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Review article

Appropriate future targets of biochemical research in the developing countries

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ABSTRACT

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Currently, about 80% of chemical and biological science research in the world is claimed by the discipline of biochemistry. The major reason for this lion share is that biochemistry forms a strong foundation on which stands the whole model of all biological and medical sciences. That is why the spectrum of teaching and research activity in biochemistry embraces large number of fields such as molecular biology, food and nutrition, cell biology, microbiology, toxicology, immunology, agriculture, veterinary science, botany, zoology, medicine and many others. So much so that the hierarchy of evolution of life on earth from a-biotic to biotic environment is traced back and interpreted in terms of systematic construction of biomolecules such as fatty acids and lipids, amino acids and proteins, sugars and carbohydrates from inorganic compounds. All these dimensions of biochemistry highlight the importance of this discipline in the world particularly in the developing countries; the major reference for this article is to examine the current directions of research in these countries and suggest a future road map that will target the present and future problems encountered by them. The enquiry reveals that most of the experts in developing countries undertake research that leads to publication in journals of international repute with high impact factor without examining its utility on the soil where it is being conducted. This type of research is usually the basic

research which cannot be conducted without involvement of highly expensive machines and instruments. The developing countries, in the first instance, lack requisite capital to purchase these necessities. Many purchase them on loan through bilateral agreements or knock the doors of some international aid disbursing organizations. The net result is that research activity keeps going without its utility in solving the national problems. What actually required is a research targeted at national problems to offer appropriate solutions and that is the applied research. Thus the enquiry was lodged in the light of published results of the attempts of different research groups of author to examine the following dimensions of the problem stricken areas to identify what appropriate research projects the experts in the developing world should undertake to target their national problems to seek appropriate solutions:

1. Disposal of wastewaters: sewage, garbage, industrial effluents with a target of cleanliness of environment.
2. Techno-economic disposal of agricultural waste.
3. Techno-economic disposal of solid waste.
4. Rationalization of the use of oriental/traditional medicines on scientific.
5. Production of the products of micro-organisms to dispose of waste and extract along with that the economic benefits.
6. Indigenous production of plant and animal enzymes to reduce import under national substitution policy.
7. Microbial leaching of ores and minerals for indigenous production of highly expensive metals such as uranium, etc.
8. Preservation of foodstuffs such as raw vegetables and fruits for off-season use and avoiding their spreading in the environment to cause a large number of environmental problems.

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1. Introduction

There is hardly any doubt about the fact that the developing countries are currently in the worst trap of problem multiplicity. The major problems that may be highlighted are food and hunger, poverty and unemployment, health and disease, depleting energy resources and energy deficit, small size of the industrial sector and scarcity of capital and so on. Solutions to all these problems cannot be worked out unless all experts from different scientific, technical and social fields join hands to plan appropriate and systematic strategies and subsequently implement them on different frontiers through the development of a strong interdisciplinary culture equipped with strong indigenous innovation systems. The best solutions can be offered by the concept of "Appropriate Technology" floated on the global level by some well known experts such as E. F. Schumacher, James Pickett and others on the screen of twentieth century in its second half. The concept remained active till the turn of the century and unfortunately it has been let aside due to lack of appropriate forces essential for its pursuit and implementation. The revival of this important concept may prove to be a blessing for the poor nations in making them stand on their own feet.

1.1. Appropriate technology

Appropriate technology is defined as a technology that is in tune with the conditions and environment of the place where it is to be transferred or for which it is to be planned or developed. It should be technically sound and economically viable in the said conditions and environment. Thus, every nation needs to erect its own brick-by-brick model developed by its own talent and skill because that is more familiar with its local conditions and requirements. Such a model is erected through a systematic approach involving a number of appropriate steps. A few are given below.

