xIlkogretim Online - Elementary Education Online,2021; Vol 20 (Issue 1): pp.2047-2053
http://ilkogretim-online.org
doi: 10.17051/ilkonline.2021.01.224

Nanotechnology – Can It Be a Hope for Developing Economies

Dr. Prashant Vithal Kadam, Associate Professor in Economics**,** Goa.

Abstract- The present human capital of the world has been increasing and is expected to reach 8.6 billion in 2030, 9.8 billion in 2050 and 11.2 billion in 2100. This has necessitated the development of new paradigms such as future food crisis for the future generations, sustainable agriculture and the possible imbalance to our ecosystem in the absence of a sustainable innovative technology which can deliver it on time. As per FAO, 60 percent of the world's human resource depends on agriculture for survival. So if the population is about 7 billion now and grows rapidly, 12 percent of the total available land, or about 1.5 billion hectares, would be used for agricultural crops. Though off late there has been a decline in the demand for agricultural products on account of fall in the growth rate of population in many countries combined with a fall in the food consumption, it should be noted that the developing countries will face the food crisis and will tend to become more dependent on agricultural imports. The food security in such poor developing economies will suffer in the absence of a rise in the agricultural production. At present, around 9 percent of the world population is above 65 years of age, a number expected to increase to 16 percent by 2050. In Europe, such a demographic projection exercise leads to 28 percent of the population being above 65 years of age in 2050, up from 19 percent in 2020. The median age of Europeans, currently 42.5 years, is projected to increase to over 47 years. In Asia, the median age has been 30 years or lesser, with an upward trend in the growth of her population. The demand for food is expected to rise along with a rise in her population. The world is at the mercy of an innovative technology which can help the developing economies from their miseries in the years to come. The paper has diagnosed the scope of nanotechnology for the developing economies which are primary producing economies and lag in many institutional parameters which are necessary for the promotion and the development of nanotechnology so that its benefits become inclusive rather than exclusive – A domain of advanced economies so far….

Keywords: Nanoparticles, Developing, Population, Agriculture, Developed

I. INTRODUCTION

A developing country is also known as an LMIC, or a low and middle-income country. It is less developed than countries classified as developed countries but these nations are ranked higher than least developed countries. These countries are characterized by being less developed industrially and a lower Human Development Index than other countries. However, developing countries have the potential for high growth and security when evaluating factors, including the standard of living, gross domestic product, and per capita income. The term refers to the current state of a nation and is not used to determine changing dynamics or future progress.Several characteristics are commonly held throughout developing countries. This includes health risks such as having low access to safe water and sanitation and hygiene problems. There may also be high levels of pollution and a high percentage of people with infectious diseases. Other common characteristics include widespread poverty, low education and literacy levels, and government corruption. There are also challenges in energy and higher rates of violence against women. The United Nations has set a list of Sustainable Development Goals designed to help developing countries overcome these challenges. Development aid through federal governments and other agencies is distributed in order to help tackle the social, political, economic, and environmental problems faced by these countries. Table 1 shows that most of the developing economies suffer from various externalities on account of its excess human resource. It has been acting as a liability on the food security of these nations. The contribution of agriculture to the GDP has also been very low and has been decreasing over time. The HDI index also has not been satisfactory.

Table 1 Developing Economies and Agriculture with Human Capital

Countries	HDI	Population	Contr. of Agr. to GDP(%)
India	0.647	1380004385	15.96
Bangladesh	0.614	164689383	12.68
Nigeria	0.534	206139589	21.91
Pakistan	0.56	220892340	22.04
Ivory Coast	0.516	26378274	15.69
Vietnam	0.693	97338579	13.96
Indonesia	0.707	273523615	12.72
Philippines	0.712	109581078	8.62
China	0.758	1439323776	7.1
Brazil	0.761	128932753	5.5
Mexico	0.767	331002651	3.47

