

*In the present context of the crisis in Indian life and economy here, is a thought provoking essay which has unleashed lashing attack on Indian planning which cares little for the socio-economic context of your present day living. This speech delivered by Prof. D. D. Kosambi in the Seminar organized by the C. S. I. R. in April 1966 focuses deep and penetrating light on the problem and illuminates the way out of it.*

## **PROBLEMS OF SCIENCE AND TECHNOLOGY IN UNDER-DEVELOPED COUNTRIES**

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What I have to say here is, admittedly, going to be unsatisfactory for two reasons. First, most of us know what our problems are; secondly, I have no spectacular solutions to offer; only a rather small technical suggestion or two which may help analyze the particular problems in each case, and may help towards a planned solution.

### **The Context**

The background is all important. Most of us are so deeply concerned with science and technology that we forget the context in which both science and technology must be applied. The context may be divided into three parts, deeply interconnected: Political, Economic and Sociological. After all, we have no special science or technology of our own. Arabic science or Indian algebra, once the leading disciplines in the world are both out of date. One cannot speak of African chemistry or South-East Asian engineering. Science and technology know no national frontiers. Therefore, the background before which they must function becomes a prime consideration for us.

The political situation is all important. Most under-developed countries have been under foreign domination for a long time. That is, in fact, the primary reason for their being under-developed. So, freedom must come first. We cannot speak of science and technology for Angola and Mozambique, for example. The South African situation is even more complex. The land has a few outstanding, technological developments; their laboratories and engineering works are by no means to be despised. But the real Africans are not even citizens in South, Africa, which remains for them under-developed, while being in a quite satisfactory stage of development for property owning whites and for the investors-in London who stand back of them. A similar situation is true, with lesser development, of Rhodesia.

In such cases, we have no solution to offer, for our conference restricts itself to science and technology. However, the context tells us that the special problems in such countries cannot even be discussed here. There may be some exceptional possibilities. Perhaps Hong Kong may claim to be one of those exceptions. But it would be difficult even here

to consider the problems of Hong Kong without a solution of the obvious political question.

The second point, which too many tend to regard as the main problem, is economic. In fact the very word 'under-developed' has this connotation, namely economic underdevelopment. Most of our countries lack the necessary resources for development, along with the actual manifestations of development: electric power supply, factories, railways and shipping, roads, motor transport, airplanes, and of course, consumer goods and decent housing. The lack of resources is fortunately not present in all countries. Several Arab lands have discovered in oil and natural gas a commodity which can be exploited sufficiently well to solve their economic problems. However, whether the oil and other resources are properly used or not depends once again on the context. First, the foreigner must not take away the lion's share, as happened in Iran for so many years. Secondly, those in power must feel the need for developing the country rather than for building palaces for their own families and living a life of Arabian Nights Style. This remains, therefore, again an internal political matter, namely who plans and for whose advantage. It is not sufficient to announce grandiose plans; one has to convince the people that they stand to gain and to secure popular support. Development in Ghana and Indonesia show what happens otherwise. Going deeper into this question but that would cause unpleasantness.

However, we reach one important principle here: *underdeveloped countries need a planned course of development, which necessarily implies a planned economy.*

Merely admitting this principle is not enough. The context once again thrusts itself upon your attention who does the planning, and for whose real advantage? The solution generally offered is to invite foreign experts to offer advice and draw up schemes. With the best will in the world, this will not succeed. The foreign expert has been used to planning for an entirely different purpose, in totally different surroundings. He pays little attention to local needs during the course of development. Oftener than not, the foreign expert is interested in selling the products of some companies with which he might be connected. Here, we could learn a good deal from Chinese experience, were it not for the political problem, once again, which makes it impossible to secure cooperation from that great country at such a meeting. But let me give some simple examples to illustrate what I mean.

