Path Formation for Rural Industrialization in India: Lessons for Peoples' Democracies

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Abstract: The paper historically explores the origins, directions, drivers and dynamics of path formation for rural industrialization. The challenges facing the protagonists of anti-imperialist industrial development in post-independent India are critically traced. The protagonists of anti-imperialist industrial development treated the path of rural industrialization as a residual path for development planning. The long time required to achieve a significant transfer of population away from rural areas to cities was the key consideration, which requires revisiting. A critical evaluation is made of the historical legacy of the ideas cultivated in the course of India's freedom movement by the social movements and scientific workers collaborating in the quest of decolonizing knowledge production, generating their distinct heuristics of industrial and technological upgrading and influencing the making of science, technology and innovation (STI) spaces with the state for the promotion of rural industrialization. The real world experiments undertaken by the Nehruvian, Gandhian and Left to the technological and industrial upgrading heuristics formation and their influence on the directions of innovation making are critiqued. Limitations of the real world experiments as well as their continuing relevance for the formation of agenda of peoples' democracies are delineated in the light of contemporary challenge of rural industrialization.

Introduction

The paper suggests that there is much to learn from the Indian historical analysis of path formation for rural industrialization through industrial integration and technological convergence. The key lesson is that the agenda of path formation for rural industrialization should be rooted in the directions and systems of innovation making that are proficient in upgrading the peasants, artisans and landless rural workers for a competitive access to resources, capabilities and markets and for the creation of newer markets for their manufactures and services. The big business should not be allowed to encroach on the livelihoods of peasants, artisans and landless rural workers in the interest of ecological and social justice. The barriers to entry of large firms in areas of cost to ecological environment, human health and social justice must be raised in the interest of planetary health.

The other important lesson is that the social carriers of innovation and transformation will have to be ready to involve peasants, artisans and landless rural workers as active partners in the determination of directions and system building, struggle with the state apparatus of peoples' democracies when required and determine politically the policy making agenda in respect of the market creation and science, technology and innovation system (STI) building. The dynamics of industrial upgrading is currently driven by the neo-liberal state interventions putting the big business in the driving seat through a cluster development policy to expand low wage employment. The protagonists of rural industrialization will have to rethink and implement the agenda of socio-ecologically coupled integration of primary, secondary and tertiary industries in the nations wanting to pursue the agenda of peoples' democracies.

Origins and directions

In 1947-48, ninety three (93) percent of the Indian people lived in rural areas. Only seven (7) percent lived in urban areas. National Plans were under debate in India on the path formation for rural and urban industrialization from the standpoint of how to cater to whom. The big business had to contend with the influence of the discursive power of Nehruvian, Gandhian and Left politics wherein the peasants and artisans had some influence. In 1948, India's first higher education commission (also known as Radhakrishnan Commission) recommended not only for the formation of Indian Institutes of Technologies (IITs), regional engineering colleges (RECs) and city level universities but also for the establishment of rural universities to undertake the path formation for rural industrialization[1].

In 1948, the Radhakrishnan Commission (Higher Education Commission) deliberated with the adherents of Nehruvian, Gandhian and Left views on the path formation for industrial and agricultural development and the policies for science, technology and innovation (STI) landscape transformation and higher education institutions. The rural university model received maximum attention; it was the longest chapter in the report (Dinesh Abrol, 2007, 2012). Recognising the need to practice the diversity and pluralism in respect of the development of higher education agenda the Radhakrishnan commission consciously allowed the formation of variegated spaces for the perusal of real world experiments on the path formation for industrialization.

But as the rightwing leaders were not in favour of implementing land distribution to the tiller and preferred feudal landlords to be given all the support to make a transition to capitalist farmers the Congress party went in for altogether a different model of rural development. The Congress party opted to establish the first agricultural university with the help of United States Department of Agriculture (USDA) at Patnagar and paved way for the promotion of high external input system agriculture, a very different model from what was recommended in the higher education commission though still presenting it as a rural university to the public.

Thus, what came through ultimately in the name of rural universities was actually the model of land grant model of agricultural university and the actual model of rural university was completely relegated to the background. High external system of agriculture led to not only the demand for the rural industries weakening considerably but also the conditions for the establishment of the local economies as a system-in-itself getting lost in the euphoria of increase in wheat yield and the celebration of improvement in food security of the Indian nation. While the rural university was officially imagined, it was effectively marginalized eventually due to the inability of the democratic forces to push for the real world experimentation on the lines recommended through the higher education commission.

The model of upgrading local economy as an integrated system of primary, secondary and tertiary industries failed to take root in India. Partly it happened due to the historical fact of the model not sitting well with the ideas and imagination of the political forces. They were optimistic about the ability of urban manufactures and services to absorb rural surplus labour and considered rural industries as technologically and economically backward. The agricultural universities governed by the Department of Agricultural Research and Education

[1] Sarvepalli Radhakrishnan OM, FBA was an Indian politician, philosopher, university vice chancellor and statesman who served as the second president of India from 1962 to 1967.

grew eventually wherein the model was served by the large firm in public sector. Fifteen (15) rural institutions, receiving little funding from the Ministry of Education, one of these institutes is established at Wardha in Maharashtra, are unable to implement the model of local economy as a system-in-itself[2].

It is a historical fact that immediately after gaining political independence in India as the social movements had to carry on their head the responsibility of identification of areas in which public sector enterprises (PSEs) should be established for urban industrialization the protagonists of national democratic transformation determined what should be done to promote the development of rural economy in post-independent India. Although the social movements offered suggestions on how the urban and rural industrialization could be better planned by the Indian state pursuing the development of modern capitalist sector, yet the agenda of development of STI directions for rural industrialization was a residual agenda for the national planning committee. The platform formed in the form of a national planning committee established in 1938 had come through the efforts of the Science and Culture group and others working at Calcutta and the Science and Culture group members were not completely convinced of the agenda recommended by the Radhakrishnan commission.

However, the social movements that had identified essential needs, suggested the activities, imagined the structures and products for the path formation for urban and rural industrialization could not make the peasants, artisans and landless rural workers as active partners in the participants in real world experimentation. The co-evolving mechanisms of collaboration through which PSEs and publicly funded research institutes (PSRIs) could achieve technological development and convergence of technologies in the sectors of modern capitalist development did not consider the integration of primary, secondary and tertiary industries for the formation of path to rural industrialization as an essential developmental intervention (Dinesh Abrol, 2007, 2012, 2017, 2023). The other relevant historical truth is that the vision and strategy of systems building for science, technology and innovation (STI) for post-independent India's development were directed predominantly in favour of the formation of pathways to industrialization by the bourgeoisie dominated state apparatus actively pursuing the cultivation of the rationality of capitalist modernity[3].

Indigenous innovations for economic independence

India's national level programmes included the development of solar energy utilization for cooking and water heating, biological reclamation of saline lands, development of vegetable dyes, coal beneficiation for steel and power generation, coal gasification for the manufacture of fertilizers, condensed milk out of buffalo milk, vegetable tanning of leather and many other such technological innovations. In the sectors covering the manufacture of pharmaceuticals and vaccines IDPL and HAL were involved and worked with Regional Research Laboratory (RRL), Hyderabad, National Chemical Laboratory, Pune and Central Drug Research Institute (CDRI), Lucknow. Hindustan Insecticides Limited (HIL) and RRL,

[2] Even the rural institutes have lost their moorings and forgotten the model as recommended. They are supporting the development of education and training for the establishment of rural industries without attending to the challenge of area based integration of primary, secondary and tertiary industries.