The level of technology in these countries is very low with the exception of China. The farmers still inefficiently make use of conventional inputs (land, traditional manures, water, energy and pesticides), resulting into huge wastage of agricultural production globally. Their traditional methods of retaining the productivity of soil, deforestation and livestock has been a major factor in greenhouse gas emissions worldwide. Amidst this anomalies, the concept of nanotechnology is hailed as a blessing in disguise for such economies which is anticipated to face food crisis in the years to come. Further, the European countries produce approximately 90 million tons of agricultural wastes per year. Nanotechnology has been recognized by the European Commission as one of its six "Key Enabling Technologies" that contributes to sustainable competitiveness and growth in several fields of industrial applications underpinning the shift to a greener economy It has been seen as a blessing in disguise to enhance and increase the agricultural productivity in a most sustainable manner. But the question arises as to, given the state and the level of development of the developing economies, can the nanotechnology and engineered nanomaterials (ENMs) improve sustainability of agri-food systems?Theoretically, there has been a rise in interest in research in the field of agriculture and nano-technology between the end of twentieth century and the beginning of twenty-first century. There has been increasing number of peer-reviewed scientific literature per year retrieved in Elsevier Scopus database. A number of 508 scientific products have been indexed in Scopus database: 264 (52%) papers, 143 (285%) reviews and 91 (18%) conference papers. As regards the distribution of publications among the most productive countries, United States and India share the research leadership in this field, having published together about 63% of papers (27 and 25%, respectively). China possesses the third rank (10%), whereas EU countries contribute with about 20% of publications. In 2019, China pioneered in the nanoscience publications with more than 40 percent of the world's publications relating to nanoscience, followed by the United States, India, and Iran, holding 13.5, 8.5, and 6 percent of the publications, respectively. Table 2 shows the number and share of nanoscience articles in the total articles of different countries in 2019.

Table 2 Number and share of Nanoscience Articles			
Rank	Countries	Nano Articles	% Share
1	China	74,387	16.17
2	USA	23,999	5.47
3	India	15,083	16.45
4	Iran	10,494	21.22
5	South Korea	9,431	14.31
6	Germany	8,446	7.12
7	Japan	7,429	8.58
8	UK	5,682	4.66
9	France	5,465	7.17
10	Russia	5,392	10.52
11	Australia	4,632	6.17
12	Spain	4,554	6.45
13	Italy	4,253	5.68
14	Canada	3,756	4.85
15	Saudi Arabia	3,519	16.92
16	Brazil	3,345	5.49
17	Turkey	2,959	7.36
18	Taiwan	2,943	11.06
19	Egypt	2,726	14.9
20	Poland	2,661	8.11

It can be observed that even in the emerging area of nanoscience publications, the developed countries are at the lead with the exceptions of China, India, Brazil, Egypt, Russia and Turkey. The technological publication in nanoscience has been mostly dominated by the developed nations like United States, Canada, Germany, Japan, UK etc. This is an indication that the benefits of the nano technology has been directional and in favour of advanced economies thereby further perpetuating the existing inequalities and widening the gap between the have and havnots.

Nanotechnology in India

Nanotechnology has been emerging as one of the sustainable source of meeting the mismatch between the demand and the supply of resources in the ecosystem. With the increasing population across the globe, the pressure on the ecosystem has increased manifold, thereby calling for the new innovations which are sustainable amidst the climate change. Though the concept of nanotechnology has been at the infancy stage in the emerging economies like India, it has been optimally used by the advanced economies like United States, Japan, and Germany etc. The funding and the significance of the nanotechnology have been on the rise.The global nanotechnology market is valued at$1,055.1 ml (2018) and is projected to reach $2,231.4. million by 2025. Its grew at a CAGR of 10.5% from 2019 to 2025. There has Increasing Investment in Nano Technology across the globe. The Indian Nanotechnology Market is expected to be USD 100 million in the years to come. Further,in terms of its composition, it is found that Nano materials constitutes 85% (Largest), followed by Nano tools, Nanolithography and the least share is of Nano devicesin India the efforts to promote research in nanotechnology began early in the millennium. The—Nanoscience and Technology Initiative|| started with a funding of Rs. 60 crores. In 2007, the government launched a 5-year programcalled Nano Mission with wider objectives and larger funding of USD 250 million. The funding spanned multiple areas like basic research in nanotechnology, human resources development, infrastructure development and international collaboration. Multiple institutions like Department on Information Technology, Defense Research and Development Organization, Council of Scientific and Industrial Research and Department of Biotechnology provided the funding to researchers, scholars and projects. National Centers for Nanofabrication and Nano electronics were started in Indian Institute of Science, Bangalore and Indian Institute of Technology, Mumbai (CENSE, 2018).