1. A careful survey of the conditions and environment of the place for which a strategy is to be framed.
2. Identification of social, cultural, political, economic and technological problems.
3. Grading of the identified problems on the basis of their intensity and gravity and fixing of priorities.
4. Picking of the problems that need immediate attention and planning to solve them via short term strategies.
5. Planning of long term strategies to solve the problems that fall on the lower end of the priority list.
6. Working out short term and long term strategies for targeting the problems.
7. Forceful implementation of strategies to achieve objectives and goals.
8. Measurement of the achievements and assessment of the causes of failures to learn lessons for future targets.

Here it should be clarified that all that has been hinted above is to be done in an indigenous way. The best way for a local expert is to sit in a calm and quiet atmosphere and think about the problems immediately around, storm his brain for identification and solutions, put on paper whatever accumulates in the brain and frame own opinion without referring to anything by anyone anywhere. The comparisons may be made later for changes and alterations.

Before presenting the details of the article, it sounds pertinent to introduce the reader to the background of the author that acted as a stimulus to place him in search of appropriateness for the developing countries in all walks of life. He was put on this track by David Living Institute of Overseas Development Studies (DIODS), Strathclyde University Glasgow created under the control of Economics Department with James Pickett its Director and Eric Rahim as Deputy Director. Allocating E.F Schumacher the status of first advocate, the next advocate of appropriate technology for the poor countries was DIDS. It defined appropriate technology as follows:

“Appropriate technology is a technologically sound and economically viable technology that suits the socio-economic conditions and environment of the place where it is transferred or developed and installed”

This definition, in spite of the developing countries as focus of the techno-economic studies, gave appropriate technology a global touch saying that it is for all and not restricted to the developing world only. Thus, the definition had broad spectrum characteristics. It suggested the developing countries to adopt even most modern automated technologies provided there was a sanction of adequate availability of resources behind their adoption.

The Institute developed an “Appropriate Technology Group” that was composed of graduates from various sciences, technology, engineering and social sciences particularly economics as Research Fellows and Senior Research Fellows to work on a pilot project titled “Choice of Technique in the Developing Countries.” Nine industry studies were conducted to sort out the prospects of creation of labor intensive jobs at sub-process level for recommendation to the poor countries to reduce intensity of poverty and unemployment in these countries.

To conduct a study, teams were framed and each team consisted of two researchers, usually one economist and other a scientist, technologist or an engineer. The teams collected data from almost whole world, processed the data to frame projects at different scales of production using different choices of machinery available in different countries and finally wrote reports that were published by Scottish Academic Press Edinburgh. The author was also a part of the group in the capacity of a post-doctoral research fellow and worked with Eric Rahim an economist originally from Pakistan to investigate corrugated board and box industry. The report forms Volume 9 of David Livingstone Institute Series on Choice of Technique in the Developing Countries (Khan, MR, 1985). The best about the reports was that all were written in text and style easily understandable in the developing countries. The author well

remembers that once the Institute sent a progress report to the Steering Committee, British Ministry of Oversea Development (ODM) because it was the major grant giver to the Institute. The report was returned with the remarks that the text may be revised to make it understandable at the level of developing countries. The report was revised accordingly and sent to London for the perusal of the committee.