3 Dinesh Abrol (2014), Pro-poor Innovation-making: Lessons from the Indian Experience, in Shyama V Ramani (Edited) Innovation in India: Combining Economic Growth with Inclusive Development. Cambridge University Press

Hyderabad were involved in the development of processes for the agrochemicals sector. All of the R&D programmes were planned to use the locally available key starting materials and intermediates.

A large number of examples are available from the sectors promoting domestic natural resource utilization and tackling import dependence. Largely the national level R&D programmes were implemented to reduce the dependence on imports rather than for the development of agriculture and rural industries at the area level in an integrated manner. While even the scientific and technological work of Central Food Technological Research Institute (CFTRI), Mysore, a publicly funded research institute proved the British Scientists wrong, but the area based integration of primary, secondary and tertiary industries was not the vision or the priority. The Indian scientists worked on condensed milk powder being made out of buffalo milk led the country. They were successful in developing the dairy industry and the milk processing program of AMUL but the milk processing was undertaken as a project of developing an urban industry. National Dairy Development Board (NDDB). While it was set up as a cooperative sector institution involving farmers of Gujarat and has borne fruits in the form of AMUL brand of the India's dairy sector which is called the Taste of India now, but it has not followed the strategy of technological convergence for industrial integration.

The British scientists believed that the Indian coking coal is of no use for the steel making and the non-coking coals with high ash cannot be used in thermal power stations. Low grade coking coal utilization and metallurgical research involved first TATAs, a private industry, Bharat Coking Coal Limited, Steel Authority of India Limited and Bharat Heavy Electricals Limited (BHEL), public sector enterprises and Central Fuel Research Institute (CFRI) and National Metallurgical Laboratory, publicly funded research institutions. Domestically available coal with high ash considered to be unusable by the British scientists were put to use for the creation of boilers suitable for thermal power generation using low grade high ash non-coking coal. This effort involved the Bharat Heavy Electricals Limited (BHEL) in house R&D, a public sector in-house R&D working in the area of manufacture of power equipment and the CSIR research institutions and the regional engineering colleges providing engineers to BHEL as well as to the state electricity boards.

Cultivation of pluralism in innovation directions

The immediate post-independence period agenda of integration of the STI practices with the project of national development was essentially informed by the Nehruvian thinking on industrialization. But it was not limited to pursuing only the Nehruvian agenda of development of home market for domestic capital; in this project diversity and plurality of alternative political philosophies were actively accommodated to a significant extent until the mid seventies. Of course, this is due to the surviving influence of the ethos of the freedom movement. The freedom struggle had come up as a united struggle of the Indian people against the institutions of colonialism sustained through the mechanism of drain of resources, consolidation of semi-feudal relations and the underdevelopment of science and industry to serve the interests of British imperialism, and the necessity of multi-class alliance front was a political necessity of the leaders of the anti-imperialist movement.

The Nehruvian thinking, ideologically and in practice, had to leave a lot of space for the accommodation of STI practices informed by Gandhian and Left politics in the spheres of knowledge production. The diversity of paths and challenge of engagement with plurality of

knowledge systems was in-built into the need of the freedom movement[4]. The ideas of planning for science and technology came out of the intense ideological struggle of the perusal of Nehruvian Gandhian and Left ideas within the political leadership and in the scientific community. Contestations between all these ideas focused also on the strategies to be used to cultivate modern science and technology, engage with the issue of choice of technique, foresight and assessment of technology and socio-technical system design(s) and coevolving social relations of scientific and technical change[5].

A vast majority of leaders of emergent scientific community had embraced the Bernalist idea of directing S&T towards transformative social and economic development[6]. The Bernalist imagination of planning for science and technology was pushed by the Association of Scientific Workers (ASWI) to organise its own agenda on technology interventions in the CSIR system of laboratories. By the seventies plans for STI implementation included appropriate technology and people centric plans; these plans were promoted through the efforts of the scientists of Nehruvian and Left ideological moorings in the CSIR system of laboratories. ASWI consciously promoted interaction with the Arab World and African nations to promote an alternate vision of science development for the newly liberated countries.

ASWI too had to face the challenge of how to keep alive the contestations and experiments in respect of STI systems building going in the direction of people oriented development after its members took positions of leadership in the CSIR system[7]. The Association of Scientific Workers (ASWI) did try to sustain as much as possible these efforts too with the help of the mobilized publics for the perusal of alternatives in S&T and development during the first four decades of Indian independence[8]. Even as India's then Prime Minister Jawaharlal Nehru who had accepted to become the president of Association of Scientific Workers (ASWI) patronized many of the scientists who were till the fifties "outsiders" to the policymaking after they became insiders within the emergent national S&T system faced the systemic constraint and had to face their own respective challenges and dissonance[9].

Post-independence period politics of innovation policy

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[4] See the writings of Jagadish Sinha, Benjamin Zaccharia, Deepak Kumar and Dhruv Raina and Irfan Habib, Saradindu Bhaduri on colonialism and nationalism in STI to build a more detailed view of the dynamic unleashed by the anti-colonial movements in India.

[5] See also the writings of A R Rahman, and the ideas put forward in the "Science for Nation", a document released by the peoples' science movements during Bharat Jan Vigyan Jatha (BJVJ)-I in 1987 even while collaborating with the DST, GOI, and in the development of a series of documents released by the AIPSN during "Sabka Desh, Hamara Desh" campaign launched in 2015 to contest the politics of Modi Government, which are available on the website of AIPSN. See also the writings of Dinesh Abrol on pro-poor innovation, grassroots innovation and technology futures.

[6] See the divergent conclusions arrived at by Shiv Visvanathan, Benjamin Zachariah, Jahanavi Phalkey, Arnold David and Aqueil Ahmad on the prospects of planning of S&T in India.

[7] Organisationally and politically speaking, the process of outsiders becoming insiders to the establishment faced a huge challenge. While they had some voice and space in the system, the Nehruvian path had also fostered the hegemony of capitalist industry and its managers who were inspired by an imagination of replicating the agenda in agriculture and industry that did not align with the peasants, artisans and workers trying to become social carriers of transformative STI. The leaders of ASWI worked on several programmes themselves and led the national labs and contributed to the grassroots efforts.

8 See Om Prasad unpublished dissertation on the history of Association of Scientific Workers of India, ZHCES.

9 See the documents produced by National Planning Committee, Peoples' Plan, and Scientific Policy Resolution (SPR) for the details in J. N. Sinha, Dinesh Abrol, and Deepak Kumar.

The need to develop the human resources for science and technology as well as the need to practice the culture of science in all the creative endeavours united the Left, Nehruvian and Gandhian tendencies far more than the agenda of rural industrialization in their subsequent theoretical practice and in the struggles for STI against imperialist maneuvers[10]. Constructive action as an ideological and political instrument of resistance, counter-hegemony and reconstructive approach to the construction of S&T was still the repertoire of all the social movements active during the period of 1950-1980. Progressive social movements could get much support from the state agencies. Although the scientific leaders of Nehruvian and Left imaginations differed and diverged, yet they were open to accommodating rural industrialization at least as a residual path to development planning.
The National Planning Committee (NPC) functioned under the leadership of Jawaharlal Nehru whose own socialistic vision of national S&T system was supportive of a politically independent path of "autonomous development". This strategy of autonomous capitalist development allowed the Indian nation to reduce import dependence. India could pursue self-reliant development and could walk walking on two legs and even develop high external system of agriculture without subjecting to the exigencies of export oriented development of agriculture[11]. The National Planning Committee was set up through the efforts of M N Saha and others active in the Science and Culture Group in 1938. At the core, although the NPC's ideas of scientific and technological nationalism evolved were imbued with anti-imperialist, secular, socialistic and transformative values of social and political change, yet it needs to be recognized that they were ideological struggles on the relevance of rural industrialization[12].

