Roadmap for rural India*

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Sustainable development of rural India is the only way to create wealth in these areas while at the same time reduce and eventually stop rural migration to the cities. To achieve this, a three-step approach is proposed: (a) make modern devices available at reasonable prices for rural households; (b) create rural livelihoods via high-tech farming and (c) engage the best brains in the country for rural development.

Keywords: Precision agriculture, road map, rural areas, sustainable development.

LONG-AGO (mid 1990s), I visited a hut (tin shed) of a farm labourer in Jadhavwadi village, Phaltan Taluka, Maharashtra, India. The poverty that I saw in his hut shattered me. He had a broken kerosene hurricane lantern for light which had become black with soot. He cooked food in a few beat-up aluminum utensils and mostly survived on bhakari (sorghum or bajra bread) and chutney (made up of green peppers and some spices). He cooked his meal on a three-stone wooden stove and ground the chutney on a flat stone grinder. He had few clothes which he washed every day, and a thin mattress with a worn-out sheet that also doubled up as a pillow. These were his total possessions. Anytime I think of a rural household, the image of this hut and its belongings comes in front of my eyes.

It should be a matter of shame that even 67 years after independence, 60% of our rural population (100 million households) lives in conditions of poverty. The rural people lack the basic amenities of life that we take for granted. For example, they live in one-room huts with nearly non-existent electricity; cook on primitive biomass cook stoves which produce tremendous indoor pollution; lack potable water and toilet facilities, etc.

According to the latest World Bank report, 33% of the world's poorest people live in India[1]. Yet, there is another India which has an ambitious space program, is a world powerhouse in the information technology (IT) sector, and aspires to have an economy that is among the top five in the world. I feel that unless and until this 60% of the rural population is brought into mainstream development, India cannot join the league of major economic powers.

Work done at the Nimbkar Agricultural Research Institute (NARI), Phaltan, since 1981 has given us good insight into the subject of rural development[2]. Based upon our limited experience we would like to propose a possible roadmap for rural India. The roadmap has the following components: (1) Strategies for providing modern devices to rural households; (2) Creating rural livelihoods; (3) Getting the best brains in the country to engage in rural development.

All three components have to work in tandem to produce rural prosperity.

Improving the lives of the rural poor – one hut at a time

Energy requirements

There are several areas that need to be improved before a real dent in rural poverty is made, but I will focus mostly on energy, since we believe that this is the basis of life and from it flow all other issues like those of environment, commerce, society, etc.

I also feel a good way to approach the issue of poverty is to be personally engaged with it. Thus each of us should ask ourselves whether we would be able to live comfortably in those huts with the available amenities. Based upon this approach we feel that rural poor should have a house with two rooms, a kitchen and a toilet. For providing energy to this household for decent living, our calculations show that they would need 1220 kWh/yr of electricity and 260 kg/yr of liquid petroleum gas (LPG) or equivalent biogas. This amount of electricity can provide energy for two fans, four LED lamps (providing 500 lumens each), a small refrigerator (20 litres capacity), charging mobiles and electric transport. For rural mobility, we believe that electric motorcycles are increasingly becoming more efficient world over and powerful enough to form the backbone of rural transport[3]. Similarly, air-powered motorbikes are also becoming available[4]. These are far more efficient and environment-friendly than petrol-driven ones. However, at present they are expensive, and so the main challenge is to bring down their cost and run them on electricity from locally produced resources.

For cooking and heating, the most user-friendly fuel is LPG or biogas (mostly methane). Thus, 260 kg/yr/household will take care of all the cooking and water heating requirements for a family of five. Similarly, other liquid fuel systems with excellent combustion capabilities

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like kerosene/diesel lanstoves can provide a user- and environment-friendly source of energy for cooking[5].

To provide the above energy to 100 million poor rural households, India needs to add about 14,000 MW electricity generation capacity and double the LPG production. Both are doable goals and the challenge is how to produce this energy from locally available renewable fuels like solar, wind and biomass.

