illustrate the complexity of the investigative process by briefly describing how the hole in the ozone layer was discovered by humankind.

IV. CHEMISTRY OF THE OZONE LAYER[4]

11. Until the hole was discovered, scientists believed that they understood the chemical proceses at work in the ozone layer. Oxygen molecules (O^2), abundant throughout the atmosphere, are split apart into individual atoms (O—O) when energized by radiation from the sun. These atoms are free to collide with other O^2 molecules to form ozone

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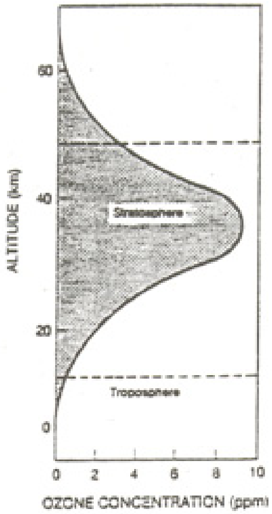
4 This description is from *"One Earth, One Future"*, published by the National Academy of Sciences Washington, D.C., U.S.A., 1990.

(O^3). The particular configuration of the ozone molecules allows them to absorb the sun's radiation in ultraviolet wavelengths that are harmful to life if they penetrate to the earth's surface. The ozone molecules formed by collision are partially removed by other naturally occurring chemical reactions, and so the overall concentration of stratospheric ozone remains constant. High above the stratosphere, the density of gases is so low that oxygen atoms rarely find other molecules to collide with, and so ozone does not form in abundance. Below the ozone layer too little solar radiation penetrates to allow appreciable amounts of ozone to form. Thus most of the world's ozone is in a stratospheric layer bulging with ozone at altitudes from 25 to 35 kilometers.



Ozone is found in varying concentrations from the earth's surface to a height of some 60 kilometers. Its concentration increases sharply in the stratosphere. Maximum ozone concentrations occur at a height of 25 to 35 kilometers but even here never exceed about 10 parts per million by volume. (Adapted from U.N. Environment Programme. 1987. *The Ozone Layer*, Fig. 2, p. 9. Copyright © 1987, U.N. Environment Programme.)

12. Closer to the ground, in the troposphere, ozone produced through a series of chemical reactions involving hydrocarbons and nitrogen oxide emissions from vehicles and industrial activity is an effective greenhouse gas. Thus ozone plays two very different roles in global environmental change: one in the stratosphere as a shield against harmful ultraviolet radiation and another nearer the ground in the troposphere as a greenhouse gas and a health hazard.

13. Atmospheric chemists studying chlorine released into the atmosphere from industrially produced chlorinated molecules found that natural mechanisms for their removal are not known. Researchers observed in 1974 that stable CFCs rise unchanged through the troposphere and are dispersed so that there are as many CFC molecules over Antarctica as over Washington, D.C. Researchers hypothesized that upon reaching the stratosphere, the CFCs encounter high-energy ultraviolet light, which breaks them down, releasing their chlorine atoms, the chlorine atoms then engage with ozone in a catalytic reaction in which each chlorine atom destroys up to 100,000 ozone molecules before other chemical processes remove the chlorine from the atmosphere. The hypothesis was borne out and improved by measurements and observations. In 1970 chlorine was

present in the stratosphere at 1.2 parts per billion, but in 1985 it more than doubled to approximately 3 parts per billion.

V. OZONE LAYER AND LIFE

14. The ozone layer is essential to life because it shields it from damaging ultraviolet radiation. Researchers are now studying how humans vegetation and aquatic ecosystems each are being affected by ozone depletion. We have learned that direct exposure to ultraviolet radiation can damage the human immune system, cause cataracts, and increase the incidence of skin cancer. Researchers have tested numerous plant species which show sensitivity to increased ultraviolet exposure. Soybeans are particularly susceptible to ozone damage as are members of the bean, pea, squash, melon, and cabbage families. Plant responses to ultra violet radiation include reduced leaf size, stunted growth, poor seed quality, and increased susceptibility to weeds, disease, and pests. Scientists are also in the early stages of understanding how ultraviolet radiation might affect marine ecosystems and animals.