Gandhian heuristics for upgrading of traditional industries

At the time of independence, a pre-capitalist traditional manufacturing for subsistence living was the dominant mode of production. Cottage industries existed in large numbers as family labour-oriented labour units. As India entered a period of transition to modern form of large-scale industry, the need to promote cottage industries for employment considerations was also actively considered by the mainstream. The mainstream leadership accommodated the Gandhian tradition through the policy of promotion and protection of the cottage industries. The mainstream policy regime provided considerable space for the governmental protection, economic support and incremental technological upgrading of traditional manufacturing. The cottage industries sector acted as a bargain sector.

The state apparatus filled with mainstream Nehruvian leadership gave also support to the activists of Gandhian orientation for the protection, modernization and development of

[10] Even this agenda of human resource for S&T contributing to independent or indigenous innovation is not anymore the agenda of Indian state apparatus at the moment.
[11] During the post-independence period the freedom movement inspired government formations could consciously accommodate the challenge of development of rural industries through the policy of sectoral or product reservation, R&D and technology assistance and market support in their overall policy framings. Even while the dominant path of implementing urban industrialization embedded in heavy industry and science based industries was the main vehicle for capitalist accumulation the initiatives for rural industrialization continued to receive the state support as a residual path.
12 See Special issue of EPW on Gandhian embrace of the method of scientists and the writings of Meera Nanda on Ambedkar and science. The ideas of B R Ambedkar, the icon of dalit movement, have been identified by Meera Nanda in her writings as the key to the universal legitimacy of science. Ambedkar understood the rural areas as source of socially backward ideas. Modern science had made a break with the sacred sciences of the past. Ambedkar thought urban technology and industry would be more important as an instrument of social change.

cottage industries in parallel to the mainstream programmes of heavy industry based industrialization. Gandhian experiments had encouragement directly from the State via the Khadi and Village Industries Commission (KVIC). The KVIC had the benefit of policy space and financial support for the practice of 'constructive action' for pro-poor development. Activists of the Gandhian orientation could use the support of KVIC to implement programmes for the development of cottage industries and strive to meet the challenge of technological upgrading of traditional manufacturing. In terms of its "socio-technical" frame, the Gandhian imagination followed the heuristics of upsizing by modernizing the indigenous technology[13].

The individual producer was sought to be made competitive by upgrading the local / traditional technology. Schumacher inspired appropriate / intermediate technology (AT) movement its practitioners to use the heuristics of Gandhian tradition. During the decade of seventies this AT frame became the heuristics of State sponsored movement for a wide range of departments and agencies. The governmental agencies encouraged the practitioners to upgrade the technologies embedded in indigenous / local knowledge, local raw materials, skills and capabilities to make the individual producers competitive. In the Gandhian tradition, the holistic meant an individual producer completing the production process without any or minimum division of labour. In this movement the "small was beautiful" but the small could not be made powerful.

During the sixth five-year plan (1980-1985), the government launched a new package of incentives for the rural poor to make use of opportunities for self-employment through programmes like the Integrated Rural Development Programme (IRDP), Training of Rural Youth for Self-Employment (TRYSEM), Development of Women Children in Rural Areas (DWCRA) and State-specific schemes for self-employment of SCs & STs and Women. These programmes were initiated with the aim of targeting households below the poverty line, and the idea was to provide each of them with a productive asset through a subsidised loan so that they can rise above the poverty line.

The assets provided to rural poor under these programmes included milch cattle, goats, sheep and poultry; equipment such as sewing machines, tool kits, camel carts, handcarts, rickshaws or bicycles for hiring out; or working capital for petty trading, tea or pan shops and the like. During the seventh five-year plan (1985-1990) this strategy was supported in a bigger way through large allocations in the form of both government funds and bank credit. This emphasis was continued during the eighth five-year plan (1992-1997). Throughout this period cottage scale units such as the individual weaver, the potter, the blacksmith, and the village shoemaker were also subsidized to ensure maximum employment per unit. For example, both Khadi and handloom were protected, the former through subsidised credit and subsidies to consumers on purchases, the latter through non-imposition of excise on hank yarn.

However, this policy had just the opposite effects. The cottage scale units had no incentives to explore technology upgrading. Low productivity, low wages and underdevelopment prevailed. Programmes for self-employment failed because of inefficient implementation via wrong selection of beneficiaries, 'leakages', failures of enterprises, loss of assets, saturation of small markets for produce, etc. Moreover, projects were not on a cost-effective basis;

[13] J C Kumarappa was the member of planning commission and his differences with Nehru on the role of animal driven Tonga as a mode of mobility in the city of Delhi were finally his resignation from the planning commission.

backward and forward linkages were absent; beneficiaries selected among rural poor were not adequately skilled and lacked management competence; the role of the middlemen and contractors was inimical, leading to 'leakages', training in isolation without integrating them with specific projects, and often without reference to local demand for skills.

It was during the seventies the practice of undertaking S&T for the industrial upgrading of traditional manufacturing received from the government a big push in India. But most of the technological solutions that this effort offered were unable to connect well with the local markets and capabilities accessible to rural poor and hence were mainly ineffective in improving competitiveness. Unfortunately, this technology push approach persists till date uniformly in all the agencies. An illustration is readily provided through some examples of technology upgrading attempted by the Khadi and Village Industries Commission (KVIC). The KVIC's strategy was to improve traditional technologies by scaling them up to intermediate levels and introducing power-driven machines.

However, this approach increased the costs, made practical functioning difficult and adversely affected the formulation of viable projects. For example, although the semi-automatic improved loom was developed in 1972, 90 percent of handloom weavers continue to use the pit loom. The power pottery wheel entered the market about two decades ago (1970); yet the village potter continues to operate the traditional wheel. The traditional ghani (oil expeller) is fast disappearing but it has not yet been replaced by the power-driven ghani. The large producer using solvent extraction / expellers is more competitive. Improved gur (jaggery or molasses) furnaces have been developed but not adopted adequately. These are only a few illustrations.

In most cases technologies got developed keeping the individual enterprise of a small producer in mind. The practice failed to incorporate local resources-raw materials, engineering materials, energy sources immediately accessible by / or with the people in the technological solutions. Local markets were ignored. There were no efforts to develop technologies that could strengthen inter-links in the local economy by developing input output relations among existing occupations, in terms of specific products and services. There were no attempts to innovate using local engineering capabilities and materials to substitute non-local products e.g. replace stainless steel vessels by glazed clayware and, if necessary, metal bottom or internal pipes, etc. for heat transfer. Then, it would have been possible for the agencies to lower investments and scales, and develop inter-links in the local economy. Non-conventional energy sources were not suitably integrated into industrial activities requiring machines. The focus was more on providing non-conventional energy sources for the purpose of cooking and lighting. Technology for co- products and by-product formation was given very little attention (Panditrao, Y. A., 1994).

Efforts made by the KVIC to overcome the limitations of individual artisan's resources through the use of common facilities centres also failed to finally upgrade the production of rural artisans in an economically viable way. These centres have ended up serving only those artisans who are working for large urban markets under the control of large traders or a state sector owned bureaucratic marketing facility. The rural non-farm sector (RNFS) occupations are even today largely subsistence employment. They have survived because the RNFS occupations are linked to either serving the local rural markets or meeting those needs of the urban poor that the modern industrial sector is yet not able to satisfy. However, millions have

lost their livelihood on account of the lack of technological upgrading in the face of increased market competition14.