Incidentally, the Planning Commission (PC), Government of India (GoI) in its energy policy document of 2006, has only made provision for 365 kWh/yr of electricity and 72 kg of LPG per rural household[6]. This is less than one-third of the energy proposed by us and I feel this meagre amount of energy will not be able to bring the rural people out of poverty regime.

Provision of household devices

The next challenge is how to provide drudgery-reducing devices to rural households at affordable prices. Most of the devices and services are produced and sold by the corporate sector. Presently, their strategy is based on the principle of producing goods for urban areas and let the market forces eventually diffuse them to rural areas. This strategy has worked partially so far, but has consequences in terms of cost and energy.

For example, majority of the devices for urban households run on electricity. Since electricity is mostly unavailable in rural areas, such devices are of no use in these places. The strategy therefore should be to design and develop household goods which run without electricity or use very little of it.

Secondly, these devices are shipped thousands of kilometres away from their place of manufacture to where they will be used, consuming huge amounts of energy in transport. Modern technologies like 3D printing (or desktop manufacturing) can transform the rural landscape by providing household devices with minimal energy, and whenever and wherever they are needed[7]. It is quite possible that this will give rise to small-scale manufacturing units in rural areas producing goods under license from large companies. As the technologies evolve, these 3D machines will become quite cheap. I believe providing 3D manufacturing in rural India will be a great challenge and possibly allow India to leapfrog into the fourth Industrial Age.

Enhanced R&D for rural areas

Excellent energy-efficient devices world over are an outcome of good R&D. Most of the corporate sector in India hardly does any worthwhile R&D, and this is especially true for rural areas. Somehow technology risk-taking is not in the DNA of the Indian corporate sector. Part of the reason is that most companies in India are not equipped to do R&D; another reason is that most of the captains of industry do not believe in R&D. Hence most of the time we buy technologies from abroad and now are even buying products from China. By sensitizing the corporate world regarding the need for R&D and opportunities for it in rural India, this lacuna could be addressed.

One way to do this is to constantly educate managers and captains of industry regarding these issues. This should also include making them aware that India Inc. survives only because rural poor help in providing food for them. As a nation we cannot survive by eating software, or nuts and bolts.

Another way is for GoI to take a lead in forcing industries to do R&D for rural areas. There are estimates that the GoI already gives sops, tax write-offs, etc. to the corporate sector to the tune of Rs 5320 billion/yr (Rs 5.32 lakh crore/yr)[8]. This is in addition to the billions of rupees that the Indian banks write off as bad loans. Incidentally, this much money is five times more than the entire subsidy given to the poor via the Public Distribution System (PDS) scheme.

Additionally, GoI can herd the private sector to do R&D for goods and services for rural areas by making it a part of their Corporate Social Responsibility (CSR). After all, improving the quality of life of the rural poor is the most appropriate CSR activity. GoI can also increase the limit of CSR spending by corporates from 2.5% at present for rural R&D. This will hopefully bring an R&D culture into the corporate world.

The much-touted PPP (public–private partnership) should be implemented for a national mission on 'Improving rural lives – one hut at a time'. If we can have a successful space programme run in mission mode, we can make a success of this vital mission too. But there is a need for political will to take the lead.

For starters, the innumerable R&D establishments of the GoI can be given a mission and mandate to develop devices for rural households. GoI spends nearly Rs 30,000 crores/yr in its well-equipped R&D laboratories and employs about 90,000 full-time R&D personnel in them[9]. Even with such a huge expenditure, unfortunately there is hardly any worthwhile output in any field, let alone for rural areas. One of the main reasons for this is the lack of vision and direction. If this manpower and infrastructure can be harnessed to solve the problems of rural areas, then it can transform India.