1.2. Research and authorship without lab

The author returned to Pakistan and resumed his duty in the Department of Chemistry, Government College Lahore in 1978. The misfortune he first encountered was the lack of biochemistry laboratory in which he could continue his research interests in enzymology. He recalled two lessons that he had learnt from his senior colleague before he left for higher education and from DIODS where he worked as a post-doctoral research fellow. The lesson from the senior colleague was, "Research facilities are not always available; these are to be created." while from DIODS was, "One should learn to plan and conduct research work with whatever is available at his work place." To these lessons he added at his own that he should not sit idle in the period he strives for the creation of facilities; instead he should do something positive on the theoretical side. He was a born missionary and the first translation of his missionary zeal was his university level book "Biochemistry" published by The Caravan Book House Lahore in 1972 (Khan, 1972). Because, it was the first attempt of a young author, it was well appreciated all over the country and sooner it found a place in national universities and graduate and post-graduate institutions. It extended over 672 pages written in a classico-modern style that was a popular feature of the Sub-continent. He decided to revise it with the addition of knowledge from abroad. He broke it into two volumes that together formed around about 1500 pages (Khan, 1981, 1982).. Both volumes are there in the national market without a parallel after minor revisions. As he had returned as an advocate of the developing countries, he continued his activity and started expressing his opinion through the print media with the central idea of sorting out what is appropriate and what is not appropriate for the developing countries with special reference to Pakistan. The leading English daily of that time, 'The Pakistan Times' published his articles on the leader/editorial page and in Sunday Magazine. His articles were not restricted to a single field that was biochemistry/chemistry. These embraced many fields such as economics, education, science, technology, overall development and many others. Within two years he contributed more than a dozen articles and earned so much fame that the University Grants Commission approached him to write for its famous journal, 'Higher Education Review'. Its first issue was out with his review of scientific research in Pakistan as an opening article in 1983 (Khan, 1983). It was soon followed by his article on educational development in Pakistan (Khan, 1983). At the same time his door was knocked by Ministry of Education, Curriculum Wing, to write for its 'Pakistan Education Journal'. His two articles pertaining to appropriate textbook design and appropriate science education were published in the journal along with an article on appropriate biochemical education in a prestigious foreign journal and one in Pakistan Education Journal (Khan, 1983,1986, 1991) He kept on writing in context of appropriateness till their number reached 21. He decided to publish a collection of these articles in the form of a book. Because he was not in a mood to stop writing targeted at betterment of the developing countries, he decided to start a series of books with the first book as Volume 1 with the hope that those which will be compiled later will add to the series as Volume 2, 3---.Till now three volumes (Khan, 1998, 2001, 2010) are out and plan of the author is to go on adding volume after volume till he is there in this world. The central theme of the series is the choice of the appropriate projects both from sciences and social sciences and appropriate technologies for uplift of the developing countries. This was the background story from which it is now easy to switch over to undertaking of appropriate research projects in the discipline of biochemistry with a central theme of sustainable development in the developing countries.

1.3. Systematic research in labs

Usually, the scholars after returning from abroad are seen interested in a single field in which they had worked for their higher degree. A general observation about governments of the developing countries is that they send scholars abroad for higher education without a plan of their placement after

their return. Majority want to continue the field in which they had worked during their higher education. This is particularly true of research scholars returning from abroad. After resuming at home they don't have facilities essential for undertaking future research projects and are thus placed in odd positions such as teaching assignments without research, administrative posts and others that have nothing to do with research. Some of them are promoted to senior administrative positions on the basis of the higher degrees. Unfortunately, the mindset of majority in the developing world is such that people hanker after the administrative jobs as they consider them superior to teaching and research because after getting them they become equipped with a significant authority to subjugate others and ample facilities to live an easy and luxurious life. Thus, they even don't repent sacrificing their intellectual caliber for apparently attractive powers associated with the administrative posts. An important example that can be given from Pakistan is of her provincial education departments which sent lecturers, assistant professors, etc, for higher degrees and after their return, they were promoted as principals of degree colleges in higher grades or posted in senior positions in respective departments to sign file after file throughout their career. Those not adjusted as above remained in the research and teaching institutions lacking research facilities. As they don't look into the problem on broad spectrum basis and keep waiting for adequate facilities to continue their projects handled abroad without due consideration of their relevance to local and national requirements, they continue as dejected human resource in their careers. The whole process ironically translates into wastage of time, talent and huge investment made in getting them qualified in terms of higher education and research degrees.

