

Ergonomics of Developing Countries: the state of the art and future prospects

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Abstract:

It is estimated that $\frac{3}{4}$ of the world's population live and work in Developing Countries which account for 134 countries in Africa, Latin America, Middle East and Asia (Shahnavaz. H, and Abeysekera JDA, 1991). But it is believed that only one quarter of the world's economic resources are available to be used by developing countries. This is definitely an unfair distribution of world funding. The population explosion in Industrially Developing Countries (IDCs) have brought with it enormous problems to the inhabitants of IDCs. The rate of accidents is believed to be 10 times that of Industrialized Countries (ICs). Other specific problems in IDCs observed in studies conducted by human scientists have been high prevalence of occupational illnesses, high wastage and losses in industry, low quality of working life, low incomes, inefficiency and low productivity. A new science born in 1940s called Ergonomics and currently known as Human Factors and Ergonomics (HFE) which has been successfully used in technology development in ICs is believed to provide effective solutions to the specific problems confronted in IDCs today.

In simple terms HFE is a science that fits the job and work environment to the characteristics of the human worker. The scope and approach of ergonomics do not differ between ICs and IDCs. But there are large differences in how ergonomics is applied in IDCs when compared to ICs.

Unfortunately, the practice of HFE is still in its infancy in IDCs. Most people in IDCs are unaware of this new science due to the lack of educational facilities in schools and universities and the inadequate exposure of this new discipline in industry and among the general public.

IDCs striving to leapfrog in development process are depending on ICs in adopting modern technology. Past studies have shown that IDCs have been confronted with many problems in the use of IC technology in its raw form. Therefore, it is recommended that the transferred technology including the ergonomic knowhow obtained from ICs has to be adapted to the conditions, environments and people of IDCs prior to use. This area needs to be adequately researched. ICs today depend very much on cheap labour, raw materials and marketing, on

IDCs. Unless ICs also take a keen interest in introducing and promoting HFE in IDCs it is warned that problems in IDCs can boomerang on ICs development and hi-tech activity.

However, a positive trend observed recently in IDCs is the great urge and interest to learn, practice and apply HFE in industry and in other diverse activities.

A case study from Sri Lanka (a typical IDC) is described in this paper to illustrate the steps followed in the development process and in the application of HFE.

Keywords: IDCs, Human Factor Ergonomics, Technology transfer

1. INTRODUCTION

Clamour to acquire more money by individuals in the world and the desire for economic dominance by both Industrialized Countries (ICs) and Industrially Developing Countries (IDCs) have been observed in all parts of the world. According to the latest statistics as revealed by the World Economic Forum, 85 of the richest persons in the world own nearly 50% of the world's economy (Daily News, Sri Lanka, 2014). It is not surprising to know that only $\frac{1}{4}$ of the world economic resources are used by IDCs where $\frac{3}{4}$ of the world's population live. An old report from the World Bank reveals that $\frac{1}{2}$ of the population in IDCs live in absolute poverty. Another report has shown that $\frac{1}{4}$ of the world's population who live in ICs is using $\frac{2}{3}$ of the world's energy resources.

The above statistics speak of the effects of population explosion in IDCs and the unbalanced and unfair distribution of world funding between rich ICs and poor IDCs.

Examining the secret of success in the technology, economy and productivity in ICs several research studies conducted in the past have shown the contribution made by HFE (Human Factors and Ergonomics) applications for the success stories in ICs. Recent trends indicate that IDCs are striving to adopt similar strategies and applications to achieve development in double quick time.

Ergonomics can be simply defined as a science that fits the job and work environment to the characteristics of the human worker. Ergonomics seeks to adapt work to known human physical and psychological capacities in order to promote, health, efficiency, well being and productivity. Practitioners of ergonomics contribute to the planning, design and evaluation of tasks, jobs, products, organizations, environments and systems in order to make them compatible with the needs, abilities and limitations of people.