This is the age of innovation. Every product that we use in our daily lives is the result of excellent R&D done somewhere in the world. We should therefore create conditions for increasing R&D infrastructure in our country. Innovation allows price reduction of goods and also manufacturing them more efficiently with less energy. Our industries know this cardinal principle and yet they do not practice it. In fact, Indian companies are some of the lowest spenders on R&D in the world[10].

Business-wise it makes sense for India's private sector to develop and manufacture rural household devices with inputs from excellent R&D. There are close to 3 billion

poor people worldwide, who can benefit tremendously by the inventions of Indian companies. Today these people get most of their goods from countries like China. In order to become major international players, Indian companies need to penetrate this market with outstanding products based on excellent R&D.

Rural livelihoods

Energy from agriculture

For the rural poor to afford modern household goods, it is necessary that their purchasing power is increased. That can happen by improving their livelihood choices. Around 80% of India's rural population is involved in the farming sector. Their lives can be made better by increasing their wages through highly improved farming.

Traditionally, agriculture has been considered mainly as a provider of food. However, it can also provide energy and developing this dual-purpose function to provide both food and energy security will create a major transformation in India in terms of increased remuneration to farmers, and energy production[11].

India produces 600–800 million tonnes/yr of agricultural residue[12]. Residue is what is left of the plant after the food is harvested from it. A major portion of this dry residue is burnt in the fields as waste disposal, since the farmers want their fields ready for the next crop. Not only does this create tremendous air pollution, but is a waste of an important energy source. There are also speculations that this residue burning is creating a brown haze over the subcontinent and could be the source of climate change in this area[13].

Theoretically this much residue has the potential of producing close to 80,000 MW of electricity via biomass power plants, or nearly 50% of India's total installed capacity. Biomass power plant technology is well-developed worldwide and there are close to 140 plants in India with installed capacity of about 1000 MW (ref. 14). Alternatively, this residue can also produce about 150 billion litres/yr of ethanol via lignocellulosic conversion and can take care of about 50% of India's total oil demand. Similarly, if we go via the pyrolysis oil route, we can meet around 80% of the country's diesel demand. Pyrolysis oil is produced by rapid heating of dry biomass to 500–600°C and quenching the smoke rapidly to produce oil. With the help of suitable catalysts this oil can be converted into automobile fuel. The residue can also be converted into biogas, which can provide energy for cooking and decentralized electricity production; the slurry from the gas digester is a good fertilizer. Which route the residue will take will be dictated by the market forces, i.e. how much money a farmer gets for selling them?

The use of residue for energy production can substantially ease India's present energy crisis and can be a Rs 2 lakh crore/yr industry. At the same time, the use of biomass for energy production can also produce nearly 50 million jobs in rural areas[15]. Thus, farming for energy can create huge wealth and infrastructure development in rural areas. For this to happen two things are necessary. First, farmers need to be paid for the agricultural residue. Secondly, agriculture needs to be modernized through inputs of high technology.

Precision agriculture

It is a peculiar aspect of farming that only 25–40% of its produce fetches money and the remaining 60–75% is agricultural residue, which being of little value, and has to be discarded. No industry can run on such norms, where one-fourth of its produce is not sold and is in fact discarded. Yet, for farming we accept these norms.

When agricultural residue is capable of producing high-quality energy like electricity and liquid fuels, it should be given a good price. Our estimates show that with proper pricing of this residue (Rs 3000–4000/tonne), a farmer can easily earn about Rs 5,000–7,000/acre/season by selling it for energy production. Any marginal farmer can produce agricultural residue even if the main crop fails. The income from this residue can give additional benefits and is the best hedge against farmer suicides. I feel that unless and until the farmer gets remuneration from his entire produce, farming will never become economically viable.