2. Methodology

Within a year or two, the author was able to consolidate some lab facilities; some from the stores of Chemistry Department that were created by his ancestors before creation of Pakistan in 1947 in the form of both equipment and chemicals not used by any researchers for the last three decades, some from the research organizations particularly from friends at Pakistan Council of Scientific and Industrial Research on request or through joint ventures and some managed by the post-graduate research students of the department through personal contacts. He did not want to leave the field of Enzymology in which he had submitted his PhD thesis from which two research articles were published by him on resuming back home in a leading journal, 'Applied Microbiology, contemporarily Applied and Environmental Microbiology' and four in other prestigious international journals (Blain, 1978, Khan, 1979, ,1980, 1981,1982, 1983). His work was on microbial enzymes in which his lab lacked growth facilities. The solution was soon worked out as the work in his expertise field could be continued substituting microbial enzymes by plant enzymes because no growth facilities were required to study them. Moreover, Pakistan being an agricultural country, there was no problem in getting plant samples for their analysis for different enzymes for active contents and subsequent study of their characteristics to construct a database for making choices for applications in different fields. As he had returned with an interdisciplinary mind and as a problem solver for the developing countries, he considered opting for any research project without focus on a national or human problem a big sin because it was ultimately expected to translate into wastage of resources such as qualified human resource, time and capital. Thus he stormed his brain for indigenous national problems for which he could work out some solutions. He identified the following fields for his research orientation on utilitarian basis:

1. Disposal of wastewaters: sewage, garbage, industrial effluents, etc with a target of cleanliness of environment.
2. Techno-economic disposal of agricultural waste.
3. Techno-economic disposal of solid waste.
4. Rationalization of the use of oriental/traditional medicines on scientific basis to down cost the prices of drugs to bring them in the range affordable by the poor strata of society.
5. Production of the products of micro-organisms to dispose of waste and extract along with that the economic benefits.
6. Indigenous production of plant and animal enzymes to reduce their import under national substitution policy.
7. Microbial leaching of ores and minerals for indigenous production of highly expensive metals.

8. Preservation of foodstuffs such as raw vegetables
9. Fruits for off-season use and avoiding their spreading in the environment to cause a large number of environmental problems.

The research work was undertaken almost in all the fields highlighted above. As students are equipped with unlimited potential and energy and work responsibly when under pressure of the degree, they were deployed on different frontiers taking care that their own interests were not negated while making the choice. In many cases even student's personal and family contacts with research set ups and helpful businesses were also kept in mind. The work was started with a missionary zeal. The researchers on work were seen in the labs till late in the evening to complete their experiments leading to the promising results. It can be claimed without any hesitation that the researchers succeeded on all frontiers and produced results that were widely accepted for publication in some prestigious international journals published in Pakistan. There were many constraints in the way to publish in European and American journals. These journals expected highest techniques that involved highly expensive equipment which most developing countries lack and thus often returned the manuscripts without processing for review without giving any importance to the importance of results in applied context with regard to poor countries. Apart from that many high standard international journals started demanding printing charges from the contributors who could not pay even for the postal correspondence. The author well remembers the time when he was not provided even the typing facilities. There were two offices in his college that could help him in this context: Office of Head of Chemistry Department and Office of the Principal Government College Lahore. There was only one clerk in the department equipped with a baby typewriter. He used to type not more than one-page letters for the head and thus could not respond to about twenty teaching/research staff members. Similarly, there were hardly two to three typists working in the principal's office and could not attend to more than two hundred and fifty teaching staff members. The author had to go to private typists and thus prepared the manuscript by spending from his own pocket. The development of the research facilities was extremely difficult because in teaching institutions the stress was mostly on teaching and not on research. With invent of information technology, the situation is now totally changed. Everyone can now compose on one's own desktop and save it for alterations per need. Currently, Internet can provide more than eighty percent background and review material in the light of which researchers can easily plan their projects and if dedicated can create wonders. The author's yearly teams worked very well and produced good results that can be utilized if extended further to solve many problems of the developing countries both in sciences and social sciences. The author celebrates his successes and signals successes in future in biochemical research by linking past with present and forecasts for future through a cause, effect and measure chain from this point to the conclusion.

The primary step in planning for something for a place is its need assessment with special reference to its conditions and environment. The current conditions and environment of the developing countries are characterized by scarcity of capital, shaky overall economies, subsistence agriculture, small size industrial sector, lack of facilities for local experts in their workplaces including machinery and equipment in laboratories, lack of trust in local expertise and many others that have ultimately translated into poverty and unemployment, malnutrition, squalor and disease, shortage of energy manifested in the form of load shedding, sickening and closure of industry, etc.