Considerable literature is available regarding introduction, application and pitfalls in the process followed by IDCs to learn, practice and use HFE. This paper tries to describe and explain the state of the art of ergonomics practice and suggest recommendations to prevent the pitfalls and effectively use HFE in IDCs. Further, the

current problems confronted in IDCs and the strategies of interventions are also described. An attempt is made not to repeat some topics on IDC ergonomics, which are already published and found in literature. Steps followed in successfully introducing HFE in an IDC e.g. Sri Lanka is described.

2. IDC PROBLEMS NEEDING ERGONOMIC SOLUTIONS:

HFE had its origin and recognized as a science in Europe during World War II. ICs realized the advantages of this science and started to apply it in all activities. In IDCs HFE was not even known until recently. But our ancestors by mere experience and common sense improved their hand tools e.g. knives, hammers, screw drivers and agricultural implements e.g. hoe, rake, plugging equipment etc. without having the faintest idea of the principles of ergonomics. However, their final products, which are even used today, contain many ergonomic ideas in the design. After the technology of the West infiltrated to IDCs the scientific knowledge used in the West viz HFE was needed in improving the design of even hand tools and other products to keep pace with development.

2.1 IDC Problems:

The problems prevailing in IDCs are adequately covered in the publications by the authors Abeysekera JDA (2012, 2001, 1997, 1990, 1987), Shahnavaz H, (1996, 1991, 1983) and McNeill et al (2008). Other practices and problems that may have been overlooked in the above publications but are prevalent in IDCs are listed below.

- Inadequate and poorly maintained roads and incommodious public transport.
- Overcrowded and makeshift work places and uncomfortable work seats
- Infrastructure not developed to fit the imported technology
- Scarcity of drinking water and the need to walk long distances to fetch water for domestic purposes
- Lack of advanced methods of communication to cope up with the fast developing technology
- Mosquito menace which spreads diseases such as malaria, filarial and dengue and deprives sound sleep
- Traditional work postures e.g. squatting, sitting on the floor adopted by some women workers causing back problems
- Strenuous manual work in subsistence farming in agriculture
- Culture (Meshkati, 1988) and Customs (Ong C-N 1991)—Practices prevalent in diverse religions and adherence to traditional customs which are alien to imported IC technology.
- Not recognizing the dignity of labour and the adoption of the caste system in marriages and allotting low jobs to people of specific castes

2.2. Strategies of ergonomics in IDCs:

Considering the current situation in IDCs the need for a science like ergonomics is imperative. Out of the innumerable problems confronted in IDCs today the following need further highlighted

(Abeysekera JDA, 2012).

- There are large scale mismatches that occur between humans and the work environment.
- High levels of sicknesses and accidents at work
- Manual labour is still a major activity
- The use of old and maladjusted technology
- Production losses and the low product quality

Due to the unfair distribution of world's economic resources and considering the enormity of the problem, IDCs today are in a dilemma. In the technology development process followed by ICs, a traditional step by step seems to have been adopted. Cost of production was controlled using energy intensive devices and minimizing labour using hi-tech methods. However, the development process in IDCs has been slow and long drawn out. IDCs are struggling with traditional technology in a labour-intensive society. The information revolution and advanced technology have made both ICs and IDCs to join the network of global business. Therefore, IDCs have started to skip the intermediate phases of development and copy the technology of the West in double quick time. In this process, glaring mistakes occur, as the technology is not adapted to the conditions prevailing in IDCs. HFE interventions and principles seem to help in a large way to solve the problems of technology acquisition in IDCs. Due to the poor economies prevailing in IDCs, any application should be cost effective. Prof. Hal Hendrick (1998) has revealed this fact in his paper 'The Economics of Ergonomics' presented at the Global Ergonomics Conference in South Africa in 1998.

2.3. Technology Transfer and HFE:

Due to the high level of technology prevailing in ICs, the people in ICs are experiencing super standards of living. It has taken a considerable period of time for ICs to reach this stage. But IDCs or the third World Countries are skipping the step-by-step approach and trying to leap frog by copying the technology of the West. There are advantages and disadvantages in this approach adopted by IDCs.