Nanotechnology and Agriculture

Nanomaterials involves the use of eco-friendly and environmentally sustainable methods which can play a significant role in increasing the agri-productivity by improving the fertilizationprocess, plant growth regulators and pesticides. In addition, they minimize theamount of harmful chemicals that pollutes the environment. . The different applications of nanotechnology in agriculture consists of (1) nanoformulations of agrochemicals for applying pesticidesand fertilizers for crop improvement; (2) the application of Nano sensors incrop protection for the identification of diseases and residues of agrochemicals; (3)Nano devices for the genetic engineering of plants; (4) plant disease diagnostics; (5)animal health, animal breeding, poultry production; and (6) postharvest management. The technology can also be feasible to minimize the nitrogen losses. Its applications include nanoparticle-mediated gene or DNA transfer in plants for the growth of insect-resistant mechanisms, food processing and storage and a rise in its life. Further, Nanotechnologycan also contribute to the development of biomass-to-fuel production.However, there has been concern and a need has been felt for a holistic approach towards the soil, water and environment and the occupational health of workers. Off late, there has been tremendous research in the applications of nanotechnology in agriculture across the world. The applications of nanomaterials in agriculture aim to reduce sprayingof plant protection products and to increase plant yields. Nanotechnology derived devices are also explored in the fieldof plant breeding and genetic transformation. The potential of nanotechnology inagriculture is large, but a few issues are still to be addressed as the risk assessment. Nanotechnology has many uses in all stages of production, processing, storing,packaging and transport of agricultural products. Nanotechnology will revolutionizeagriculture and food industry such as in case of farming techniques, enhancing theability of plants to absorb nutrients, disease detection and control pests.

II. DEVELOPING ECONOMIES AND NANOTECHNOLOGY

The concept of nanotechnology has been a mixed blessing to the developing economies. Though some perceive it as an opportunity, others have analyzed it as a tool for increased exploitation of the developing world and concentration of economic power among the already developed economies having its dominance in nanotechnology and other drivers of technology. Most of the developing economies (with the exception of China, India, Vietnam) lag behind the advanced or so called advanced emerging economies of the world. These developing economies basic attributes such as low GDP, low GDP per capita, existence of absolute poverty, low performance at HDI indicators, high population, low penetrations in the technological advancements and etc. deprive these economies from the benefits of the so called nanotechnology. Further, in terms of their performances in terms of innovations in R & D, working capital. Knowledge diffusion, GDP etc., the countries performances has been not satisfactory. The Global Innovation Index Report 2020, published by Cornell University, INSEAD, and the World Intellectual Property Organization, in partnership with other organizations and institutions has brought out the performances of the developing and developed economies on certain parameters. Table 3 explains the relative standings of the selected developing economies of the world vis-à-vis developed economies in select parameters which can help in technological upgradation and growth that can facilitate and encourage the growth of nanotechnology for both the economies. The relatives score in different parameters have been measured from 0 – 100.

Table 3 Relative performance of select countries in select parameters of Global Innovative Index (2020)

Countries	R & D	IT	ES	Credit	KW	IL	KC	KD	OC	GDP ($ PP	GDP PC(($ P
China	58.8	75.8	32.5	53.1	77.9	24.5	70.4	44.5	4.1	27308.9	17,027.50
India	32.9	63.3	20.2	43	25.9	26.6	19.8	54	9.1	11325.7	7,314.60
Indonesia	10.2	54.2	26.2	39.2	8.9	19.6	5.7	11.4	14.1	3737.5	12,220.80
Myanmar	0.1	29	21.8	8.6	3.3	2.6	1.9	19.7	0	355.6	5,855.60
Nepal	1.9	54.2	15.1	50.6	23.5	23.7	8.6	25.9	10.8	94.4	2,896.90
Bangladesh	3.8	53.5	25.1	29.9	13	18.2	6	12	5.9	837.6	4,389.60
Argentina	28.1	67.6	30.7	21.9	28.7	16	12.9	26.2	17.9	903.5	17,508.90
Madagascar	0.1	23.5	14	22.7	4.9	22.1	4	16.4	2.5	46	1,483.50
Cambodia	0.6	32.7	19	66.4	11.8	25.7	3.1	14.6	3.1	76.9	4,072.20
Nigeria	0	38.3	15.6	35.3	34.7	18.2	4.9	10	1.8	1216.8	5,286.00
Brazil	34.3	77.5	29	30.9	46.1	21.4	20.6	26.4	16.4	3456.4	14,371.60
Pakistan	8.8	38.7	21	21.1	21.1	18.5	15.3	19.5	8.4	1202.1	5,126.10
Egypt	11	50.3	26.8	30	15.2	19.3	12.7	14.6	8.4	1391.3	12,242.70
Malaysia	37.4	79.4	31	52.1	37.3	30.3	12.1	45.5	15.9	1078.5	28,705.90
Mauritius	2.5	67	36.7	49.5	16.2	17.2	7.1	18.3	20.8	31.7	21,822.30
Mexico	26.3	74.1	31	42.1	28.5	17.8	11.4	32.3	11.1	2627.9	18,218.10
Vietnam	7	62.8	23	67.6	30.5	19.3	11.1	46.7	25.7	770.2	7,041.60
Philippines	6.2	68.9	29.7	24.3	40	21.3	14.9	57.2	11	1025.8	8,268.30
Russian Fed	34.9	81.2	20	45.2	44.8	17.6	32.7	23.6	25.3	4349.4	25,878.70
United Kingdom	67.6	93.6	54.2	68.1	59.6	51	66.2	51.8	61.6	3131.2	40,881.30
Australia	59.4	88.6	39	78.9	53	44.1	42.5	20.3	51.5	1364.8	46,601.00
Canada	57.2	85.3	28.7	85	48.3	55.4	49.3	34.9	50.6	1899.9	44,284.80
Denmark	71.8	92.4	53.6	72	65.6	57.8	62	42.5	68.6	312.8	47,040.40
Germany	72.7	88.5	43.5	51.9	65	53.7	68	45.8	59.1	4444.4	46,765.50
Ireland	52.5	83.8	59.6	43.3	55.8	43.2	24.6	86.4	49.9	412.8	72,810.00
Japan	74.9	90.2	47.5	65.7	65.1	47.7	57.2	49.8	24.2	5747.5	39,763.10
Repulic of Korea	88.1	93.5	34.4	66.4	77.7	48.8	65.8	46.3	27.8	2319.6	39,059.70
United States of America	77.1	90.4	30.8	89.7	69.8	60.6	72.8	45.9	50.4	21439.5	56,844.30