15. This is what scientific investigation and scientists gave to all humankind. The scientific consensus that CFCs deplete the ozone layer prompted nations to come together leading to the Montreal Protocol (in 1987) on Substances that Deplete the Ozone Layer. This protocol calls for a 50 per cent reduction in CFC production from 1986 levels by 1999. The Montreal Protocol has proven to be a model for actions that span national boundaries and interests as the world addresses common environmental issues such as greenhouse warming and other forms of global change. Three other protocols have followed. They are perhaps the best illustration of the central role of scientific information and scientists in discussions about policies to manage transboundary environmental issues. Their other, equally important, role is to provide solutions for "national" and "local" problems and provide the basic knowledge for technology development. This role is central to economic growth and is fully recognized by industrialized countries, but not as well by the developing world.

VI. PAKISTAN'S CHALLENGES FOR SUSTAINABILITY

16. The environmental problems of the world are interlinked scientifically and politically. Scientifically, their resolution requires an under-

standing of the physical, chemical, and biological processes that govern the earth, and of the interaction of these processes in the entire earth system. Politically, policy options to address these problems converge on the need for internationally accepted actions relating to energy, technology, land use, and economic development. These issues are large and are challenging world political leadership. National actions and international cooperative action is needed to address these transboundary problems.

17. In this context, let me submit that the consequences of global and local environmental changes for Pakistan need more attention than they have, so far, been given. This is partly because we, as a nation, are struggling with the challenges of today and seem to be incapacitated by the weight of poverty. It is also partly due to our limited domestic scientific capability which appears inadequate for the challenges of sustainability.

18. To illustrate the magnitude of Pakistan's growth and environmental challenges let me describe the current picture in terms of:

- Environmental mis-management (Table-1)
- Profile of human deprivation (Table-2) and
- Resource use imbalances and extent of inequality (Table-3)

The highlights are:

- **The annual environmental cost** from air and water pollution and land degradation exceeds **US$2.2 billion.** This is about 4% of Pakistan's GNP. The people impact is in tens of million.

- The **profile in human deprivation** affects most of the country's population. The biggest deprivation is, of course, **illiteracy** which **afflicts 85 million** people and closes many options for the poor. Close to **40 million,** one third of the total, **live in absolute poverty.**

- **Inequality of income is extreme.** The ratio between the income shares of the top and bottom quintiles is six. In a comparison with India, Indonesia and Bangladesh—**Pakistan has the highest level of inequality.**

• Pakistan also spends the **largest fraction of its GNP on Defense.** Perhaps, it is necessary in our geopolitical environment, but this bears re-examination, given our inequality and our poverty.

19. Let me also highlight two of Pakistan's most serious environmental deteriorations: salt balance in the Indus Basin; and watershed erosion in the catchment areas of our rivers systems. Together these two are destroying our most precious resource, i.e. the integrated irrigation system of the Indus Basin which feeds us and provides the bulk of our export earnings.

The **salt balance** issue springs from the relatively straight forward arithmetic that unless the outflow of salts out of the Indus Basin equals or exceeds the salts flowing into the Basin, salt accumulation would occur in the Basin. If such accumulations occur, then it is only a matter of time before salt accumulation in the soil and the underground aquifer becomes intolerable to plants and life as it is known today. The Indus basin system is unique in that it has virtually no return flow of subsurface drainage water—effluents from canal commands remain[5] in the canal commands. In gross terms, about 25 million tons of dissolved salts enter the Indus Basin annually, about seven million tons are (presently) discharged into the sea, leaving a net annual addition of 18 million tons to the canal commanded area. This amounts to 1000 lbs per acre per year—an insignificant annual increment, but adding up to significant proportions with the passage of time.

20. The salt balance arithmetic of the presently usable ground water areas deserves special mention in this context. So far, human reclamation efforts or natural processes have essentially moved soil salts from the upper soil layers to either below the root zone or into the aquifer itself. As more surface water is brought into these areas and/or ground water is recirculated without providing effective salt drainage the soils or the aquifer continue adding to their prior accumulations of salt. This positive salt accumulation process has to be stopped or slowed down; if neither is done, these areas would eventually become saline ground water areas. So far, drainage projects (SCARPs) in usable ground water areas have only

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5 Minor exceptions are the Swat Canals, the Right Bank Canals of Guddu and Sukkur Barrages, Khairpur Scarp, and the Chaj Saline zone scarp.

attempted to address water balance issues i.e. lowering the water table. In the longer term view, the salt balance issue acquires cardinal importance. The on-going construction of the Left Bank outfall drain is the first effort to export salt from the basin into the sea. We have just began to scratch the surface of this environmental issue.