The second aspect of farming is the need for improving it with high science and technology inputs. High technology allows the efficient conversion of dilute, locally available energy resources like biomass, solar, wind, etc. (which rural areas have in plenty) into useful end-products and services. In this process we need to follow nature and so biomimicry should be the mantra of technology development. This approach of high technology for rural areas was first proposed by NARI more than 20 years ago and now it is in vogue[16]. The approach is superior to the normal approach of tinkering or 'jugaad', which has been the mainstay of most rural development work[17]. We believe that all technological progress and evolution, whether for urban or rural areas, should follow the route of good products. This is based on excellent R&D; product manufacturing, sales, and excellent after-sales service. Jugaad or tinkering does not follow this cycle and hence is too person-dependent and ad-hoc resulting in poor-quality goods to be produced and made available in rural areas.

Presently, Indian agriculture uses ancient agronomic practices and very little mechanization, with the result that our farm productivity is one of the lowest in the world. The problem has also been compounded by the fact that because of land reforms and practice of equal division of land among one's children, land holdings have reduced thereby restricting the use of existing big and heavy farm machines. Presently, 80% of farms in India are less than 2 ha in size. In fact, this small farm size

could be a boon in disguise, since it can allow the use of precision agriculture (PA) which includes the use of inputs to the crop at proper times and precisely as well; in the process reducing inputs and increasing productivity[18]. PA is becoming quite popular in the Western countries.

Nevertheless, extensive R&D is needed for developing efficient machinery for small farms. This requires an infusion of bright young scientists and engineers into the farming sector. Presently, all the bright students opt for engineering, medicine, MBA, etc. and agricultural sciences and engineering have limited appeal. There is a need to make agriculture attractive to bright students.

Since precision farming is mostly robot and drone-driven, there is a natural attraction of most students to it. However, we need creative programmes in engineering and other agricultural sciences to sustain their interest and may even help create a huge educational infrastructure.

Another major problem of farming today is that since it is non-remunerative, farmers' children do not want to get into it. Besides being uneconomical, farming is also hard work. By developing high-technology farming equipment like small tractor-mounted combines, harvesters, bailing machines, etc. for small farms, it is quite possible that farming can be made less labour-intensive and more attractive to the younger generation. Advertisement agencies need to make a very concentrated effort for agriculture to look glamorous. However, for farming to increase so that it can bear the increasing load of food and energy production, adequate water supply has to be ensured.

Water requirement

With the coming of the Green Revolution to India, there has been an extensive use of water, resulting in shortages in some parts of the country. India has the highest rate of groundwater usage of any country in the world. Not only is there water shortage, but lack of clean potable water results in millions of deaths every year due to diarrhoea and other diseases. This is despite the fact that there is enough rainfall.

Every year India receives ~4000 billion cubic metres of rainfall, whereas the present yearly water consumption is only 650 billion cubic metres, or 16% of the total rainfall[19]. However, the rainfall is not evenly distributed over India and it comes in short spells, thereby pointing to the need for rainwater harvesting and storage. Rainwater harvesting will require large-scale deployment of qualified engineers and technicians in water-related technologies. Rainwater harvesting technology and management should be made a compulsory minor in all engineering and agricultural universities and colleges. This will not only help in agriculture, but also in watershed development.

I strongly feel that when the farmers are neglected, the long-term sustainability of the country is threatened. When farms produce both food and fuel, then their utility becomes manifold. In India, around 55% of the total population depends on farming. With energy from agriculture as a major focus, India has the potential to become a high-tech and wealthy farming community.

Best brains for rural development

The two components of the roadmap discussed above can only be taken forward by truly dedicated people. Getting the best and the brightest people for rural development is the biggest challenge.

One of India's biggest assets is our people. India is a young country with 54% of the population below 25 years of age. The energies of this youthful population, if directed for rural improvement, can bring about wonders for the country. However, to train and guide them to be useful to the society is a big challenge.

With the focus in our society on making money by any means, which ultimately leads to corruption, the training of youngsters has suffered tremendously. This reflects in their education which hardly teaches them any skills but only how to pass exams; the focus is on rote learning and not on working with their hands[20]. It is a well-known fact that most of our science and technology graduates are unemployable. It is not the fault of these students, but of a corrupt and broken education system which most of the time fleeces these students without imparting any meaningful education.