This topic has been adequately covered in many publications viz. Shahnava .H. 1991; Abeysekera JDA and Shahnava (1989); McNeill et al, (2008). Over and above these publications, some specific issues can be mentioned which emphasize the need of technology of the West and the requirement to make adaptations based on HFE to be considered prior to transfer and use in IDCs.

The authors of the publications on this topic have emphasized the fact that the blind adoption of technology of the West in IDCs can be detrimental to the majority of inhabitants in IDCs. The major reasons of mismatches of IC technology have been caused by not considering the human factor needs. Numerous human factors need to be considered as illustrated by the above authors are summarized below. Detailed information of the variables between ICs and IDCs which have been overlooked in the transfer process are described in

the above publications.

- Hot and humid environments
- Body sizes
- Physical strength and abilities of people
- Manual dexterity
- Psychological and cultural variables
- Organizational design and methods
- Language
- Education and skill
- Infrastructure
- Standard of living

In addition, it has been observed some specific variables (not mentioned above) unknown to the transferors of technology and comprehensively described in a publication on Ergonomics and Technology Transfer by Abeysekera (1990). A brief summary of these unknown variables is listed below:

- Very low incomes received by majority of people and very high income received by minority of the population. Large gaps in incomes received by people.
- Haphazard energy supplies
- Inadequately maintained roads and vehicles
- Special abilities of people in vehicle repair, weather forecasting and IT knowhow
- Extraordinarily high literacy rates in some IDCs

3. HFE Educational Facilities, Applications and Activities in IDCs:

3.1 HFE Activities in IDCs:

As pointed out earlier HFE is still in its infancy in most IDCs. But the interest is fast catching up due to the realization of enormous benefits ICs have obtained from HFE applications. It is reported that ergonomic activity and research in IDCs began in 1960 but was restricted to environmental ergonomics and work physiology (Edholm et al, 1963; Sen, R.N., 1964) which are still major issues in IDCs.

A Center for Ergonomics of Developing Countries (CEDC) was established in 1983 in Luleå University, Sweden, which was engaged in ergonomics research, and education needs of IDCs. This Center held its first Conference on Ergonomics of Developing Countries in June 1983, which brought in 60 delegates from 15 IDCs and 6 ICs, and which had the following aims (Shahnavaz, H, 1983).

- Stimulate discussion on ergonomics applications in IDCs
- Define research and application needs in IDCs
- To spread awareness on specific requirements of IDCs
- To develop close scientific cooperation between ICs and IDCs

In 1985 an International Symposium on Ergonomics in Developing Countries was held in Jakarta, Indonesia where more than 300 participants from 20 countries attended. The major topics

discussed at the Symposium were; (ILO, 1987).

- Ergonomics in development
- Ergonomics in the rural sector
- Ergonomics in industry
- Ergonomics training and education in IDCs

CEDC in Luleå University inaugurated a Master's of Science Programme in Ergonomics in 1989 and offered it for 13 years which produced 85 Masters Graduates from 36 countries. In 1999 a 2 day International Conference was held to celebrate the 10th Anniversary of the Masters Programme at Luleå University of Technology, Sweden. The Conference brought in together past students (mainly from IDCs), teachers, and world ergonomic experts. Participants from 26 countries attended the Conference where a total of 52 papers were presented in 14 scientific sessions. The objectives of the Conference were; (Abeysekera J., 2000).

- To promote ergonomics in IDCs
- To establish collaboration between universities, past and present graduates
- To formulate guidelines to meet the challenges in the new millennium

In the year 2012 Algiers held a Conference entitled 'Ergonomics and its role in the prevention and the development in the Developing Countries' at El-Aurassi Hotel. It was the first Conference of its nature in Algiers where over 300 participated. The objectives of the Conference in brief were as follows. (Boudrifa, 2012).