Nehruvian heuristics for modern in small scale and technology

In the CSIR system of laboratories, scaling up of the cottage industries and of the micro, small and medium scale industry (MSMEs) were developed through the pathway of "downsizing of modern technology". Under the State-sponsored programmes of technology diffusion the down-sized modern technology was provided from the publicly funded agencies to the small-scale industry for implementation. The Nehruvian heuristics promoted the frame of "appropriate" / "economical"/ "commercial" sizing & designing using sectoral reservation. This socio-technical frame of modern small-scale unit was implemented not only in the Council of Scientific and Industrial Research (CSIR) but also in the Indian Council of Agricultural Research (ICAR). It was implemented through the Department of Textiles, Small-scale Industry Development Corporations and National Small-scale Industry Corporation. Some of the notable achievements of CSIR system are presented below

Table 1: Selected notable pro-poor innovations of the CSIR

Product/Process	Nature of the innovation	Impact on rural/urban households/producers
Amul – leading brand of dairy products in India	Process developed by the Central Food Technology Research Institute (CFTRI) to make condensed milk powder from buffalo milk- a difficult challenge by the dairy technologists at that time.	Access to milk, butter and dairy products across the entire country; livelihoods for hundreds of households
Improved vegetable tanned leather	Process innovations by the Central Leather Research Institute on whose strength the national leather technology mission has made an impact on the leather industry as a whole.	The units working across the country could shift to a low cost solution which not only solved the problem of pollution facing this important export oriented Indian industry but also provided for improved incomes, associated value added products out of fallen carcass utilization and social justice.

14 Currently within the agricultural households a substantial share of work time is increasingly being spent on non-farm activities, but mostly on construction (Santosh Mehrotra, 2022). Construction sector is the single most important source of non-farm employment in rural areas. Vinoj Abraham (2023) adds that diversification in employment to rural non-farm is a key characteristic of the rural economy today and diversification in employment is a strategy for the rural populations to mitigate the risk rather than maximization of income earnings. Households are moving out of agriculture and are increasingly becoming mixed or non-farm households. Vinoj Abraham (2023) also underlines the point that non-farm households are higher in the economic ladder. The gap between the agricultural household and rural non-farm household is also however reducing. Casual labor is declining. All of this is primarily attributed by him to the movement of workers to being self-employed in the agricultural households. There is no decline in casualisation within non-farm and mixed households. It is not shift which may be more akin to earnings maximisation. It is a process of diversification through self-employment.

Extracts of citronella, lemon grass, Japanese Mint	Agro-processing technologies	Provided livelihoods to hundreds of farmers.
Development of improved hand pump, low cost culverts for rural roads, red clay based sanitary wares, leaf cup production, leaf cup making machines, iron removal plants, technology for the two-pit latrine system etc.		These technologies contributed to the use of local raw materials and skills and benefited the local economies.

The practice of technology blending, which demands that traditional and modern shall be appropriately combined by the practitioners in context specific ways, became far more acceptable as a socio-technical frame across all the political traditions. With the emergence of new generic technologies namely microelectronics, information and communication technologies, biotechnologies and new materials a number of new opportunities were opened up for the practice of networked development in which the peasants, artisans and rural workers could see opportunities for themselves as social carriers of innovation. Technology blending began to be actually recognised as their solution to socially just development by the social movements.

Yet, the combined and sincere efforts of social movements could not achieve significant victories. Although all the trends have seemingly undertaken the efforts to organize their followers for the conduct of experiments, perhaps their system building was inadequate. Inappropriate socio-technical frames were selected for pro-poor rural industrialization pathways. The analysis suggests that socio-technical frames embedded in a primitive conception of competitiveness would not be the best fit for rural India. Furthermore, their technology implementation efforts were poorly developed; pro-poor innovation system building needs a serious re-conceptualization. Therefore, efforts of the "State S&T" (S&T being carried out by the KVIC, CSIR, ICAR, IIS and IITs) failed to make their full contribution.

Many CSIR rural technologies were based on the processes intended for being used in capital-intensive small-scale industries. These technologies were meant for catering to the urban markets and needed high inputs of non-renewable energy source to be utilized in the course of production. Entrepreneurs who successfully used these technologies tended to come from well-established business families. The CSIR R&D personnel failed to configure their R&D projects for the appropriate economies of scale and scope of rural contexts. Technologies developed did not meet the real needs of targeted regions and the available physical infrastructure. The process of technology transfer was undertaken by pushing the available solutions without the technology adaptation effort required for fitting the technology to the conditions of the users. This is because interaction of R&D workers with users was weak. Attempts to understand the users as systems and to manage technology transfer as an interactive process were feeble and few.

Technology programmes for pro-poor rural development continued to be weak on the aspect of networking of external resources such as expertise and funding. During the phase of technology development the interaction with users was usually poor. In the case of rural technologies, the laboratories continued to depend mainly on the efforts and inputs of their scientists alone and in-house R&D funding for technology development. Evidence suggests that involvement of external experts and multi-disciplinary background of laboratory scientists significantly improved the technology uptake in the CSIR system of laboratories. In

the case of village industries, the conditions for technology development have not changed in any kind of significant way.

From a survey of the five hundred users of CSIR rural technologies undertaken that the author took in collaboration with his colleagues, it has come out quite clearly that even the newly developed technologies are failing to make an impact on the rural scene. Only 18% of CSIR rural technology users were in production and the rest have either not started or have chosen to discontinue the production (Abrol, 1998). This report shows that the programmes of rural development have been apparently going on in the laboratories without any kind of critical evaluation being undertaken by the CSIR headquarters. The rural non-farm sector (RNFS) is a field where the CSIR has had the possibility of contributing a great deal, but even after twenty five years of involvement it remains an area of extremely low priority for the CSIR leadership.

After the announcement of economic reforms the situation changed further. In the document entitled 'Creating an Enabling Environment for Commercialisation of CSIR Knowledge Base: A New Perspective' (1993), the RNFE sector did not get much attention of the committee. In the CSIR Vision document of Dr. R. A. Mashelkar, this area did not get attention. Dr. Mashelkar can be presumed indirectly to have mentioned it in the document through the reference made to the objective of technology for human welfare. There are no specific targets with respect to this area in the Vision document, though in all the other domains the numbers are clearly indicated in the document. Dr. Samir Brahmachari, the new Director General led the CSIR to implement Vigyan Kutirs in the same way as also done by most of the past director-generals. Implementing rural development residually, as a part of the CSIR-800 mission programme, through again technology push approach, was again the fate of rural technology implementation.

From the top to the bottom, there has been very little learning in respect of the management of R&D and technology transfer for rural development in the last twenty years. Scientists continue to self-indulgently believe that their technologies are fully viable economically in rural areas. There is very little record being kept by the laboratories on the status of technology utilisation. Since the top management has been mostly indifferent to the efforts of R&D and technology transfer for rural development, there have been hardly any investments in bringing the users closer through the encouragement to link organisations/ agencies that could have acted as the bridge. This lack of investment is reinforcing the habits of CSIR scientists in favour of technology spin-offs without any feedback loops that embed it appropriately in the rural context for which it was designed. Both technology development and implementation continue to be oriented toward the linear model of innovation, where the laboratories produce spin-off technologies without fitting them to the conditions of users or involving them in the adaptive efforts (Pulamte and Abrol, 2003).

To conclude, CSIR leaders took up technology development projects for the rural areas only when the government of the day wanted them to pursue this objective. Since the CSIR leadership's lack of commitment to the development of rural technology comes from the fact of that the political bureaucratic apparatus treats innovation making for rural industrialization as a residual activity for its own design of development, it is important the CSIR's becomes accountable through the introduction of a special research audit system to parliament. Of course, this is not only the responsibility of CSIR; but the CSIR will succeed only when its partners in the government and the private sector are also ready to give a priority to pro-poor innovation-making activity.