Source: Global Innovation Index 2020 Report (1)

R &D (Research and Development), IT (Information and telecommunication), ES (Ecological sustainability), KW (knowledge workers), IL (Internal Linkages), KC (knowledge creation), KD (knowledge diffusion), OC (Online Creativity),

The GII is computed by taking a simple average of the scores in two sub-indices, the Innovation Input Index and Innovation Output Index, which are composed of five and two pillars respectively. Each of these pillars describe an attribute of innovation, and comprise up to five indicators, and their score is calculated by the weighted average method. The study has taken some select parameters to measure the degree and the extent of variation in the performance of such parameters y both developing and developed countries. The table clearly reflects a wide gap in the performance of such parameters with the exception of China and India. The degree of R & D shows a high variations ranging from 0 to 88 out of 100. The developing economies like Myanmar, Nepal, Bangladesh, Philippines, Nigeria, Egypt etc. are lagging behind in R& D as compared to advance or developed economies such as United States of America, japan, Australia, Denmark, Germany, Canada etc. The relative performance of India in R & D is also not satisfactory with a score of 32/100 in R &D.Similarly, even in knowledge workers, internal linkages, GDP per capita, the developed economies have a competitive edge over the developing economies. Though India's performance in some parameters is satisfactory, but a lots of learning will be the need of the hour for India to effectively integrate nanotechnology not only in agriculture, butalso in other areas of medicine, electronics etc.

The regression analysis of some of the parameters of innovation has proved a strong dependency between the parameters as shown in Table 4.

Table 4 Regression Analysis			
Y on X	Multiple R	R Square	Adj. R sq.
Credit(X) and Innovation Linkages (Y)	0.8	0.63	0.62
Credit(X) and Knowledge Diffusion (Y)	0.32	0.1	0.06
Information Technology (X) and Innovation Linkages	0.62	0.39	0.36
R & D(X) and innovation Linkages(Y)	0.89	0.79	0.79
Knowledge of workers(X) and Knowledge Creation(Y)	0.9	0.81	0.81
Credit and Knowledge Creation	0.69	0.48	0.46