In our sugar producing cooperatives, the bagasse was burned for fuel. One brilliant and remarkably honest foreign expert suggested that this wasted most of the contents of the bagasse, except what remained in the ash. The cellulose could be used in paper manufacture, the wax and oils extracted for other purposes, and so on. In fact, Indian chemists had actually analyzed the possibilities so that no foreign expert was needed. It was suggested that the paper factories be set up, by the cooperatives or sugar companies themselves, and the bagasse used to proper advantage. But in the event this could not be done economically for two reasons. First, the Factory machinery would all have to be imported. Secondly, the amount of bagasse withdrawn from the fuel used in sugar manufacture would mean greater outlay for other fuel. Oil is too costly, we have no natural gas in the sugar producing regions, and coal meant additional strain on the transport. In any case, the extra fuel costs would have made just the difference between a successful cooperative and one running at a small deficit half the time. The solution in the

*present context* was given by Hungarian experts. They suggested, and worked out in data a scheme for using the bagasse as fuel without losing all its value in other ways. The stuff was to be fermented in vats, and the gas used as fuel, converting one or more furnaces completely to gas burners, as the total amount of bagasse would not suffice to stoke all furnaces. Then the wet sludge could be put directly on the fields, with every substantial savings in fertilizer. In fact, there was an added advantage in lightening the soil, which would be ruined by steady application of chemical fertilizers over a number of years. Finally, I pointed out that there would be an educational advantage: The peasant members of the cooperative could use the method for their own surplus bagasse, and also for cattle dung. At present, the cattle dung is dried into cakes and used for fuel, again destroying its value as fertilizer. Gas generated from such waste products would save all the fuel value without affecting the fertilizer value, and make for easier cooking as well.

The scheme has not been adopted, after all. The reasons were political and sociological, for the people who were to make the final decision had other ideas of their own, when they had any ideas at all. We still go on wasting the bagasse, though a factory two for paper will eventually be set up-with foreign expert advice, of course.

### The Sociological Context

Hitherto, I have only pointed out the difficulties without suggesting a solution. As a matter of fact, I hold very strong views on the proper political structure and the correct foreign policy for under-developed countries; but this is not the time or the place to develop those views. We are not here to offer political advice or to suggest political courses. Similarly for the economic situation. Most countries want and ask for capital. This conference cannot provide it, nor can it suggest means of raising funds. The scientific approach, on the other hand, tends to be rather vacuous and devoid of application unless these primary difficulties are solved. At least, we have proposed one main principle, namely that the economy must be planned, and the course of full development charted in outline, rather than left to individual initiative which means leaving it to private greed. Most of us fail to ask why our countries are underdeveloped, when we go begging abroad for financial aid and technical experts. The reasons for underdevelopment are precisely that our raw materials and our great markets were exploited by the foreigner to his own advantage. Our products were taken away for the price of the cheap labor needed to take them out of the earth, and we paid the highest prices for the finished goods. In a word, the developed countries with very few exceptions are developed precisely because they made profit both ways from us; we were never paid the actual value of the things taken away. It is our resources that have helped in the development of the great industrialized nations of the world: yet we have to go to the same nations as suppliants, not as people demanding return of what is rightfully our own. Naturally no such demand could be enforced, even if it were made.

The foreign domination, whether in the form of colonialism or by other spheres of influence, has left an unfortunate mark on the society of our countries. The very languages we speak at such meetings are those left to us by the foreigner. This would not be bad, were it not for the insidious foreign way of thinking that too often goes with the languages. Most of us become honorary Englishmen, or Frenchmen, or the like. The models seen in New York, London or Paris don't seem out of reach in Bombay, Calcutta

or New Delhi. But go a few miles away into the unaffected countryside and you will feel that you are in a different land altogether. Our development is not uniform. Attempts at catching up with foreign lands should not, but always do, accentuate the differences that already exist between towns and country.

Illiteracy, lack of technical education, lack of transport, paucity of telephones, cinemas, radio sets, absence of television—all these seem impossible hindrances to any foreign or foreign-trained expert. Very few people see the need for and the possibility of development by getting the common *people* interested and by using the techniques available in the countryside. Let me again give an example of what I mean.