If need assessment is done, the current needs of the developing countries are not different from those identified by the author and his team about thirty years ago. As the needs multiply with the passage of time with major cause as the uncontrolled increase in population. Some increment may be added in the light of additional problems encountered during his continuous involvement in research and teaching activity. The problems are the same because the research and development in the past have not been focused on their identification and planning for search of their concrete solutions. Most of the scientists in the developing countries have been conducting research for the sake of research and not for life around; often producing replicas of what has been done in the past stressing more on reviews and less on the experimental significance. A dominant network of experts have been continuously stressing on basic research in preference to the applied research oriented towards national problems seeking essential solutions. Unfortunately, this state of affairs continues even now. In some sectors even worst downfalls can be viewed. Here an attempt has been made to highlight some successes on different frontiers and

signal some tracks that may show a way to the experts from the developing countries to lead their nations for their emancipation from the yoke of diversities trapping them. Starting from the first principles the experts should learn how to work with whatever is available for conducting research and not waste time in waiting for the up to the mark facilities to arrive at their doorsteps.

When the author returned from UK as an expert in enzymology with research interests in study of proteases produced by microorganisms he had had no growth facilities in the labs of his department and thus he temporarily shifted the center of gravity of his interest towards plant proteases to study their enzyme content followed by their characterization in the crude state and seeking their application with regard to the national needs. A similar type of research was also initiated on animal enzymes because the techniques involved were similar. At that time, none was seen working for PhD and there was no program in his department leading to even M. Phil degree. So he had to engage M.Sc. students to make his research group on yearly basis. Luckily, all the students took keen interest while carrying out their projects because they intrinsically felt that they were rightly channelized and being rightly guided. Boys as well girls remained in their labs till 9 o'clock in the evening and thus built the research atmosphere that could be clearly viewed by whosoever visited or casually passed through the department. Their dedication was indebted to the hope that they will have a significant publication in a national or international journal after the project would be completed. Most of them achieved publication target after completion and some even were lucky to have a paper published during the course of conducting research. A few even had two or more research articles published from their theses, where and when, is given in list of references at the end.

3. Results and discussion

3.1. Plant and animal enzymes

To trigger off research studies, the research activity in the field of plant and animal enzymes was carried with equal intensity. The spectrum of activity involved extraction, study of crude state characteristics, isolation, characterization and immobilization of plant and animal enzymes. The results of all the studies were highly promising and were published soon after completion of projects.

Proteases being widely applied in health and industry particularly in milk clotting for cheese manufacture, some Pakistani plants, seeds and fruits were screened for their protease content and rennet action (Khan et al, 1981, 1983). The major source of rennet for cheese manufacture being abomasums (Fourth stomach) of cow calf, the work was also undertaken on abomasums of buffalo calf that is not slaughtered in the west but widely slaughtered in Pakistan. The results of general screening are given in the related journals (Khan et al, 1980), Khan and Yasmeen, 1986). Later, the stomachs of other animals such as goat, lamb [Khan, et al 1980), chicken (Khan and Akhtar, 1985), etc. were investigated for milk clotting proteases from animals commonly slaughtered in Pakistan.

The results indicated that there are a large number of plants and animals rich in their protease content and rennet action. Those which were conceived highly significant in applied context were particularly focused upon for isolation and characterization. From plants, *Calotropis procera* and from the animals both buffalo calf and cow calf were found most promising, thus their proteases were isolated and characterized (Khan and Masood, 1986). The spectrum of activity was also extended to work on other plants that were being primarily looked into for their protease content in other contexts such as traditional medicine (Khan, et al 1990), meat tenderization, etc, New rich sources such as *Carum copticum* and *Alium sepa* (Shaukat, et al 2000, Khan, et al 2006), were identified and subsequently characterized and during the enquiry, the cells of *Carum copticum* were found the richest source of proteases. Meanwhile, the researcher became acquainted with another field in enzymology and that was immobilization of enzymes to sustain their life (Nawaz, et al, 2006) and setting up continuous systems for enzyme action to make commercial products. Thus this option was also scheduled and immobilization of protease of *Calotropis procera* was successfully attempted [Khan and Talib, 19]. The results were attractive and thus other plants such as *Eurphorbia royleana* (Nawaz and Khan, 2000) and *Carica papaya* (Khan and Bukhari 2008) were looked into. Because the cells of *Carum copticum* were found very rich in protease activity, the continuous proteolysis of casein by cell bound protease of *Carum copticum* was