21. In the northern catchment areas of the Indus and Jhelum, **watershed erosion** has been a recognized issue for quite some time, but little authoritative data are available on the rates of watershed erosion and their likely effects on Kharif and Rabi river flows and on the siltation of the rivers and reservoirs. Since human populations inhabit watershed areas, erosion control has a more immediate imperative—as it deals with the problem of poverty in the uplands, which is partly the result of misuse of watershed areas though over intensive farming on steep slopes. Over grazing of range lands, and removal of forest undergrowth. Loss of vegetation in low rainfall hilly areas through uncontrolled grazing has not only reduced the carrying capacity of the land for livestock, but has led to loss of top soil, in some cases down to bedrock, and has increased rainfall runoff rates, aggravating flooding downstream. In many areas this process may already have gone beyond the point of reversibility.

VII. PAKISTAN'S SCIENTIFIC MANAGERIAL CAPABILITY

22. These **environmental, inequality** and **resource-use imbalance** challenges would be formidable for any nation. They are huge for Pakistan. What scientific, managerial and technical capabilities do we have as a nation to meet these challenges?

I have chosen to focus on **scientists and engineers** who are the technical problem solvers and managers of the nation's resources. It is through this "group" that present industrial countries (older and the newer) have accomplished economic transformation. If a society is to become self-reliant it is essential that the **problems** of its **agriculture,** of its **local pests** and **diseases,** of its **local materials base,** of its **environment, water bodies, soil mass, salt balance, watershed erosion, energy production, industrial production, be solved locally.**

Pakistan's scientists/engineers population is about 290 thousand. Of those, only **seven thousand,** or less than 3% of the total, are engaged in research and development. This translates to 58 scientists/engineers per million of population. In comparison, India has 150; Indonesia 170; Korea 2000; Germany 4000; and Japan 5700. That is, Japan's **scientific/ engineering capability** is about 100 times that of Pakistan. **India's is three-fold** and **Korea thirty-fold.** In addition, the proportion of the **scientist/engineering workforce engaged in research** and development **is half that of India or Indonesia** (Table-4).

23. The above was quantitative capability comparison. For making a **"quality of capability"** comparison we would use the **"number of scientific journal articles published[6]"** as a proxy. Pakistan's share of **"mainstream science journal articles"** (in 1994) was **0.06 per cent.** This rate is one fourth of Turkey; one-tenth of Brazil; one-thirtieth of India (Table-5). These inter-country comparisons are meant to indicate the extent of the **"quantitative"** and **"qualitative"** effort that Pakistan has to make to join the ranks of those who have succeeded in the 20th and are likely to retain that lead in the 21st century.

VIII. DOMESTIC SCIENTIFIC COMMUNITY

24. In the work done for the South Commission, science and technology were divided into four overlapping subsets (Table-6). These are:

- **A. Basic science**
- **B. Applied science**
- **C. "Classical" technology - based on science we know**
- **D. "Future" technology - based on tomorrow's science.**

Middle income developing countries, and Pakistan should be totally familiar with "A, B and C" and most technological and industrial problems can be addressed adequately through the synergistic application of these three. The future, however, cannot be harnessed without becoming at home with "D." This is the domain of **new materials, microelectronics, photonics, biotechnology, fine chemicals,** .... In an increasingly globalized world the competitive distinctions between countries will be in terms of their scientific and technological capabilities. This

6 This is a partial measure due to the extra-ordinary difficulties that Third World scientists face in getting their research published in scientific journals in the west.

point about competitive advantage was made by the London Economist in September 1980 after the second oil price increase:

> "If solar energy is to provide the solution to the world's fuel crisis, the solution will not emerge from loss-technology roof-top radiators. A breakthrough will come from applying quantum physics, biochemistry or other sciences of the 20th century. Today's technology-based industries all depend on new science."

That was 1980. Now we approach 2000 and there remains little doubt that the essence of the above statement is true to the core.

25. Another truism today is that "basic" and "applied" sciences are synergistic and must co-exist. You may be surprised to know that NESTLE uses **fourteen basic and applied sciences** (see Box-1) to develop its basic products from the Soya plant. The scientific base of all products and process is becoming stronger. The more science a new product or process has, the more it is likely to be competitive. Most developing countries have hardly any creative science. **Ninety per cent** of the world research capability is concentrated in about 35 countries with about 25% of world population. Hence the imperative necessity for developing countries to find the most effective policy to bring about rapidly a **macro science transfer** on which to base sustainable development. Without such a science transfer developing countries will continue to be technologically, and hence economically and politically, **one-sidedly dependent.** However it should be noted that science transfer is **effected by and to communities of scientists.** It cannot be done when there is limited scientific capability in the host country. Domestic scientific communities (in developing countries) need building up and this calls for wise science policies with long-term commitment, generous patronage, self-governance and free international contacts. Few developing countries have promulgated such policies; few aid agencies have taken it as their mandate to encourage and help with the building up of the scientific infrastructure. Few world class universities are focusing on this as an important international function. We are also doing very little in Pakistan which has contributed to putting us at bottom of the league table of scientific capability.