Rural industries, innovation making and petty producers as competitors

India's pro-poor innovation-making activity in rural industries has suffered from the implementation of a primitive conception of competitiveness. The niche of pro-poor innovation-making was accommodated to fit with the residual path vision of rural industrialization. The view that innovation in rural industries should be restricted to the transitional objectives of poverty alleviation has its roots in the practice of a primitive conception of industrial competitiveness. The approach towards implementation of technological upgrading in the rural industries is to target the individual small producer to become individually competitive. In this approach, competitiveness of this segment gets judged by comparing the existing relative costs and prices to individual producers because there is no recognition of potential competitive advantages that might accrue through the exploitation of economies of scale and scope and cluster or network effects. Therefore, these synergies are not generated or captured and in their place, small producers are forced to accept intermediate technologies with higher costs of inputs per unit of production.

Competing large capitalist enterprises are in a position of erecting barriers to competitive access for small producers in the input and product markets and often use it. Mutual competition amongst small producers also leads to narrowed access to inputs and technologies and adversely affects the effective demand for their products. In those cases where small producers are being organized only for access to inputs and credit, the absence of cooperation in production results in mutual competition at the marketing stage that in turn breaks their existing alliances. Often both, the traders and the large-scale capitalist enterprises (competing with them in the market for the sale of products) have an interest in aiding the processes that can disrupt the cooperation of small producers. As in turn this failure of cooperation among small producers leads to the establishment of a vicious circle for the utilization of intermediate technologies in these sectors, the selected approach to pro-poor innovation making has adversely affected the pro-poor innovation diffusion15.

Technology and market are interlinked issues. Often, for the markets where the rural poor can compete with ease, even the ready to transfer technologies are not even available. For the rural poor the problem of access to markets is a systemic problem. The rural poor cannot compete with everyone anywhere and everywhere. The markets for which the rural poor should compete must be within their reach. Further, for the enterprises of rural poor to succeed the programmes of industrial modernisation must have a strategy of developing the local economy as a production system in itself. Despite these challenges, there have been success stories and they yield the following insight. Useful technologies were created by understanding the needs of targeted beneficiaries. For many traditional industries the users come mostly from among the rural poor**16**.

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[15] Rural technology interventions evaluation got built around cost-benefit analyses for their ability to compete in the markets dominated by products under production through large firms. Assessment of the negative externalities under development for the large firms was rejected as essentially a manageable problem through regulation and compensatory solutions. Peasants, artisans and agricultural labourers continue as passive recipients of the technologies selected for promotion by intermediaries. Technology support has been conceived in the form of one-time injection. Improved user support is not oriented to the task of improving the 'participation' of peasants and hardware. A common feature of failed ventures evoked in the rural technology studies is that the technology implementation in the CSIR system was guided by the artisans as the social carriers of development of "intermediate appropriate" technologies.

16 The lesson is that there must be an assessment of the needs of potential users especially in terms of the type of competition they face and their market and non-market opportunities as well as their current level of access to markets,

There are many lessons from the real world experiments undertaken in India. Efforts of public agencies to improve the competitiveness of rural firms cannot conceptualise the problem of technology support as only of a one-time injection of improved hardware. The concept of improved hardware cannot be limited to creating the machinery and equipment through downsizing of large-scale modern technologies, upgrading of traditional technologies, blending of modern with traditional technologies with the aim of making an individual producer efficient. If the improved technologies are poorly connected with their existing local production as well as technology systems, the targeted users cannot be convinced to adopt the new technology. It cannot be assumed that for every improved technology there will be an obvious business model available in rural areas that would increase the profitability of the user.

Calculations of the economic viability of technologies cannot be made with the assumption that small producers in village industries are incapable of organizing themselves for a better access to the higher scales of production. Selection of technology development objectives and choice of partners for user development need to be designed with the perspective of organizing small producers in village industries to interface for achieving economies of scale and scope through their appropriate organization and assuring network and cluster effects, so far ignored in competitiveness evaluation. Technology implementation must be guided by a systemic conception of competitiveness. The production and technology systems of the targeted users must be identified such that any new technology package reduces their costs by either resorting to alternate input-using technologies or using the present inputs more efficiently.

The most important lesson is that the social carriers of pro-poor innovation will have to actively co-operate among themselves in production to break the monopoly of large capitalist enterprises. In order to be systemic in the approach to innovation, small producers will have to not only utilise those technological opportunities that connect well with the local markets, capabilities and resources, but also organise, develop and obtain technology for co-operation in production among themselves. This kind of cooperation implies the maximum utilization of local advantage while linking them internally and developing their capacities to plan for better market access and egalitarian organisation of production. They need to undertake technology choices that enhance co-operation in production via the development of production linkages, value addition, improved production & greater diversification.

Innovation making, rural industrialization and the Left

The Left tradition gave support to public sector, cooperative sector and protection of small-scale industry in the private sector as a social carrier of transitional strategy until it is able to mobilize the support for peoples' democracy. The State apparatus formed under the Nehruvian leadership accommodated only the views of the Left in part when it supported the public sector and small-scale industry. Land reforms did not receive support from the state apparatus. Nehruvian and Gandhian politics did not prioritize land reforms as an essential

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resources and capabilities. There must be a close collaboration between the scientists and the prospective users; otherwise it will not be possible for S&T agencies to help them become competitive users of the technologies developed. Analysis of the pattern of success indicates that the formulation of strategy for system transition starts from the standpoint of how to improve the 'participation' of the end users in the system of innovation.

policy. The measures such as protection of small producers, promotion of public sector and restrictions on foreign direct investment, bank nationalization and sectoral reservations came to be an integral component of the policies of Mrs. Indira Gandhi. The Left encouraged the heuristics of workers' participation in the management of the state sector. In order to build the accountability of large technical systems was accommodated in the banking sector.

The Left tradition of Indian politics through the peoples' science movements (PSMs) continues to support the approach of cooperation in production of peasants, artisans and landless rural workers. See for more details Dinesh Abrol, 2012, 2018. The PSMs have been making efforts to develop the social carriers from amongst them to experiment with the pathway of multi-sectoral rural network system of group enterprises. The state support has ceased its support for this approach altogether now. Only until the mid-1980s these measures actively received priority in the process of planning from the state apparatus. Now, the actors promoting pro-poor innovations in India include corporate non-governmental organizations (NGOs). The new actors are unlikely champions of the poor as they take active support from large firms including foreign multinationals. Some of them are also active as a part of the cluster development strategy of the government. But it is already clear that they are not effective as social carriers of rural industrialization[17].

The State S&T remained supportive of the followers of social movements only up to the end of 1990s. The situation started to change only after the 1990s. The peak period of the state support was the decades of seventies and eighties. The creativity of social movements as well as of the State S&T institutions was unleashed during the 1980's. The social movements utilized the niche to work on their own respective notions of rural technology upgrading and developed the intermediary organizations with a pro-people orientation in large numbers. Developmental and educational action related efforts could be conceptualized in the field on a scale unheard earlier. Experimental spaces were created. Real world experiments acted as a tool of ideological debate as well as of political mobilization. Attempts of the S&T volunteers were supported by State S&T institutions as well as S&T based voluntary organizations.

India had not been as yet engulfed by the syndrome of there is no alternative (TINA). During the 1970's and 1980's niches for the ideas that were not socio-technically mainstream got established in some of the finest state sector institutions in the form of Application of S&T in Rural Areas (ASTRA) in Indian institute of Science, Gaon Ka Karigar and Science in the CSIR system of laboratories, peoples' science movement and other S&T based Voluntary Organizations working in collaboration with the institutions of higher learning (IITs, Universities) and CSIR laboratories. These niches have given a meaning to the departments and programmes being set up for the development of rural technologies by the scientists and engineers to encourage the S&T based Voluntary Organizations to participate in the making of innovations for rural industrialization.