successfully accomplished. The enquiry on plants for proteases is yet in progress (Khan and Bukhari 2008, Khan and Iqbal 2011, Khan and Amir, 2011,) and will continue indefinitely because Pakistan is rich in supplying different plant samples. On the animal side, a comparative study of the enzymatic composition of buffalo and cow rennet was carried out. The study showed that the buffalo calf that was an unexploited source of rennet up to that point of time was richer than the cow calf in rennet content (Khan and Yasmeen, (1986) and thus source could be exploited to substitute the import of rennet from abroad for the minor end cheese industry in Pakistan.

The successes highlighted above clearly signal that research on plant and animal enzymes bears a handsome potential for industrial exploitation and thus it is also an important field for the extension of the research work in future and thus pursuit of targets already set are strongly recommended for setting the direction of biochemical research.

3.2. Microbial enzymes

Within one or two years, some growth facilities were developed. The lab was without an orbital shaking incubator for growth in submerged cultures. The pure cultures were promised by some friends working in the field of microbiology in different research labs such as PCSIR, and others that could be easily reproduced on blood-agar base slants or in Petri dishes for which a constant temperature incubator was already available. Thus, it was decided to work on microbial enzymes side by side. While planning the projects, care was taken that the products to be produced were of direct significance to Pakistan in terms such as food, energy, etc, and disposal of wastes that created pollution problem. Young researchers worked dedicatedly and the results exhibited partial successes on different frontiers. Efforts of the post-graduate research students were widely appreciated in terms of published research articles. The enzymes worked upon were protease (Khan, et al, 1985), amylase (Khan and Malik, 1987) and cellulase (Khan and Jamil, 1991, Khan and, 2003, Majid, Khan and Perveen, 2010, Khan and Amir. 2012, Khan and Subhani, 2012). The objective of work on protease was its increased microbial production by changing growth conditions for commercial applications while that of work on cellulase was transformation of polysaccharides into sugar in food context and transformation of sugar thus produced into alcohol in energy context. Some joint ventures were also undertaken that also translated into an adequate payback. The enzymes undertaken for study were alpha-amylase (Zulfiqar and Khan, 1982) and pectin lyase (Khan, et al 1987, 1994, 2004).

3.3. Rationalization of use of traditional medicine

Current situation of health in the developing countries is highly deplorable. A major reason underlying this situation is high cost of medical advice, diagnosis and treatment and that has rendered the medical treatment only for few and not for all. It's down costing is the need of the whole world particularly of the developing countries. Alternative medicine based on crude herbal drugs prepared from medicinal plants and seeds are these days in the field as rescue of the victims. Medicinal plants and seeds are in human use since antiquity but unfortunately without rationalization on scientific basis. A number of projects were carried to rationalize the use of traditional drugs taken as medicinal seeds, plants and herbs in the form of powders and extracts. The basis of undertaking these projects were

1. Skyrocketing cost of the drugs currently in the market due to the involvement of extraction, isolation and the purification of the active principle.
2. Side effects of the drugs currently in use.