During the Japanese occupation, when all major industrial areas of China had been taken over and the Kuomintang armies pushed into the backlands the problem of supplies became desperate. Chiang Kai-shek needed two million blankets for his armies, with no way of importing them from abroad. The blankets were supplied by a remarkable man and a remarkable movement, the Gung Ho (Work Together) cooperatives formed under the direction of the New Zealander REWI ALLEY. He knew China well having worked with its common people for over twenty years. The blankets were made by handicraft methods, were of satisfactory quality and capable of standing up under rough wear. Moreover, they were supplied in less than a year. The methods by which the work was organized, with the overwhelming majority of workers illiterate, scattered in small units over nearly two thousand miles, were undoubtedly the most astounding feature of the entire project. I only wish the history of Gun Ho were written, published and made available to all underdeveloped countries. In this case, Alley worked out a system of accounting that did away with almost all clerical work. The workers organized themselves in such groups as they liked, whether by families or by local crafts-guilds, with Alley guiding them in each case at the beginning. The wool was produced by the shepherds of the backlands. Per bale of wool supplied to the spinners, one colored bead was put in a bag. When a bale was used up on the spinning wheels one bead was taken out of the bag, so that the residue could be tallied with the stock in hand. Per unit of yarn produced (large hanks), a bead of a different color was put into another bag. Similarly for the yarn supplied to weavers and units (blankets) woven. This system worked without a hitch and without a penny lost, with almost no paper work. It furnished employment to the neglected areas, and blankets for the soldiers.

I wish the story could end here. Unfortunately the blankets delivered to Chiang's officials did not all reach the soldiers. Not a few went into the black market. Other corrupt officials managed to get themselves jobs as managers of district cooperatives or of the larger factory units, and stole as much as they could. At the very top came Chiang Kai-shek, the CC group, the Kungs, Sung and their selected henchmen, stacking away gold in the USA and letting the war take care of itself. The Academy of Sciences (Academia Sinica) had been evacuated to Chungking and Kunming. I recall making and sending copies of scientific papers from India for them, to help research that had no connection with the war or national needs; in some cases, I had also to arrange for publication. A few noble scientists and scholars were studying in India on generous subventions. One captain in the army had taken long leave to study Indian philosophy, while his company was fighting in the front line; he managed to get through the war years without difficulty. In other words, the social and political context was, after all, the determining factor.

Nevertheless, let me draw one more basic principle from this: In technological matters, particularly in consumer goods manufacture, use local technique, organized by drawing in as many of the local producers as possible. Naturally, this means primary producers, not the moneylenders, nor landlords. It also means organization without bureaucracy.

I have to make clear to this point the fundamental difference between this method and the philosophy of hand spinning on the hand wheel, charkha. The charkha is inefficient and uneconomic as a full time implement of manufacture. The late Mahatma Gandhi discovered mystical qualities in the art of hand spinning which raised it above yarn manufacture on power spinning machinery. Having gone rather thoroughly statistics of the resultant khaddar cloth, I can assure you that its effect was political, but nothing to speak of in national production as such. It shamed people into boycotting British imports before the war, and provided a badge for the revolutionary. Today, khaddar cloth is a drain on the Government budget and a mark of the professional politician or his servant. This is in strong contrast, however, with handloom products which provide excellent patterns and has been a valuable aid to India's export drive. The handloom which means mill spun yarn can be used as a part-time tool of production, especially in seasons when agricultural operations are slack. It saves transport of cloth and can break the shopkeeper's black-market monopoly if used with proper care. It is also of considerable help in drawing partially disabled and otherwise unemployed people into useful production. Finally, it is simple in operation and easy to manufacture with local tools and materials. That perhaps, is the essential difference between what I should call the Gung Ho approach and the Gandhian: Use whatever local methods you can to produce consumer goods, while heavy industry is being built up.