[17] Although this approach has been seen also as catering to the poor, but their 'bottom of pyramid' (BoP) or 'frugal' innovations in practice is at the most serving the consumption needs (Kaplinsky R, 2009). Findings of the UNDP survey of inclusive business also indicate that large corporations, be national or transnational, were mostly unable to include the poor as producers (UNDP Survey, 2008). Corporate self-interest dominates, be vertically integrated or organized as networked systems corporations are not able to offer to the poor the benefits of competence enhancement and organization of local production. Reasons are due to their failures to build partnerships with the poor as producers, higher transaction costs given the diversity of interactions, difficulties in interpreting local demand, inability to deal with heterogeneity and underestimation of the investment required in local capacity building for deeper inclusion of the peasants, artisans and rural workers (Saurab Gupta, 2009).

Indian pathways to rural industrialization and its limitations

The heuristics of individual producer being made competitive has not been able to help the peasantry and artisans and landless workers to successfully compete as producers in the market even when the state apparatus was offering the support from mainstream innovation making structures. The corporate sector has succeeded in earning far more space and obtaining market power. The social carriers of rural industrialization in making could not organize themselves for the implementation of the integration of primary, secondary and tertiary industries. The possible pathways to ecologically coupled industrial integration and technological convergence have not been able to emerge and take root as a driver of rural industrialization. The rural industries failed to seek greater support from not only the state apparatus but also from the left and democratic forces pursuing the cause of agrarian revolution in India.

Certainly there were real world experiments on the ground for the establishment of the heuristics of developing the ability to access resources, markets and capabilities in rural areas to develop the structural competitiveness of local economies. The ecologically coupled technology convergence required for the integration of primary, secondary and tertiary industries in rural areas could not be pushed forcefully by the Nehruvian, Gandhian and Left tendencies. They were targeting the individual producer to become competitive. Although the Left tendency did try the route of cooperation in production, but it could not become an integral part of the political and ideological practice of the left and democratic forces. The structural rigidities and voids co-evolving on account of the demand formation for rural industries are connected to the support for high external system agriculture based strategy of development of productive forces and production relations in the local economies. Non-market calculations of ecological and social environment were not factored into by the industrial and agricultural policies for which there is a larger purchase from the people. Rural industries are absent from the quest of ecologically and socially just development in the processes of demand articulation and innovation directions for the development of new technologies and sciences required for the path formation.

Contemporary challenges facing rural industrialization path

Currently there is much less value addition taking place through local industry for the promotion of co-products and by-products use. It is essential that these contradictions for the design of technology interventions are suitably resolved. The resolution will have to be environmentally, socially and economically beneficial. There has to be en evolution towards new paradigms of agriculture and agro-industrial production in which inter-linked farm and rural non-farm sector occupations can develop as systems enabling peasants, artisans and landless workers to achieve economies of scale and scope and remain competitive, while being compatible with existing socio-technical norms (Abrol Dinesh, 2006).

The challenge of innovation making for rural industrialization has become more complex. In order to understand the implications of the newly emergent scenario for the future interventions, the protagonists of rural industrialization shall focus once again on the political and ideological aspects of pro-poor innovation-making. Socio-ecologically coupled industrial integration and technological convergence using the synergy of rural non-farm sector (RNFS) with the agricultural sector is the way forward. Agriculture will have to act as the sources of investment demand for RNFE sector. In rural areas, the additional demand will follow

through the production of light industrial products if the input and output side of agricultural sector become the driver of rural manufacturing and services produced in rural areas.

Undoubtedly rural manufacturing has the potential to fill the gap in the industrial structure and grow through such sources of demand only. But which of the sectors (between rural and urban manufacturing) would dominate will very much depend on the relative returns to the production embedded in their own respective paths. In India, presently the rural non-farm enterprises (RNFE) sector requires greater state intervention in the directions for innovation making and technology development. In the sectors covering food products, dairy sector, wood based and bamboo based construction materials, non-metal materials available in the rural economy as the materials for processing into value added non-food items, leather products, social movements have experimented with the growth of rural manufacturing and rural manufacturing is going to take place through the networking of OAMEs, DMEs and NDMEs[18] to absorb surplus agricultural labour available in a synergistic way for agriculture.

Even during the mid eighties, Vaidyanathan (1986) had also underscored the preponderance of the residual nature of employment in the non-farm sector due to the sustained neglect of agricultural infrastructure especially irrigation and also the choice of a variety of farm technology favoring large firms promoting urban industry. Lack of attention to building a range of physical infrastructure, especially, transportation and electrification through the route of technological convergence embedded in the integration of primary, secondary and tertiary industries, has ended up adversely affecting the growth of both the farm and non-farm sectors. The two crucial political processes: "the politics of knowledge production" and the "politics of technology implementation" were weakened during the post-1980s economic reforms led political debates. The State will have to be compelled to accommodate technology interventions for the benefit of pro-poor innovation-making aiming to advance rural industrialization.

In a study conducted on technology interventions for the National Commission on Rural Labour by the working group formed for the study of technology interventions for rural labour on the eve of the reform period, T S Papola (1990) brought out how village level studies bear out irrelevance of the technology development investments being made in the publicly funded R&D institutions to the traditional artisans and recommended that an alternate informal system of R&D be set up in which the people can collaborate with the technologists. Artisans have been traditionally the social carriers of techniques for rural industrialization. The traditional artisan has become costlier and non competitive. The technology development in the area of artisanal work and craftsmanship has been few and far between except in weaving, tanning and pottery.

The main finding of the study done by T. S. Papola was that rural labour has certain definite characteristics, and that technology to suit these, are few, and the existing ones are inefficiently disseminated. Largely, the process of technology development itself has not been adapted to cater to the needs of the rural worker. The results after the analysis show that institutional and procedural changes would be required. Besides, the direction of R&D would

[18] Rural manufacturing consists of three categories of manufacturing enterprises (1) own account manufacturing enterprise (OAME); (2) non-directory manufacturing establishment (NDME); and (3) directory manufacturing establishment (DME). OAME does not use any hired labour; an NDME has at least one hired worker, with total number of workers being less than six (including hired workers and household workers); and a DME employs six or more workers (including hired workers and household workers).

have to focus more on rural labour needs and on certain specific activities and occupations. Technology intervention can do the following thing, raise productivity to generate a surplus, diversify work possibility for alternate employment, review and improvise on traditional activity and practices. Technology use and adoption is severely hampered by low affordability among rural workers.

The working group noted that technology intervention for women workers will have to provide enough income to the household so that child get an opportunity to educate themselves (information technology has a special role to play in the lives of women workers) and eradicate child labour by devising innovative methods to replace children specific activity, e.g. bangle making. By carefully examining the requirements of women, innovative technology and better water resource management practices can be adopted. Additional opportunities through forest related industries and through plantation work to reforest land may be created. Special requirements of technology for rural labour included technology to take into account the seasonality of work of rural labour. Technology to suit rural labour should be economically viable, affordable, adaptable, relatively simple level of technology, have low level of external dependence and should be in consonance with socio-cultural factors.