Most of the work was focused on the determination of the antibacterial activity of medicinal herbs and seeds in search of the substitutes for antibiotics. A number of research papers have been published (Khan, et al, 1991, Javed and Khan, 1993, Qasim and Khan, 2001). The spectrum of activity was extended to the determination of the antibacterial activity of the oils from different seeds and their subsequent analysis to know the factors responsible for the activity (Saad and Khan, 2003) [49]. Results being highly promising, the scope of study was further extended to conduct biochemical investigation of a number of seeds and their oils. Many papers have been published (Khan and Iqbal, 2012, Khan and Haq, Khan and Khan et al 2012, Khan and Iqbal 2012)) and many are ready to go for publication. The results indicate that this is also a very promising field for future projections. Apart from the biochemical investigation highlighted above, some enquiries were lodged keeping in view the traditional use of some gums and

medicinal seeds for some illnesses such as those of alimentary canal (Khan and Mahmood, 1984, Khan and Jafar 1991). Medicinal seeds were also looked into for their mineral content particularly the trace elements due their well recognized role in health and disease (Khan and Rashid, 2012).

3.4. Regular medicine

A number of projects were undertaken on patients as joint ventures with the teaching and research staff of the medical colleges at Lahore to study the changes of the levels of some physiological parameters such as lipids, hemoglobin A1C, heart and liver enzymes, etc, to determine their correlation with the diseases such as diabetes, coronary heart disease, myocardial infarction, etc. Large number of patients and normal controls were scheduled as samples and the results were analyzed by statistical method (Khan et al , 1985, Khan et al 1990) . This enquiry was also conducted in applied context because it carried importance for assessment of prevalence of different diseases in humans.

3.5. Chemistry

Primarily some joint research ventures were undertaken in field of general chemistry to carry out the chemical analysis of some essential oils of different origin as these were of medical significance (Haq, et al 1981, Akhtar, et al, 1982, 1982). The techno-economic disposal of banana waste by microorganisms through the production of cellulase and the subsequent action of the enzyme on cellulose for its transformation into sugar for further transformation into alcohol already narrated under the microbial enzymes. Later, it seemed pertinent to carry out the chemical analysis of banana waste and it was also done (Khan and Rizvi, 1984).The cellulose content of some fibrous agricultural materials was also determined with an aim for use in production of paper pulp and for transformation of cellulosic content into sugar and alcohol in context of energy,(Faryal and Khan), . The yield of biological transformation of fibrous waste being low, chemical transformation was also attempted (Jamil and Khan, 2009)..

3.6. Food and nutrition

The author had submitted his M. Sc. thesis on nutritive value of cooked food-stuffs in 1961 along with two class-fellows. Before this episode most of the work was on raw food-stuffs and no nutritional survey for nutritive status of Pakistani food intakes had been undertaken. The author had to his credit an article published out of this work (Marium, et al, 2004). After being a PhD, he started a nutritional survey of Pakistani diets on whole meal intake basis at different class levels with three student research associates. The techniques applied were classical type such as AOAC methods of analysis and others, yet the results were highly significant to prove that at the time of the survey the nutritional condition of Pakistanis was satisfactory (Chughtai, et al 1979, Maium, et al, Marium and Khan, Jalal, , A, 2001, Nawaz, et al , 2001).

3.7. Environment

After floating of the concept of sustainable development after Earth Summit 1992, a strong linkage between environment and economic problems emerged and that led to the disposal of wastes to keep environment clean with simultaneous extraction of economic benefits. The author's research groups had already started on these lines in 1980. The primary work was done on disposal of banana waste into sugar and alcohol in context of food and energy as described under microbial enzymes. The activity was later extended to the enzymatic transformation of other fibrous wastes into sugar. The transformation was there but yield of products was low. Thus, attempts were made to increase the yield by chemical transformation and by alternate chemical and biological operations on wastes, the yield was increased to the optimal sugar concentration required for fermentation by yeast. An active attempt was also made on the biological digestion of plastic refuse for disposal (Lodhi, et al 2010, Khan ,et al 2012). A study on air quality of Lahore atmosphere was also undertaken. Its results was well appreciated and published in an important international journal.

4. Conclusion

Recalling successes of the author's groups on different frontiers and his personal experience, it can be concluded that the strategy developed and followed by him and his associates has worked well in the

past, it is working well at present and will work well in future subject to the condition it is sincerely taken up by experts, administrations and political leadership in the developing countries. Indigenous planning, self reliance, confidence in individual and collective self will be the tools for successful implementation..

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