### Planning

If science and technology have any use at all, they must fit into a plan. This does not infringe the freedom of science, nor of the scientist in underdeveloped countries. There is an essential difference between the scientist in backward lands and his teacher in those parts of the world where science had long been developed. The latter is amply supplied with the costliest apparatus, good libraries and reference material, and a large number of auxiliary technicians. Such a scientist in advanced countries has often to fight for his freedom. His funds may come from some government project, dictated by third rate bureaucrats who insist upon secrecy for discoveries that ought immediately to be made public. Often, top scientific talent is wasted in 'defense' projects. This cannot be the case with underdeveloped countries. Mostly, they have no scientist of the first rank in world science, not even of a high second class. To speak of freedom of such scientists to do what they like at someone else's expense is to allow them to waste public funds in duplicating bad work done by second rate technologists in Europe or the U.S.A.

Let the scientist be free, but let him earn his living by doing something for his country that comes in the category of vital needs. For example, many of you here are bound to be impressed by India's advance in science and may even persuade your own governments to copy us. But in what particulars? We have top class physicists, for example, our department of atomic energy is spending several hundred millions a year on an imposing establishment. But how much atomic energy is this country actually producing? The plant

that should have been in commission in 1964 will not be operating till 1968 at the earliest. The delay has passed without criticism, while some politicians demand that we should produce the A-bomb to put us on a par with the big powers. In effect, the establishment we have was built by foreign 'experts', is outdated already, and will produce atomic power if run as designed which is costlier than such power elsewhere and costlier than conventional power in India. Even then, all the basic cost will have been written off under the heading of 'research', (Science, or some such beautiful title).

Again, don't misunderstand me, India, like every underdeveloped country on the road to industrialization, needs every sort of power it can get. Costly as it is, atomic power will be cheaper than human muscle power or the power drawn from bullocks. But is it the best source under our present economic conditions? Almost all the countries represented here have a much better and cheaper source of power available for their development *Solar Energy*. This has the defect of being irregular, but can we put to uses where regularity is not in demand. For example, pumps for irrigation, of 5 to 10 horse-power capacity, run by solar energy would help our agriculture immensely. This would not need centralized administration and a fantastically top heavy basic establishment. If mass produced, the pumps would be cheap; their fuel costs nothing at all, and the irrigation they provide would be a real godsend. Maintenance would be easy and would also help mechanize the population in the most backward countries. Similarly, for cooking by solar energy. This will not only save such fuel as oil, but (in most of our lands) the firewood thus saved means reforestation of countryside now denuded. Without such reforestation, no real agricultural reform is possible, as we all know. The desert can be reclaimed, using the very sun that now blasts it. I say all this only to point to a further principle: In planning, work out the complete economic cycle at each stage. With solar energy, the cycle naturally included reforestation and development of agriculture, just as in the use of bagasse the land crop cycle was to be restored. Science does not mean working with a few test tubes but for a whole country on a country-wide scale.

The last point can be driven home a little better. The cashew nut brings such high prices on the world market that many countries, including India, plan to increase cashew plantations to the utmost. I know something about this, having owned one of the best cashew-producing farms in Goa, years ago. The tree grows with virtually no care, in the deepest jungle. But it kills the under bush completely. The water level is immediately reduced and erosion sets in. Where the cashew fruit-pulp is dumped not even grass will grow for years afterwards. The proper utilization of cashew plantations would require a strong chemical industry which would utilize the powerful phenol byproducts of the tree, fruit, and nut-shell now entirely wasted. This again means a better developed country than most of us have the good fortune to live in. Should we give way to immediate greed, as some of our State forest departments are doing, it will ruin what is left of the forests, for relatively small gain. The cashew plantation must be properly terraced, so as to retain the water even when the cashew trees have killed off other vegetation. I could multiply these examples forever. The coconut trees that are so striking a feature of our coastal strip have yet to be properly exploited. Most of what can be done is known to our coconut research institute, but hardly anyone knows that the institute exists. The husk (coir) can produce rayon, the trees improved by genetic selection, the oil processed by more efficient methods and factories, the final product scattered through the plantations. But this implies an efficient and effective method of planning which we do not seem to

possess. Our planning commission writes excellent philosophical discourses, completely futile when it comes to effective translation into useful practice. The private sector wants immediate profits, and the public sector prefers large-scale enterprises which photograph well, get newspaper headlines and are useful in election propaganda.