T.S. Papola (1991) brought out how contemporary technology, tools and equipment developed for agriculture are economically viable only at a scale of 7-15 acres of land holding and intensive cropping patterns of 2-3 crops-making them less applicable for rural workers and for small and marginal farmers. The working group therefore recommended that technologies for soil and water management were required. Available ones are either semi-proven or field tested but small farmers are not able to access them. The working group discussed how technology for infrastructure and service was not reaching and ill connected with the target group due to reasons of affordability, lack of access to information, socio-cultural practices. The working group recommended that there is an urgent need to choose the directions for technology interventions around the adoption of mechanized agriculture accompanied by employment opportunities diversification, to absorb the displaced labour. It recommended for the development of equipment for a land holding size of 2-5 acres.

The working group made a recommendation for the reduction of drudgery, specifically in the areas of inter-culture, and plant protection, technology for storage to minimize losses, resource management, erosion control, land reclamation and water lifting techniques, provision of seeds, manuring materials and information on alternate cropping patterns. It recommended product diversification in the case of artisanal activity. The working group made a case for technology upgrading to work for preservation of traditional skill and craft. It demanded increased efforts for technology for provision of drinking water, recharging of ground water, health and sanitation, shelter, fuel and fodder, communication and education, improvements in life of rural workers through application of ergonomics, improvement in the physical environment including thermal environment and other work conditions such as vibration, noise, dust, chemicals, and exhaust emissions, adoption of safety measures in agricultural machinery, suitable animal husbandry embedded in local varieties of bovines, locally available animal feeds and forages.

The post-reform twist in thinking on rural industries

The post-reform period has seen a significant change in the Nehruvian thinking on the strategy for rural industrialization. In 2007, the National Commission on Enterprises in

Unorganized Sector (NCEUS) made a move in favor of cluster development strategy where the large firms would be asked to act as lead firms. It suggested a mission mode approach for promotion of technology for the unorganized sector upgrading using cluster development strategy of industrialization. Although the CSIR and Mahatma Gandhi Institute for Rural Industrialisation (Wardha) were asked to strengthen their rural technology efforts, yet the thinking went in favor of large firms providing leadership and peasants, artisans and landless rural workers were not conceptualized as the social carriers of innovation making[19].

The National Commission for Enterprises in Unorganized Sector (NCEUS) chose to put in front the changed economic environment as its reason. It recommended to the government to embrace the growth pole strategy for the development of enterprises in unorganized sector in the rural areas20, develop the growth poles as 'cluster of clusters' and link the clusters in the area as the potential growth points and promote interdependence which allows them to enjoy external economies of scale from their simultaneous and complimentary functioning and favored the strategy of promoting closer co-operations of large and medium enterprises with micro and small enterprises to foster the growth of unorganized enterprises as ancillaries to large and medium units.

The Bihar Report on Rural Industrialization, issued around the same time in 2008 by the Government of India, saw also a solution in cluster based approach with the focus on specific farm based products. It suggested that the areas that have been identified as surplus in crops, vegetables and fruit production need to develop sound economic clusters. All necessary infrastructural development including rural extension set up for technology transfer should be undertaken intensively and around such economic clusters to increase and sustain agricultural modernisation. It suggested special emphasis on those high yielding varieties, which may be suitable for processing industries and growing off season vegetable crops. See the report of the special task force on Bihar from the Government of India (GoI, July 2008 for further details.

Modi government and rural area development planning

The new guidelines for spatial planning in the context of rural area policy formulation also realize that the relationship of the urban and the rural is contentious with the emerging competition from agri-competing urban industrial enterprises in the rural non-farm sector. In India, the land is becoming for non-farm households an asset for speculative purposes. The resources for RNFE compete with the resources required for agriculture in the case of poor rural households. The resources available with rural poor households for rural manufacturing are certainly inadequate. Although rural manufacturing is an emerging possibility for the growth of RNFS employment, but it cannot be left to the market players emerging within the large enterprise domain to drive the growth and development of RNFE sector.

[19] The NCEUS wanted the institute at Wardha to be strengthened and to be designated as the Apex Rural Technology Promotion Centre of the country. All products specific R&D Centres of the KVIC and other All India Boards catering to other traditional industries should work under the supervision of the Wardha Institute. Technological Innovations and Dissemination Centres (TIDCs) were be set up in each State/UT with following details: - TIDC to be developed as a standard IIT-CSIR venture.

20 A Report on Technology Upgradation for Enterprises in the Unorganised Sector Status, Constraints & Recommendations, National Commission for Enterprises in the Unorganized Sector, www.nceus.gov.in April, 2009

Presently the Union Government is stimulating the formation of Farmers Producers Organizations (FPOs) to develop India's non-farm sector21. There is now the scheme with a target of setting up 10000 Farmer Producer Organisations (FPOs) by the Central Government. It is only building on the earlier efforts in the non-farm sector. At the moment the scheme addresses only the solutions to the general challenges like working capital22. There is a change in the imagination even while the integration of primary, secondary and tertiary would need technological convergence for industrial integration. Over the longer term for the growth and development process agriculture does have some inherent limitations, and industry / non-farm sector has a greater potential to develop technological innovations because it can capture dynamic economies of scale and scope.

The growth pole strategy means that the efforts for the integrated development of primary, secondary and tertiary industries would be taken under the control of large enterprises, then the policy of developing the rural poor as social carriers of rural industrialization would be essentially getting little or no support and the FPOs would also be required to plug into the agribusiness led path to agricultural development. This will adversely impact on the agricultural development pathways in making in the country through integrated farming systems, natural farming and organic farming. The coupling of industrial integration and technological convergence will suffer only further.

Technological convergence, industrial integration and future prospects

The historical analysis of developmental experience suggests that technology interventions for rural non-farm enterprise building need to rethink the rationale of system development for industrial integration and technological convergence itself. As the pathways of integration of three rural industries can offer many benefits for disaster risk reduction, climate risk reduction and achieve sustainable development goals, industrial integration can also be made beneficial to ecological environment through the programs of energy and resource use efficiency improving green innovation. Science, technology and innovation (STI) studies are beginning to focus on the problems of transition management with a view to usher in sustainable development in Europe and China.

The implementation of the integration of primary, secondary and tertiary industries is once again under consideration in the wake of the need to develop the paradigms proposed for bioeconomy and circular economy development in Europe (Les Levidow, 2019)23. The

21 In the State of India's Livelihoods Report 2022, Sanjiv Phansalkar and Nimisha Katakee suggest that the non-farm sector would become more important in future and they too include in non-farm sector all 'ancillary' activities namely petty trade, animal husbandry, craft, handloom and cottage industries for the production of a wide range of items, services as well as gathering produce from forests and common lands.

22 They also recommend to the FPOs to address the challenge of establishing a clear business process. Such a business processs design must make specific choices about what stage of the process is to be collectivised. They point out that so long as poor rural households feel the need of a diversified portfolio, the constraints caused by the necessity of blending their relevant production activity in their pattern of life will remain in force. They explain that in dairy production management of feeding, breeding and management of animals and milk production is left to individual initiative. Processing and marketing of milk are the activities in the fold of the producer collective. Failure to design clear and effective business processes gives rise to occasions for dissatisfaction and conflict, resulting in challenges in the viability and scale-up as well.

23 Levidow, Les; Nieddu, Martino; Vivian, Franck-Dominique and Béfort, Nicolas (2019), Transitions towards a European Bioeconomy: Life Sciences versus agroecology trajectories. In: Allaire, Gilles and Daviron, Benoit

traditional development model of rural areas is also very much under transformation on account of rurality as context for innovative responses to social challenges. Social innovation is expected to play the role of a significant instrument or practice in the perusal of neo-endogenous rural development (Lucas, Ollmedo, Mara van Twuijver, Mary O' Shaughessy, 2023)24. The Chinese government has formulated a national strategy of the "integration of rural primary, secondary and tertiary industries". Farmers can engage in agribusiness, such as the processing, circulation and online sales of agricultural products, rural tourism, etc., which will improve the farmers' welfare and attract more entrepreneurs to rural areas.