Box-1

SCIENCE IN PROCESSING

Steven Dedijir has given an example of broad-based science necessary for applications:

RAW MATERIAL RESEARCH

Analytical Chemistry	Organic Chemistry	Ultrastructure
I. Detection and elimination of harmful factors	II. Effect of techno-logical process on nutrients	III. Nutritional and sensory Evaluations of food formulas
Clinical Chemistry Alimentary Sciences Toxicology Nutrition and Metabolism Physiology	Physics Ultrastructure Alimentary Sciences Organic Technology	Technological Mathematics Sensorial Metrology Experimental medicine Physiology Nutrition and Metabolism

The above table translated from a 1981 Nestle pamphlet illustrates the strategic advantage the industrialised countries have in all technology transfers over the other **countries.** The table shows all the basic and applied sciences Nestle uses to develop, from the Soya bean plant, a series of products, processes and production units. The Brochure then shows how these products, processes, factories are "transferred; among others, to the South. The scientific base—the know-why, know-who of science remains "at home" as a foundation for newer, better industrial outputs.

26. Most developing country policy makers and staff of aid-giving institutions speak of technology transfer as if that is all that is involved. Very few within the developing or in the donor world appear to realize that effective capacity building requires that *technology transfers be preceded by science transfers: that the science of today is the technology of tomorrow and science must be broad-based in order to be effective as a fountain of technology That is:*

> Appropriate technology in modern conditions is unlikely to flourish without science flourishing at the same time. Without science flourishing, the solutions that sustainable development demands are unlikely to be forthcoming.

27. The implication is that Pakistan needs to take a futuristic approach to the growth and transfer of scientific know-how. This will require the creation of a functioning domestic scientific community which then can act as an intelligent conduct from the international scientific community to the domestic producers. The **"absorption"** by domestic scientific community will include sifting ideas for relevance and transformation of these ideas in conjunction with the **domestic engineering community** into **"appropriate"** technology for national development of industry, services and exports. The reverse flow of "problems" from the "producers" to the scientific community would complete the feedback loop and keep this network of functions dynamically relevant. The creation and maintenance of a domestic scientific community requires a responsive educational system which produces the needed technical skills as well as the creativity which facilitates innovation. If all or most of these could be implemented there would be economic growth as well as distribution of the fruits of growth; clearly, a win-win scenario.

IX. INTERNATIONAL FOCUS ON SCIENCE

28. Most nations of the world have begun to formally carryout science and technology development. Government offices have been created in France (1983), the Netherlands (1986), Denmark (1986), the European Community (1987), the United Kingdom (1988), and Germany (1989). In 1995 the European Commission brought out a "White Paper" which stipulates that the European Community must become a **"learning**

society" if it is to keep its place in the competitive world of the twenty first century. Science and technology are, of course, central; but EEC defines a (i) broad base of knowledge and (ii) continuing lifetime of education/ training as also essential. Finally, the United States 1996 presidential contest was on the platform of education and environment for "building a bridge to the 21st Century". Pakistan also needs such institutional capacity. To my knowledge we do not have one, or at least—an effective one.

X. PAKISTAN: SCIENTIFIC INFRASTRUCTURE

29. In order to compete in the next millennium Pakistan will have to develop a **scientific infrastructure** and practice **scientific values.** It has to introduce a world class level of science and mathematical[7] education in the schools and universities of Pakistan. It will not be possible to become a high income society without an educated and scientifically literate population.

Of course, scientific or general literacy by themselves cannot guarantee transition of Pakistan's economy to higher levels of income and development. A collective "national will" is also needed to ensure availability of the enabling environment, i.e. science infrastructure and scientific values. This enabling environment will not be created overnight. Thus, we must **begin now to create** the needed **infrastructure** and to acquire and practice **scientific values --** which curiously are **similar to Islamic values.** To illustrate this congruence let me share with you a brief review of the role that science and scientific values have played in earlier Islamic civilizations.