- Reality of ergonomics in developing countries
- Raising ergonomics awareness in institutions, industrialists and social partners
- Research solutions and finding methods of applying ergonomics in DCs
- Diagnosing obstacles that prevent application of ergonomics
- Motivating and simulating researchers in organizational, agricultural and traditional industry regarding benefits of ergonomic applications

In the development of ergonomics, optimizing the interface between individual operators and their immediate environment (physical, physiological and psychological) which is referred to as Micro-ergonomics is a major application area in IDCs. However, in 1970 for overall system, functioning there emerged a need for Organizational Design and Management, which developed a sub-discipline, called Macro-ergonomics. Macro ergonomics is a top-down socio technical systems approach to work system design (human-machine and human-software interface) which is the domain of applications in ICs. HFE is at present applied mainly in industry in IDCs. It is gradually spreading its tentacles to other areas, e.g. Homes, Vehicles, Schools, Hospitals, Agriculture, etc., emphasizing hardware problems. In ICs, the major applications are in the areas of IT,

computers, offices, cars, etc., emphasizing software problems. Some major application areas on HFE in IDCs, which deserve emphasis, are listed below.

- Hot and humid climate: Rusting of vehicles, lubrication and glues, hazards of radiant heat and clothing for the hot environment.
- Environment: Pollution from cooking smoke from firewood, reduce demand for fuel, Water scarcity, Women walking long distances to fetch water
- Agriculture : Pesticides, Subsistances farming, Manual labour
- Hand tools: Grip strength among women
- Working Posture: Sitting on the floor, squatting posture, inappropriate furniture design.

As McNeill (2008) and others have correctly concluded that scope and approach of ergonomics will essentially not differ between ICs and IDCs. The difference is between its application rather than its methodology. Cultural factors between countries e.g. Stereotypes, literature on norms and low-cost solutions etc., should not be overlooked.

3.2 Questionnaire on HFE training programs and literature in IDCs:

The first step to introduce a new science in a country is to make the people aware of the principles, theory, practice and benefits of the new discipline. With regard to HFE, which was hardly known in IDCs until recently, a number of strategies have been taken to introduce educational and training programs. Extremely few ergonomics programs available in IDCs have received the bulk of the education and knowhow from ICs. They depend on ICs for specialization, literature and techniques in modern application and development of HFE.

The author carried out a questionnaire in early 1990s to obtain information on the availability of ergonomics training and educational programs in 195 institutions in ICs and 20 institutions in DCs. A literature search was also carried out in popular data bases. Response rates from ICs were 40% out of 90% questionnaires sent and from IDCs only 7% out of 10% of the questionnaires sent. The detailed results of the questionnaires as well as the results of the search in data bases are available in the following two publications.

1. Abeysekera, John, 1990. Ergonomics Education and Technology Development in IDCs
 2. Shahnavaaz, H., and Abeysekera John. 1991. Ergonomics Education and Training for IDCs, 1991
- The salient features of the results of the above surveys are briefly listed below.

3.2.1 Graduate Programmes.and Courses in ICs to IDC participants:

- Less than 20 IDC students joined 49% of IC programmes
- 24% of IC programmes offered scholarships to students from

IDCs

- 6% of the programmes designed for IDC students
- M.Sc. and Ph.D. in ergonomics were offered at the Department of Human Sciences, Loughborough University, UK. Very few IDC students participated.
- The following university and training programmes in HFE were designed for IDCs
 - o Master of Science in Ergonomics at Luleå University (Not available at present)
 - o PET, Wageningen, Netherlands. Promotion of Ergonomics in the Tropics, a 6-week programme
 - o NIVA Courses in Occupational Health. Nordic Institute for Advanced Training in Occupational Health, Safety and Ergonomics. Specially for Nordic students engaged in projects in Developing Countries

3.2.2 Ergonomic Training Programmes in IDCs:

Several IDCs from Asia, Latin America, East Europe and Far East offer ergonomic training courses as service courses in University Departments. (Kogi, K., 1989) reports of on-site, small group training programmes conducted under the sponsorship of ILO, and WHO in Argentina, Indonesia, Thailand, India and Sri Lanka, etc.

At CEDC, Luleå University, Sweden several short training programmes in ergonomics have been conducted for IDC students. CEDC ergonomic specialists have visited different IDCs as follows and conducted on site training programmes in ergonomics, (Abeysekera, John. 2001).