The primary development of industrial convergence or integration in the face of the lack of an appropriate technology development strategy and relevant legislation can have negative impacts on the ecological environment in rural China. Even in China the results suggest that rural industrial convergence and ecological environment are barely coordinated nationwide in 2017-2021 and will get better coordinated. The four developed provinces in the eastern coastal area have reached primary coordination. The high quality of ecological environment and its coordination with rural industrial convergence will contribute to rural social and economic development (Gu J. Zheng and Zhang J, 2022)25.

Peoples' democracies, innovation theory and rural industrialization

In the innovation studies, the theory of technological convergence refers essentially to the phenomenon of diffusion of the same technology. For example, see the formulations of Nathan Rosenberg, 1963. His formulations of technological convergence do not connect us with the demands arising out of the integration of primary, secondary and tertiary industries. Industrial convergence can be conceived as arising out of the integration of technologies, industries, services and markets. Socio-ecologically coupled technological convergence can involve not only the adoption of new and emerging generic technologies but also involve the co-products and by-products to realize circularity in the local economies and develop them as a system-in-itself. As a negation of the imperial mode of living that the big business and big tech is pushing so hard today this can become the path of technological convergence and industrial integration in the contemporary world.

All over the world, as even today technological convergence for industrial convergence continues to be directed towards building platforms through which different enterprises can share and integrate technologies, the process is being certainly not ecologically coupled technological convergence based industrial integration. Although industrial convergence is claimed to be occurring through the integration between products after the adoption of digital technologies, but it is helping the big tech to incorporate and insert agriculture and rural industries into global agricultural value systems as unsustainable path to rural and urban

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eds. Ecology, Capitalism and the New Agricultural Economy: The Second Great Transformation. London: Routledge, pp. 181–203.URL: https://www.routledge.com/Ecology-Capitalism-and-t...

24 Rural areas represent the vast majority of the European Territory. They are key enclaves in terms of biodiversity, food, energy and other raw materials. An estimated 29.1% of the total European Union's population lives in rural areas. Exogenous-structural forces such as global market liberalization and urbanization can, in part explain the uneven development of rural areas (Eurostat, 2020), in Lucas, Ollmedo, Mara van Twuijver, Mary O' Shaughessy , Rurality as context for innovative responses to social challenges-The role of rural social enterprises, in Journal of Rural Studies 99 Elesevier, (2023).

25 Gu J. Zheng and Zhang (2022) Research on the coupling coordination and prediction of industrial convergence and ecological environment in rural of China in the Frontiers in Environmental Science 10.1014848 doi.10.3389/ferivs 2022 1014848

industrialization only. The history tells us that Japan came to be an early adopter of industrial integration theory in the development of rural industrialization. But it gave birth to the path of late industrialization embedded in the path of just in time version of technological convergence and industrial integration.

Although this path rivaled and challenged the ford factory based car making, created a crisis and resulted in the birth of modularization and horizontal integration based global value systems to emergence across the sectors, but the path formation for peoples' democracies would have to diverse significantly to avoid the seeds of fascism or authoritarian capitalist tendencies that the Japanese path allowed and are still flourishing in the world. The application of the industrial integration related socio-ecologically coupled technological convergence theory is the need of the hour for the reason of peoples' democracies becoming very much a necessity. For the balanced development of the entire social economy promotion of the integration of rural primary, secondary and tertiary industries can have a positive impact on technology development and socio-technical transitions seeking climate resilient green industrialization. If it is the way forward today for rural industrialization across the world and particularly in the countries of Global South, then the Indian story has many lessons and some lessons are elaborated in the following sections.

The integration of primary, secondary and tertiary industries is important in itself for fostering the formation of ecologically and socially just pathways. Due to the inability of high external input system strategy to deliver food and livelihood security the climate is more favorable for the contribution of the governments to the diffusion of agroecological approaches to the development of food system. Agroecology has been accepted as a far more desirable path internationally and nationally for the development of agro-food system now. Today the governments can generate external economies for the sustained development of rural areas more than ever before. Emphasis needs to be put on ecological environment coupling to redirect the pathways of industrial integration of primary, secondary and tertiary industries in rural areas in making.

Building of the support to agricultural development requiring the implementation of agroecological approaches is certainly important in itself and these approaches would have to be consciously integrated into the future strategy of rural industrialization by the policymakers. For the innovation directions in agriculture and allied sectors to emerge in consonance with the challenges of rural development it is essential that technology interventions address the rationale and heuristics with a systemic approach to industrial upgrading for the purpose of policy formulation and programmatic support. Policies for the promotion of rural industrialization path formation need to foster structural competitiveness so as rural non-farm enterprises (RNFE) are able to contribute not only to the realization of greater absorption of agricultural surplus labour but also to the realization of ecological justice for the marginalized and socially disadvantaged peasantry.

The strategy of rural industrialization will have to increase the incomes not only of farming households but also of rural labour. It is essential to keep in mind that the urban industrial integration has not been able to provide jobs. The dependence of agricultural surplus labour on rural livelihoods is likely to continue in the near future. The RNFE sector should help to reduce the risks of all kinds multiplying for peasants and rural labour. There exists a strong case for the path formation for rural industrialization to receive attention for the accordance of a holistic meaning to the socio-ecological and socio-technical agenda of peoples' democracies. Pro-poor innovation-making systems need to create more opportunities of a

local nature in the local economies as systems in themselves for the protection and promotion of livelihoods of the poor. This challenge becomes more crucial as large corporations enter rural areas to compete in the same activities with far greater resources.

The path formation for rural and urban industrialization need to realize the goals of ecological environment improving industrial integration and technological convergence; rural manufacturing led developmental processes will have to be based on location specific agricultural resource endowment available in abundance and cater to the demand arising out of the possibility to invest in value addition for the promotion of co-products and by-products utilization. Strategies for the demand formation processes would need to be strengthened to prop up the future prospects of rural industrialization for which the opportunities do exist now due to the ecological concerns also becoming prominent. These opportunities can be identified and implemented by the social carriers of innovation and transformation in India. Innovation making and technology interventions would have to consciously target the implementation of strategies capable of bringing down the costs of logistics and communication and prioritizing the development of co-location of production through the planning of integrated development of co-products and by-products in services, industry, and agriculture. The path formation will have to cater to the development of local economies as a system in itself.

Concluding remarks

Peoples' democracies demand the path formation allowing selectively delinking from the imperialist mode of living by pushing the multi-level rural and urban economy at the national level towards the path of challenging ultimately the big business dominated global economy itself. The rural industrialization pathways would need the implementation of strategies capable of 1) bringing down the costs of logistics and communication, 2) prioritizing the development of co-location of production focused on the development of co-products and by-products, 3) achieving technological convergence to pursue the ecologically coupled integration of services, industry, and agriculture, 4) creating diversified and integrated systems of production to prioritize the use values connected with the demand formation processes of local populations consisting of all classes living in the country including urban working class and 5) developing the capabilities and consciousness of alternate social carriers of innovation and development from among peasants and artisanal workers needs.

The path formation for industrialization will have to ensure that the decline of the hegemony of class coercion and of the domination over nature by capital is achieved and the peoples' democracies also ultimately advance towards the communist goal of "state itself withering away". It is posited that transformative innovation making for peoples' democracies imply the creation of structures for 1) achieving greater publicness in the structures of knowledge production, 2) realizing more and better level of solidarity of the peasants, artisans and landless rural workers with each other and 3) getting to higher stages of cooperation in production of peasantry, artisans and landless workers at a superior pace by developing the local economies as a "system in itself".