30. The period 750 AD to 1100 AD has been described by Abdus Salam as the Golden Age of Science in Islam: it was in this period that the foundations of the experimental method were laid for humankind. Ibn-al-Haitham was a great Muslim physicist. In his work on optics he anticipated Fermat's Principle of Least Time by many centuries. Roger Bacon's opus majus Part-V is essentially a copy of Ibn-al-Haitham's

7 It is revealing to note that in a proficiency test in mathematics and science of 13 year olds. East Asian countires ranked as the top three. U.S.A. was fiteenth. Pakistan was not on the screen (Table-7).

optics. It is pertinent to note Bacon's remark to his contemporaries that he **"never wearied of declaring that a knowledge of Arabic and Arabic science was the only way to true knowledge"**

31. Within a century or so after al-Biruni, Ibn-al-Haitham, Ibn-Sina, ...first class science petered out in the Islamic world. The world went into the dark ages from which it began to get revived five centuries later by the famous names of modern science... Galileo, Copernicus, Newton. Why did science in the Islamic civilization die down? Dr. Abdus Salam explained the decline in terms of increasing:

- **lack of tolerance of innovation; and**
- **isolation in the sciences.**

"Lack of tolerance for innovation" began to develop from the 12th century onward. This process led to a **loss of scientific values** and produced **"isolation of the sciences."** A lucid example of apathy toward innovation is a quotation from Ibn Khaldun at the end of the 14th century:

> "We have heard that on the northern shores of the Mediterranean, there is a great cultivation of philosophical sciences. They are said to be studied there again, and to be taught in numerous classes. Existing systematic expositions of them are said to be comprehensive, the people who know them numerous, and the students of them very many... Allah knows better what exists there.... But it is clear that the problems of physics are of no importance for us in our religious affairs. Therefore, we must leave them alone".

32. Bronowski defines sciences as **"the organization of our knowledge in such a way that it commands more of the hidden potential in nature"**. Thus the "values" science promotes are: **rationality, creativity**, the **search for truth, openness, tolerance for disagreement, respect for evidence, and for dialogue.** These "scientific values" are identical to the "core values of Islam" i.e. **tolerance, dialogue, search for truth, honesty, and fairness.** As we have seen in the brief historical review of Islamic civilizations the non-practice of these values had strongly contributed to their decline. This convergence of the "values' of science and Islam, thus, is an additional reason for Pakistan to promote

science as a core instrument in the development process. This will force us to protect independence of inquiry through legal and moral safeguards. Free speech, free thought, tolerance, arbitration through evidence are all values worth promoting and defending for a "good society" not just for "good science".

XI. CONCLUSION

33. Government has the primary responsibility in creating the scientific infrastructure and maintaining a climate where scientific or Islamic values can be practiced. But the domestic scientific community has an equal, if not greater, responsibility to demand the infrastructure and promote, protect, and practice scientific values. In the process of building the infrastructure we must not forget that Pakistan has a diaspora which has immediately tappable scientific capacity. These scientists may live abroad, but in the first generation, remain culturally tied to Pakistan. Most of them retain a strong sense of responsibility for fellow citizens "Back home". All scientific talent that we can tap for the short or long hand will have to be mobilized. Further, we should also remember the basic **universality** of science. The intrinsic nature of science is universal, its success depends on co-operation, interaction and exchange, much of which goes beyond national boundaries. The community of scientists is international, the population of Pakistani Scientists in the diaspora should be considered part of the community and not as aliens or as intruders.

Finally, the citizens of Pakistan would also have to give their full support. Edward Teller, father of the Hydrogen Bomb, likened the need for public support of science to that of art. Testifying in 1957 (post Sputnik), when science and mathematics were not highly valued by the U.S. public he said:

> "Good drama can develop only in a country where there is a good audience. In a democracy, particularly if the real sovereign, the people, expresses lack of interest in a subject, then the subject cannot flourish".

This is a long journey, but it is a necessary one for our **survival** which is just another word for **sustainability.** We should begin this journey soon. The **crisis in science** is deeper than our **economic crisis** because the former is a **solution** for the latter.

We could request the care taker government **to appoint a commission of eminent scientists and educators to study the situation and to write a white paper** on how to build the infrastructure for scientific revival. What policies and resources would be needed and why? Then we should have public discussion and action.

Thank you for the privilege to be with you.