Estonia, Latvia, Lithuania, India, Philippines, Indonesia, Colombia, Venezuela, Mexico, Tanzania, Sri Lanka, China and Vietnam under the sponsorship of the Swedish Institute, Luleå University, Sweden and SIDA (Swedish International Development Agency).

3.2.3. Results of literature survey of 3 data bases CISILO, NIOSHTIC and CCOHS:

Brief description of results on published articles, books and training programmes on HFE in ICs and IDCs (Shahnavaz H., and Abeysekera John, 1991)

- Total articles, papers and books On Occupational Health and Safety (OHS) in IDCs and ICs 192614

On OHS and Ergonomics in IDCs and ICs	4662
On OHS and Ergonomics in only IDCs	436
On IDC Ergonomics only	53
- Total educational and training programmes

On OHS and Ergonomics in ICs and IDCs	159
On OHS and Ergonomics in IDCs only	6

Please note that the statistics as per today can be completely different. The above results only give an indication of the trends in ICs and IDCs on OHS and Ergonomic literature and training programmes 20 years ago. The higher productivity and extremely low ergonomics

literature and training in IDCs 20 years ago are specifically noted.

3.3 Foreign Experts Assigned to IDCs:

IDCs receive assistance and grants in many forms from ICs under bi-lateral and multi-lateral aid programmes. The Western donor countries are responsible in appointing the experts and consultants. Unfortunately, these experts lack the needed experience in IDCs or seldom accustomed to the conditions and infrastructure in IDCs. On the other hand, authorities in IDCs are reluctant to accept non-Western experts. The net result in the aid programme is a total failure. If foreign aid to technology poor countries is to be successful changes in the perception of the local authorities and a new strategy in expert selection is needed (Abeysekera, John., et al, 1990).

3.4 Ergonomics Outside Work Establishments:

Application of ergonomics in industry started in 1970s became very popular in IDCs striving to achieve higher productivity. For example, South Africa, South Korea, China, India, Indonesia, etc., introduced ergonomics in industry as well as in education to a limited extent in universities. Benefits obtained by these countries are described in the publications by Lee, S., 1991., Candler, P.D., 1993., Lu D and Feng, G., 1991.

However other application areas e.g. outside work establishments, of HFE in IDCs have been overlooked. The authors Abeysekera, J.D.A and Shahnavaaz, H., (1987) and McNeil et al (2008) have comprehensively stressed the need of ergonomics in technology transfer which IDCs are totally dependent on ICs to acquire advanced technology. A good example is inappropriate technology in the importation of vehicles e.g. passenger coaches, etc., which are inconvenient to the passengers as they are cramped and incommodious with uncomfortable seats and ventilation not designed to the tropics or hot climates in IDCs. Due to the unawareness and lack of education in HFE, IDCs seldom realized the need for HFE applications outside regular work establishments.

After IDCs began to develop fast and acquire advanced technology, HFE began to infiltrate into areas outside work establishments e.g. agriculture in private plantations, at home, in hospitals, on the road, in schools, clothes in hot environment and a host of other activities carried out outside work establishments (Abeysekera, John., 1997).

4. CASE STUDY IN SRI LANKA:

Sri Lanka an IDC is a small island in South East Asia and usually called 'The Paradise of the East' or 'Pearl of the Indian Ocean'. The population is about 20 million with diverse ethnic backgrounds consisting of majority Sinhalese and minority Tamil people. Export earnings in 1980 were mainly from agricultural crops, tea, rubber and coconut. Later tourism and foreign employment brought in sizeable foreign income. Today the apparel exports supersede all other types of

foreign incomes. The garment industry is at present flourishing rapidly due to the availability of cheap labour coupled with foreign orders. Large Free Trade Zones established in the country employ young labour of which predominantly are females.

In early 1980s there was a rapid process of industrialization, which was hampered by a civil unrest caused by the ethnic minority clamoring for a separate state. The country was engulfed in a chronic civil war for nearly 30 years, which ended 4 years ago.