In my innumerable interactions with young students all over the country, I have always got the impression that they want to learn and do something meaningful in their lives. Yet they are neither shown the opportunity nor the path because of the paucity of good and motivated teachers[21]. I am sure if given a chance and provided motivation, our science and engineering students can do wonderful work and help the country.

A good way for students to be involved in rural R&D is for them to spend one or two years doing work or internship in rural science and technology NGOs. If they can understand the problems of the rural poor while doing internships, they will be able to solve them later on when they have resources and materials.

Presently, students have genuine fears that by working for a couple of years on rural problems, they will become unemployable. The corporates do not want to do any R&D for rural areas and hence they will not employ students with such experience. I think one way out is to involve students in R&D during their education. Once the R&D bug gets into their head, it will automatically manifest itself in innovative solutions. This R&D bug should be put into these students even during their school days by following the US-based 'Maker Movement' (MM)[22]. The US had an old tradition of youngsters tinkering in their garages on amateur radios, making small household items, etc. With the computer revolution, youngsters stopped tinkering and moved into playing with their iPads, iPods, phones, etc. With 3D printing technologies,

US schools are now making students interested in creating designs, toys and new inventions. Once bitten by this bug, it is assumed that the students will be more involved in engineering by innovating and creating hardware-oriented products during their college days.

This MM at school level is being followed by changes in the engineering curriculum in US colleges, where more emphasis is being put on students doing hardware-oriented projects rather than software.

We need to learn from MM and effect changes in our school and engineering college curriculum accordingly. Presently, the engineering education has become a stepping stone for getting into IT or management programmes, and there is hardly any use of the engineering knowledge of students in their eventual jobs. Hopefully this trend can be reversed by modifying the engineering curriculum of premier institutes so as to sensitize the students and make them aware of what R&D is and how it can be done. Later on, when they become corporate managers, they will have a healthy respect for R&D and may be able to initiate research programmes in their own companies.

To do this, it may be worthwhile to have students in the final year of their engineering programmes carry out a project which is almost like a thesis, in which they not only make a working model but also do experimentation on it. The curriculum should be modified so that the students are also taught courses on the history of modern technological developments. This will be more educative and enjoyable, rather than solving some archaic engineering problems which unfortunately have become the norm in most engineering courses.

Together with emphasis on R&D, there is also a need to have social entrepreneurship and technical management as course streams in engineering curriculum. Social entrepreneurship should not only teach the students about the problems of rural India, but how to use solid engineering in solving them. Similarly, technical management course will help students learn about technology and innovation management. Both the technology management and social entrepreneurship streams should be grounded in excellent engineering education. The rise of great entrepreneurship all over the world has been mostly guided by technology managers like Willis Whitney of GE (with Irving Langmuir), Steve Jobs of Apple, and Bill Gates of Microsoft, among others[23]. At the same time students need to be encouraged to become rural-products entrepreneurs. There are quite a number of IITs and NITs who have entrepreneurship incubation cells which encourage students to become entrepreneurs, but they are mostly in software-related areas for which venture funding is easily available. It is necessary that venture funds should be available for developing rural products and markets. GoI can help by creating a programme of venture funds for rural innovations. Just like venture funds in the IT sector have helped spawn IT enterprises, so can the venture funds boost rural innovations.

The future of India belongs to the younger generation. All of us have to do our bit to get them involved in improving the lives of the rural poor. If we do not do so, there will be serious social conflicts. The rise of the Maoist movement, which has engulfed one-third of our country, is a pointer to such dangers. Unless we can provide basic amenities so that the rural poor can live a meaningful life, we will never become a great nation. This is a great challenge for all youngsters and it is my dream that they will take it up so as to make India a better place to live and work.

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