TABLE-1

Annual Cost[1] of Environmental Mis-management

Environmental Issue	Estimated Annual Cost to the Economy (1990s) US$ Millions		People Impact (Millions)	
	Pakistan	India	Pakistan	India
Air Pollution	900[2]	1500	30+	50
Surface water pollution	750	6000	50+	100+
Groundwater pollution	Aquifer Destruction (salt; chemicals)	Not known	40+	—
Soil degradation	350	2000	Most of arable land	50% of arable land loss of ecological functions
Rangeland degradation	130			
Deforestation	50	200		
Industrial hazardous waste	Not known	Not known		
Loss of biodiversity	Not known	Not Known		

1 Most likely under-estimates of the true costs

2 Adjusted World Bank estimate

Source: World Bank Estimates

TABLE-2

Profile of Human Deprivation
Some Comparisons
(1991)

Variable	Pakistan	Bangladesh	India	Indonesia	Malaysia	Korea
Real GDP (PPP$)	1862	872	1072	2181	6140	673
Public Expenditures on education (% of GNP)	3.4	2.2	3.2	-	5.5	3.7
Without access to health services (Millions)	18.2	30.3	-	107.6	2.2	0.0
Without access to safe water (Millions)	60.9	25.3	220	110	4	9.5
Without access to sanitation (Millions)	94.4	102.2	754	106	1.2	0.3
Malnourished children under 5 (Millions)	9	13	73	9.4	-	0.0
Children not in primary or secondary schools (Millions)	27.9	20.2	73	9.1	1.3	0.2
Illiterate adults (15+) (Millions)	43.5	42	281	20.9	2.4	1.2
Illiterate females (15-) (Millions)	25	24.6	174	14.4	1.6	1.1
Adult literacy rate (% of total)	35	35	48	82	78	96
People in Absolute Poverty (Millions)	36	-	423	31	5.8	5.7
Total Population (Million)	122	116	863	188	18	44

Source: Human Development Report, 1993

TABLE-3

Military Expenditures and Resource Use Imbalances (1990s)

Countries	Military expenditure		Income share (1985-89)	
	% of GNP	% of expenditure on education and health	Lowest 40% of household	Ratio of highest 20% to lowest 20%
Pakistan	6.6	240	19	5.8
India	3.3	80	20.4	5.1
Indonesia	1.6	140	21.2	4.7
Bangladesh	1.6	60	23.7	3.7

Source: Human Development Report, 1993

TABLE-4

Scientific and Engineering Capability Inter-Country Comparison

Country	Scientists & Engineers	Scientists & Engineers engaged in R & D	Scientists & Engineers engaged R & D	R & D Scientists & Engineers Per million of Population	Country's Total Population
	Thousand	Thousand	% of Total	Number	Million
Pakistan	290	7	2.4	58	120
India	2470	128	5.2	147	870
Indonesia	640	32	5.0	168	190
Korea	95	87	91.6	1977	44
Japan	8670	705	8.1	5685	124
Germany	3670	304	8.3	4053	75
USA	5290	950	17.9	3725	255

Source: UNESCO Statistical Yearbook, 1994

TABLE-5

Share of Mainstream Science Journal Articles
(Percent of Total for all nations)
(1994)

Country	Percent of Total
US	30.817
Japan	8.244
UK	7.924
Germany	7.184
France	5.653
Canada	4.302
Russia	4.092
India	1.643
China	1.339
Brazil	0.646
South Korea	0.546
Egypt	0.280
Turkey	0.243
Saudi Arabia	0.129
Pakistan	**0.063**
Yemen	0.008

Source: Science Citation Index, 1994

TABLE-6
The Four Areas Of Science & Technology

Area	Includes
A. Basic Sciences	Physics; Chemistry; Mathematics; Biology; Basic Medical Sciences
B Applied Science	Agriculture; Energy;Medicine and Health, Environment and pollution; Earth Sciences (irrigation; soil science);
C. "Classical" Technology based on Yester years' science	Bulk chemicals; Iron and Steel and other metal fabrication; Design and Fabrication in (indigenous) industries (cotton; leather...); Petroleum Technologies; Power generation and Transmission; Heavy electrical industry.
D. "Future" Technology based on science of today and tomorrow	-New Materials; composite materials; -superconductors. -Microelectronics -Photonics -Space sciences -Pharmaceuticals and Fine Chemicals -Biotechnology and Gene splicing

Source: Abdus Salam, "Notes on Science" 1989

TABLE-7
Proficiency Test Scores in Mathematics and Science for 13 year old pupils (1991)

Country	Average days' instruction per year	Mathematics % correct	Science % correct
China	251	80	67
Korea	222	73	78
Taiwan	222	73	76
France	174	64	69
Italy	204	64	70
Canada	188	62	69
England	192	61	69
USA	178	55	67

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