Based on a more contemporary situation in Sri Lanka, a consumer finance and socio-economic survey conducted by the Central Bank of Sri Lanka has revealed the following statistics (Daily News, 1999). (Liyanage, JP and Abeysekera John, 2000)

Education: Improvement in education was encouraging with 36% receiving secondary education in 1996/97. Intensive competition among students for university education has caused a mad rush of students seeking private tuition. The literacy rate when compared with other IDCs has been relatively high (92%).

Labour: The aging population was a visible factor with 40% of labour above 26 years. The major improvement in employment opportunities and encouragement for higher education, training and vocational programmes and trends for male and female representation in labour force have become higher.

Employment: Unemployment declined (10%) due to the growth of economic activities in 1996/97. But later due to the increase of educational opportunities competition for jobs became tougher and unemployment increased to 30% in the age group 19-25 years. This problem was compensated later due to the migration of labour and motives for self-employment.

In the process of development like in other IDCs Sri Lanka obtained or copied the technology of ICs. In using, the technology of ICs Sri Lanka was confronted with many problems mainly due to the large variability between the transferor and receiver. As in other IDCs there were large differences in the body sizes, economy, knowledge and culture between the transferor (ICs) and receiver (Sri Lanka) (an IDC), (Abeysekera, JDA and Shahnava, H., 1987).

The large number of accidents and work diseases, productivity deficiency and low product quality, which are evident in statistics, can be due to the haphazard and unadapted technology. This was a stage where the application of HFE became an urgent need to solve the problems confronted by people, society and technology.

4.1 Ergonomics in Sri Lanka :

At a time when the discipline of ergonomics was not heard or known in Sri Lanka the author of this paper who was engaged in Occupational Health and Safety in Sri Lanka was invited by Loughborough University, UK to join the postgraduate course in

Ergonomics. After returning to Sri Lanka with a Masters in Ergonomics in 1979 an attempt was made to gradually introduce ergonomics in the country. Since there were, no ergonomic norms in Sri Lanka developing the standards and norms in ergonomics received priority. Therefore, three useful ergonomic surveys were carried out as follows.

- (i) A study on design requirements for a comfortable work seat for Sri Lankans (Abeysekera, J.D.A., 1985)
- (ii) A survey of body sizes of Sri Lankan Nationals (Abeysekera, J., and Shahnava, H., 1987)
- (iii) A head model reconstruction basing upon the photogrammetric data from Sri Lankan adult males relevant to the design of headgear (Abeysekera, J., and Shahnava, H., 1989).

There was a period of inactivity in introducing ergonomics in Sri Lanka as the author was away in Sweden researching for his doctorate at Luleå University, Sweden from 1984.

In 1988 two Swedish experts (including the author) were sponsored by SIDA (Swedish International Development Agency) to conduct a workshop on Occupational Health, Safety and Ergonomics which was organized by the Ministry of Higher Education of Sri Lanka. It was a 5 day residential programme on Principles of Participatory Learning conducted for Teacher Training Instructors.

In late 1997 Abeysekera (author) visited Sri Lanka to introduce ergonomics in Sri Lankan Universities. In 1998 two Swedish Experts (including the author) from CEDC, Luleå, Sweden conducted a 2-day course and a 3-day residential course in Ergonomics to undergraduate engineering students and professionals. In 1999 one-month training assignments were given to two lecturers from the University of Peradeniya, Sri Lanka at CEDC, University of Luleå, Sweden. They were involved in developing an academic curriculum on ergonomics for engineering undergraduates in Sri Lanka. The consequences of the efforts taken so far are encouraging. The major outcomes of the above ergonomic inputs were as follows:

- An optional course on 'Ergonomics for Productivity' for engineering undergraduates of Peradeniya University, Sri Lanka has been initiated.
- A course entitled 'Human Factors in Design' was started for Design Students in the Architectural Faculty, University of Moratuwa, Sri Lanka
- It has been observed that the industrial sector is gradually embracing ergonomics as there is a growing demand for more courses, seminars, workshops and training programmes

The author of this paper after his retirement from Luleå University, Sweden established a consultancy called Work Science Academy in Sweden with a Branch in Sri Lanka. He is mainly engaged in undertaking ergonomic assignments (surveys, training and education) to the industry particularly in Sri Lanka and also abroad.