Table 4 shows the line of good fit among the select parameters. It was found that though the developed economies and the developing economies varied in terms of their performances in terms of availability of credit, innovations in linkages, knowledge diffusion, knowledge workers its creation, but some of these parameters had big deviations from its other related parameters. The role of the availability of the credit in diffusing the knowledge across the society was very minimal. Similarly, only 62% of the innovation linkages was explained by developments in information technologies in these countries. More emphasis on R & D paved the way for more and more innovation linkages (89%). Most of the developing economies however performed very low in the field of R & D. Further, knowledge creation was explained by the availability of the knowledge workers. However, developing economies performance in knowledge creation and knowledge workers as per the Global Innovation Index Report, 2020 was found to be below average. Thus the benefits of nanoscience and its applications are unlikely to help the developing economies. The basic parameters explained in table 2 combined with inadequate institutional supports have been the major hurdles for the developing economies to reap the economies from nanotechnology. Table 4 clearly shows the dominance of patents and its applications in nanotechnology. It exhibits the dominance of advanced countries in the growth of the patents in nanotechnology in the year 2020.It illustrates the top 10 countries holding the largest number of granted patents and published patent applications in the USPTO and EPO in 2020. The only developing economy which has earned its place in the top ten Nanotechnology patents I China. The countries are ranked based on the total number of patents issued by the USPTO office, which is unique among federal agencies in filing the most share of patents every year.The US achieves the first rank in holding the USPTO's nanotechnology patents with a share of 51.4%, showing slight growth in comparison to 2019 (i.e., 50.8%). Chasing the US, the next spots on the list are taken by South Korea and China, respectively.

Table 5 Top 10 Countries Nanotechnology Patents in the USPTO and EPO in 2020					
Rank	Country	USPTO	EPO	2020' growth in USPTO compared to 2019	2020' growth in EPO compared to 2019
1	USA	4913	952	1.57%	-1.04%
2	South Korea	941	301	1.07%	27.54%
3	China	736	135	-1.34%	31.07%
4	Japan	661	279	-6.51%	-9.71%
5	Taiwan	513	33	1.58%	10.00%
6	Germany	310	325	-10.92%	-19.95%
7	France	214	238	-8.15%	-16.20%
8	Saudi Arabia	168	25	-4.55%	108.33%
9	UK	154	144	3.36%	3.60%
10	Canada	151	38	4.14%	-29.63%

It should be noted that the EPO's nanotechnology patents of Saudi Arabia, China, South Korea, and Taiwan grew by about 108%, 31%, 27%, and 10%, respectively, compared to the previous year, demonstrating that these Asian countries concentrated more particular attention tothrive the EU's nanotechnology markets than those of American and even European countries in 2020.

REFERENCES

1. Bayda, S., Adil, M., Tuccinardi, T., Cordani, M., & Rizzolio, F. (2019). The History of Nanoscience and Nanotechnology: From Chemical–Physical Applications to Nano medicine. Molecules, 25(1). doi:10.3390/molecules25010112
2. Campos, E. V., Periera, A. E., Oliveira, J. L., Carvalho, L. B., Guilger-Casagrande, M., Lima, R. d., &Fernandes, L. F. (2020). How can nanotechnology help to combat COVID-19? Opportunities and urgent need. Journal of Nano biotechnology. doi:https://doi.org/10.1186/s12951-020-00685-4
3. Ezema, I. C., Ogbobe, P. O., & Omah, A. D. (2014). Initiatives and strategies for development of nanotechnology in nations: a lesson for Africa and other least developed countries. Nanoscale Research Letters.
4. Golubev, S. S., Sekerin, V. D., Gorokhova, A. E., & Gayduk, N. V. (2018). Nanotechnology market research: Development and Prospects. Espacious, 39.
5. Huey-minHwang, X. H. (2019). The current application of nanotechnology in food and agriculture. Journal of Food and Drug Analysis, 27(1), 1-21.
6. Hulla, J., Sahu, S., & Hayes, A. (2015). Nanotechnology: History and Future. Human and experimental Toxicology.
7. Kadam, P. V. (2020). nanotechnology in India: A Need for Holistic Approach. SSRG International Journal of Economics and Management Studies (SSRG-IJEMS), 7(5), 73-76.
8. Kumar, A. (2014). Nanotechnology Development in India. RIS Discussion Paper 193. New Delhi, India: RIS.
9. Maclurcan, D. C. (2005). Nanotechnology and Developing Countries - What Possibilities. Azojona. doi:10.2240/azojono0104
10. Nagar, A., & Pradeep, T. (2020). Clean Water through Nanotechnology: Needs, Gaps, and Fulfillment. ACS Nano 2020, 6420–6435.
11. Qui, J. (2016). Nanotechnology development in China: challenges and opportunities. National Science Review, 3(1), 148-152. doi:https://doi.org/10.1093/nsr/nww007
12. salamanca-Buentello, F., Persad, D. L., Court, E. B., Martin, D. K., Daar, A. S., & Singer, P. (2005). Nanotechnology and the Developing World. Plos Medicine. doi:https://doi.org/10.1371/journal.pmed.0020097
13. Sharma, a. S., Saini, S., & saini, R. (2010). Nanotechnology: Future Medicine. Journal of Cutaneous and aesthetic surgery, 3(1), 32-33.