Let me give an example of inefficient planning in which I was personally involved. The problem was one of dam construction. If the dam be too big, money is wasted; if too small, there is the risk of running dry too often. Suppose that we want dams which on the available rainfall and run-of figures will not run dry oftener than once in twenty years, in the long run. What is the correct formula for estimation of capacity? The experts quarreled, so the problem was put up to me. It was a simple matter to give the right formula based on R. A. Fisher's test. But when I looked closer into the data, it was clear that many of the figures had been fake. Actually, the water run-off for certain years had not been recorded at all. The entries had been made by fitting a linear equation from the rest of the data against the rainfall figures which were accurately known. Finally, looking into the map of the area it was possible to show that large dams would be of no use as compared to many very small dams which would help terracing and would retain monsoon water mere efficiently. Small dams are of no use for power supply, but much more useful in, a monsoon country with eroded lands, for agricultural purposes. Moreover, the labor supply and most of the materials are local very little cement and no machinery would be needed. This has not only the further advantage of economy but of easing distress among the villagers by allowing them to earn some money while improving their own lands. Very little crop land is flooded by such dams, though the total amount of water conserved is nearly the same as large dam. In the event, my formula was adopted because the expert could propose as his own (he secured a promotion thereby). The remaining suggestions made by me never came before the meeting to which I was naturally not invited.

### Statistics

Hitherto all my suggestions have been critical and to a considerable extent negative. Let me speak of one special technique in order to make a positive contribution. This is statistics, and would be useful for any sort of planning, whether by indigenous or foreign experts, or simple allocation of resources. In fact, no planning can be successful' which does not use good statistics correctly.

Statistics means the census type of complete enumeration, to most people who hear the term. However, counting everything is rarely possible and often not even practicable in most underdeveloped countries. The necessary staff is not available; clerical services remain slipshod or inefficient. Worst of all, people give wrong information because they feel that the figures they offer would in some way be of benefit to them, say in saving taxes or getting some government grants in aid. Finally, the process of getting accurate statistics of this type is slow while inaccurate statistics is worse than useless. It is all very well to suggest that areas under various crops could be quickly measured and even the crops identified, by air photography. I know that this is true. But how many countries can afford air photography and have the expert staff for evaluation? India has first-rate statisticians, but they are afraid that air photography may mean lack of jobs and retrenchment, so label it as 'unpractical'. Let me add that for all the fame our statisticians

have secured abroad (and the large number of theoretical papers which form an impressive background for an even larger number of blue book reports) our statisticians have failed in their main job, through no fault of their own. They have not been able to say exactly how much food is available from last -year's harvest. As a result, we have several different sets of estimates of how much food India needs to import, whether as loans, gifts, or by purchase. I have seen it in print that five, seven, ten, fifteen, even twenty percent of our grain is eaten by rodents and vermin. No one knows how the figures were obtained. If so basic is a problem as that of food cannot be handled by really able men, there is something wrong in the way in which the men are used. We are led back again to the social and political context.

Granted the will to use statistics properly, there are now better methods than the census, quick as well as inexpensive. These are labeled sample surveys; the technique is very well known. One counts a small percentage and estimates the total. Besides, there exist methods for showing the limits of accuracy of this estimate, so that a suitable margin may be allowed. I do not mean to go into details, which will bore most of you. But if enough is known of the various types of villages, then a sample of not more than 5% of the villages, and often one of less than 1% would suffice to give all essential information's. The sample has to be scattered properly, every type of village must be proportionately represented. Some common sense has to be used. The actual sample must be studied efficiently and information about it obtained with complete truth and accuracy.

This type of sample survey gives data within a couple of weeks which would take over a year to obtain the complete enumeration. Its main uses are two: in industry and mass-production for control of quality and uniformity of the product. For example, cement from different kilns in different places differs in quality. Even different runs of the same kiln show a substantial variation. But the engineer can allow for this in his construction work if, with each run, he is given a test figure of the average strength and the standard deviation. These can be calculated by one person, with a double handful of cement from each batch, properly sampled. One such statistical assistant could easily be employed by every cement factory, sugar combine, or similar industrial enterprise. The total output of such enterprises, of course, is easily counted; in such cases one has both the census type and the sampling type of statistics.