A remarkable milestone carried out during the author's consultancy assignments in Sri Lanka is the case study conducted at MAS Holdings a specialist network of fabric, sportswear, lace and apparel. The case study consisted of visits to 15 companies for surveys, questionnaires and training in ergonomics as well as a 4-day intensive course in theory and practice given to 12 participants who were black belt holders in Lean Manufacturing.

MAS Holdings own a large share of the apparel industry in Sri Lanka. MAS has adequately realized the benefits of applying HFE as evident by the number of awards and the success in global business they have achieved in the recent past. It is known that MAS has introduced strategies originated by Toyota Production System viz. 5S, Kaizen, six sigmas etc., which are in fact ergonomic methods as revealed in the case study. A progressive project launched which MAS boasts of viz 'MAS Operating System' (MOS) empowers training and development to employees, which is also an ergonomic concept (Abeysekera, J., 2012, Visions).

4.2 Contemporary situation in Sri Lanka:

After the cessation of the ethnic conflict 4 years ago, the country is fast coming back to its former development process. Education levels of the general population have increased to a large extent. The network of roads and their maintenance have improved immensely. The literacy rate has advanced to the levels prevalent in developed countries. Due to the lack of Universities to accommodate all eligible students many parents send their children to foreign universities for advanced studies. Education offered in IC Universities has become a big business in Sri Lanka as evident in advertisements in the newspapers and in the internet. Vast strides in IT knowhow are seen in the country where many young children have become clever in handling and manipulating computers. Use of iPad, mobile phones and smart phones is a common sight among scientific and administrative workers, students and school children.

The most recent ergonomic activity is the formation of an expert committee in Ergonomics consisting of members of the Sri Lanka Medical Association (SLMA). The author is acting as a resource consultant to the ergonomics committee. This expert committee has been responsible for the following activities.

- Development of an ergonomically designed back pack for school children
- Research on safe and comfortable bicycle helmets for children
- Promoting awareness to ergonomics through seminars, workshops and the media
- A well-attended Symposium in Ergonomics was held in July 2013, which created enormous interest among the general public and industry.

Involvement of medical personnel in ergonomic activities has

been further boosted by a request made to the author by the medical college, University of Kelaniya, Sri Lanka to carry out a series of lectures and seminars in Ergonomics to the participants of Master of Public Health Programme.

It is seen that introduction of HFE in University education in Sri Lanka that started in 1997 in the Faculty of Engineering at Peradeniya University and later in the Faculty of Architecture at Moratuwa University has in 2013 demanded by the Medical Faculty in the University of Kelaniya. The multi-faceted demand in three diversified science faculties gives an indication that HFE is truly an inter-disciplinary science.

4.3 Conclusions and Recommendations for Sri Lanka:

From the above case study, it can be summarized that the most pressing needs for Sri Lanka are as follows.

- Development of reliable ergonomic data bases with localized ergonomic norms
- Consideration of HFE in technology transfer. Infrastructure information on Sri Lanka must be sent to the transferor along with the import order for goods consigned to Sri Lanka.
- Continue to improve awareness to ergonomics in media seminars and through training courses, and workshops conducted in manufacturing institutions, schools, technical training institutes, universities and among the general public
- To promote ergonomic education in the universities by introducing the discipline of ergonomics in the university curricula and offering Diploma and Graduate courses in HFE.

5. DISCUSSIONS AND RECOMMENDATIONS:

It is clearly understood that when introducing a new discipline to a country priority should be given to educating the natives. According to literature HFE, educational programmes in IDCs are few and far apart and available in a few partly industrialized countries. Among most populations in IDCs, this discipline is not even known. Some IDCs assume that ergonomics is a luxury and expensive. It has been proved that this idea is completely a wrong notion as ergonomics can be effectively applied in simple and traditional technology and cost beneficial.

Due to the non-availability of any formal educational programmes in developing countries keen in increasing productivity and knowing the advantages of HFE applications for development and higher productivity, the respective governments send their students to ICs for advanced education. This method has so far become a failure as those who receive the higher education are reluctant to come back to their home lands as they have better prospects for jobs in ICs ultimately resulting in a brain drain (Eckaus 1977).

There is a school of thought that IDC students can be trained in IC institutions, which emphasize IDC ergonomics or allow students to

carry out research projects on IDC ergonomics. In such instances the chance of returning home for IDC students after completion of education in ICs are greater. Short courses of training workshops and seminars in ergonomics to small groups with training manuals and ergonomic check lists (ILO, 1996) have been carried out successfully by IC experts in IDCs.

In 1990s while ICs had advanced and developed technology IDCs were classified as developing and less developed technology (Shahnavaz 1991). The speed of development has been so rapid that during the past 20 years the countries in the world are now classified as advanced and less advanced. (Abeysekera, J.D.A., 2012). Since both ICs and IDCs have become close to each other in the development process globalization of the processes and applications have set in. Globalization approaches is a pre-requisite to future ergonomic research. Globalization of ergonomics is a professional obligation for ergonomic academicians. According to Shahnavaz (1991) global ergonomics means 'One World concept' not 'First World' nor 'Third World'.

For ergonomics to be a global or world science, the author Bernhard Wilpert (1994) recommends a more comprehensive ergonomics, which should solve new challenges that characterize work today. New challenges have been brought about by global companies and migration of workers. The following changes as envisaged by Bernhard (1994) are worth considering and applicable even today.

- Shifting of work force from production to service
- The increase of female labour
- Drastic reduction of working times
- Switch from physical demands to mental information handling
- Frightening growth of long-term employment
- Internationalizing markets that need to combine global thinking and local acting
- Overall increase of life expectancy

The above changes bring in new challenges to IDCs, which are already confronted with other problems such as population explosion, poor economies and struggle in adapting advanced technology.

5.1 Positive and Negative Trends in Modern IDCs:

Negative

- The agricultural lands are fast depleting which are converted to housing
- External aesthetics in house building given more importance than internal comforts
- High crime rates, suicides, and road fatalities
- Bribery, Corruption and Nepotism common in the society
- Internet facilities e.g. Face Book, You Tube, Wi-Fi, Viber, etc have been observed to ruin the teens due to inadequate preparedness among children in using these facilities

Positive

- Indigenous medicines are becoming popular also among foreigners. However, no encouragement has been received to develop this medicine.
- Due to the tropical climates, fresh food is more demanded and available than frozen food. This is a hidden advantage for good health
- Modern technology and IT knowledge are picked up fast by students and children Among some students in IDCs the IT knowledge has found to be even better than students in ICs.

5.2 Recommendations:

Ergonomics of developing countries have been adequately described in the published articles referred in this paper. Considering also the case study carried out in Sri Lanka on the step-by-step process of introducing ergonomics from an unknown science to the stage of advanced application and utilization, the following conclusions and recommendations are made.

- (i) There is an urgent need for IDCs to acquire modern technology which requires the practice and knowhow of HFE
- (ii) Since ergonomics is an evolving process IDCs are warned to consider the dangers of embracing ergonomics haphazardly in a rapid pace
- (iii) Since education and training in HFE rank high in this process it is recommended to provide On-Site training and introducing ergonomics in the university curricula. On- site training also prevents brain drain.
- (iv) Priority should be given to increase the awareness to ergonomics among the General Public, Policy Makers, Importers of Consumer Goods, Vehicles and Machinery, in Schools and in the Media
- (v) Collection of ergonomic data and developing local ergonomic norms in each nation are urgent needs. Re-conceptualizing ergonomic standards in IDCs
- (vi) Promoting and use of simple inexpensive and sustainable ergonomic methods, work implements, machines and interventions are recommended in IDCs
- (vii) Adoption of simple technology and carrying out ergonomic research geared to local needs
- (viii) Promote and develop additional factors such as considering the influences of Culture, Natural Resources, Indigenous Talents, Traditional Customs, Stereotypes, Appropriate and Adapted Technology
- (ix) Finally, it is recommended that each IDC should establish a National Ergonomics Association, which will help to boost the implementation processes of the above recommendations.

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