With the agricultural raw materials, the situation is entirely different. Without a good forecast of the crop in advance, it is not possible to plan for export, for processing of the raw materials, or for that matter even to avoid famine. This forecast can easily be provided in spite of great local variation, by crop cutting experiments before the complete harvest is in. There are, naturally, even more efficient methods. Given the variety of seed, machine planting is practiced, simply counting the number of plants actually growing in uniform squares and taking a few ears from each square gives a surprisingly accurate estimate. I have seen this in the Dobruja, in Rumania, 400 plants were put down mechanically in each square meter; and the counting frames were one meter square. The reports were sent in by the wheat cooperatives in this case, and the central institute gives the crop estimate well in advance, allowing for natural disasters such as flood and drought. Not all of us are so fortunate as to have such large cooperatives and machine planting of wheat. In that case, I suggest that local experience could be used.



Local experience means that the peasants must have been on the same land for some years, must know the particular variety of seed used, and must have farmed with the same technique. In that case, the Indian peasant can give an estimate within 6.5%, or better. The Chinese peasants, to my great surprise, could give estimates closer than 3.5%; the trouble in China (as of 1960) was an inefficient and bureaucratic central statistical organization which could give nothing accurately till the harvest was over and half-eaten. All their forecasts were revised again and again, so often as to be useless. They were gathered by the slowest possible methods, namely filling out forms and everything, sending them to local headquarters, and eventually to Peking. Neither the statistical man *nor the* leading scientists had bothered to ask the peasants how they estimated the crop, or even to compare estimates in routine yield. With our peasant, the trouble is to make him believe you that giving a truthful estimate will not lead to extra taxes. The difference between the illiterate peasant and the trained statistician is that the peasant cannot make large calculations, on the other hand, if the peasant is wrong in the estimate he makes for his own use (whether he tells it to government agents or not), he may starve. The statistician doesn't have to live by eating his estimate or his standard deviation. The difficulty in the field is always getting a truthful figure from the peasant. In China this difficulty did not exist, but no one bothered about the peasants' estimate before I tried to evaluate it. Money lenders, landlords, middlemen, purchasers and other interested parties including the profiteering grain dealer from the big city see to it that the truth is hidden when it is to their advantage to hide it. Once again, we come back to the context. There is a clear limit beyond which you cannot go by ignoring the social and economic conditions prevalent in the country.

One type of sample statistics is a valuable adjunct to democracy, namely the opinion poll. In developed countries, this is oftenest used by business firms to estimate the success of their advertising campaign, the popularity of their products (soap, tooth-paste etc.) and such profit making ventures. The politicians use it to see which way public opinion is veering. The number of people sampled even in so large a country as the USA need not exceed 700 to 1000, so that a small trained staff can give the result (from the start of the sampling to the final figure) within a week at most. But this is not practicable in most underdeveloped countries. Let me suggest the use of another technique, to be used with sampling, but on different principles. This is called Mass Observation and was first developed by the British anthropologist B. Malinowski. It was very useful in wartime England. The main idea is to let a few selected people express their own opinion on some points in their own way, instead of asking specially framed questions that could be answered either yes or no, or in some other specific manner. The result in Mass Observation is less easily calculated than by the sample-survey, but gives much more information to the trained anthropologist or to any intelligent administrator. It reveals unsuspected needs that cannot be brought out by the western opinion poll. But once again, truthful and frank expression by the person questioned is absolutely essential. He or she must be guaranteed and convinced of complete secrecy and must be free from fears of reprisals for speaking too frankly. Such observation has been used with great effect in Poland by the Wroclaw Sociological group. Let me suggest that those of our countries that struggle towards democracy would find it a useful way of ascertaining democratic goals and popular wishes.

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