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MANAGING SOIL RESOURCES
TO MEET THE CHALLENGES TO MANKIND

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J.S. KANWAR

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12TH INTERNATIONAL CONGRESS OF SOIL SCIENCE
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Managing Soil Resources to Meet the Challenges to Mankind: Presidential Address

J.S. KANWAR*

RESPECTED Rashtrapathiji, Your Excellencies, distinguished soil scientists, delegates, and friends, I have great pleasure in welcoming you to the 12th International Congress of Soil Science. At the outset, I must say how grateful we are to the Government of India, Department of Agricultural Research and Education, the Indian Council of Agricultural Research and the Indian Society of Soil Science for inviting us to hold this Congress in this historic city of New Delhi. We feel honoured and grateful to the President of India for inaugurating it. The theme of the 12th Congress is 'Managing Soil Resources to Meet the Challenges to Mankind'—a theme we adopted because mankind today is faced with many challenges, the biggest being food shortages and environmental degradation, both resulting from the population explosion and poor resource management.

The world population, which was only 2 billion in 1930, is likely to exceed 6 billion by the year 2000. In the next 60 seconds 233 babies will be born in the world, 136 of them in Asia. Hundreds of millions of people in several nations still live in abject poverty and hunger. Although famine, hunger and malnutrition have been common and dreaded conditions since the origin of mankind, their elimination was one of the great promises of the 20th century—a promise that has not yet been fulfilled.

While some developing countries have to produce more food, fibre, and fuel from less and less land, the developed countries are threatened with environmental degradation through industrialisation and urbanisation. The whole world is concerned with the global problems of hunger, malnutrition and the quality of life now and in the future. If current land-use practices continue, a child born today has less chance of getting adequate food to eat, space to live in and pure air to breathe. Therefore, there is an urgent need for careful consideration and thoughtful planning of the uses of our agricultural resources, particularly land.

The first International Soil Science Congress met in 1927 during the boom period soon after the First World War. The second and third Congresses were held during the period of economic depression that followed. After the Second World War, a new era in science began, with greater emphasis on the

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use of science and technology for peace and the prosperity of mankind. In agriculture, this resulted in the 'green revolution'—with international cooperation in agricultural research setting the pace—which dramatically increased food grain production. Between 1961 and 1980 in the developed countries 92% of this increase came from higher yields. Over the same period in Africa and Latin America, 52 and 54% of increased production came from area expansion: Asia lay between the two extremes (Barr 1981).

Expansion of irrigation and intensive use of fertiliser and high-yielding varieties became the symbols of progress. The demand for soil testing, soil survey and soil classification grew in proportion and these became important tools of modern agriculture. Fertiliser consumption everywhere rose phenomenally and continues to rise at an impressive rate. The amount of fossil fuel energy consumed became the barometer of a country's progress in agriculture. At the same time, concern over environmental hazards also grew, so that the whole period of the 1960s and 1970s is marked by the twin concerns of increasing production and maintaining a healthy environment.

Challenges to Mankind—the Theme

The 12th Congress is meeting at a time when the world has four times as much population to feed as it had at the time of the First International Meeting of Pedologists in 1909, which led to the foundation of the International Society of Soil Science in 1924. We are meeting at a time when the foodgrain exporters of the previous era have become net importers of grain; when the developing world has an expected shortage of 121 to 143 million tonnes of food in less than a decade from now (IFPRI 1977), probably rising to 171 million tonnes by 2000 A.D. (Crosson and Frederick 1977). We are meeting at a time when we see gathering clouds of severe famines of food, water, fuel and energy. Environmentalists are warning us of the rising temperature, increasing carbon dioxide concentration and pollution of the atmosphere and of water and likely changing of the pattern of rainfall. Our hopes of extending large-scale capital-intensive arable food farming, based on systems developed in temperate regions, to the lowland humid tropics of Africa and Latin America, where extensive areas still remain unexploited, have not been realised. Unfortunately, the message which visitors to the moon and the space shuttles have brought clearly indicate that we will have to continue to depend on the Earth as the only planet for producing our food.

At the time of the first Congress, the world was convinced that there was vast scope for increasing agricultural production through expansion of farmland by colonisation of new areas and migration of population from densely populated continents to sparsely populated ones. It is true that even today the world is cultivating hardly 10.6% of the total land area and there remains a potential of 14.7% more arable area to be brought under cultivation, but most of this potential is in South America, Africa, North America and Oceania.

The world is aware of the contribution of the soil scientists in critically assessing land resources and their potential; in increasing productivity of land already under cultivation; in reclaiming deteriorated lands and restoring them to productivity; and in more than doubling food production in the world in the last 30 years. Unfortunately, the increase in population has negated these achievements.

The participants in today's Congress are painfully aware of the limits to horizontal growth and see only remote chances of bringing more area under the plough, particularly in Asia and Western Europe. We realise that available resources of land and water for agriculture are scarce. Our forest resources are disappearing fast, our costly irrigation reservoirs are silting up and our productive farmlands are progressively going out of cultivation due to non-farm uses and soil degradation. The threat of floods and droughts is increasing and many land-degrading processes are assuming alarming proportions. In November 1981, Mrs. Indira Gandhi, Prime Minister of India, in her McDougall address at the FAO in Rome, remarked, 'the earth has been ravaged, desecrated, made sterile—perhaps through ignorance in the initial stages but lately driven by greed and arrogance.'

Asia, with 58% of the world's population, has only 20% of the world's arable land, 77% of which is already cultivated. In parts of south-east Asia, such as Indonesia, Thailand and Sri Lanka, serious efforts are under way, at enormous cost, to encourage the transmigration of population from relatively thickly populated to less populated areas. A similar process is taking place in Latin America. But the scope for this kind of activity elsewhere is rather limited; also the threat to fragile ecosystems in these regions is serious. The experience reported by Moormann and Greenland (1980) in Africa, and Sanchez and Cochrane (1980) in Latin America indicates the constraints of these trials. Although these areas are sparsely populated, they lack the necessary infrastructure for modern agriculture. Moreover, population in Africa and South America is also increasing at frightening rates and the agricultural environment is constantly threatened by drought and floods. In any event, the ultimate moral aspect of this situation must not be taken lightly; there are vast and potentially arable unused lands in some parts of the world and dense population and starvation in other parts.

The foregoing observations indicate that the scope for horizontal expansion is limited but the scope for vertical expansion for increasing productivity of lands already under cultivation with improved technology is enormous, particularly in the developing countries. Thus primary strategy for increasing food production in the world, particularly in Asia and Europe today, lies in improving the productivity of the land for vertical expansion, whereas in Africa and Latin America both options still exist.

Growing industrialisation, urbanisation, and civic needs are creating increasing challenges for a soil scientist of today. Accordingly, we felt it appropriate that the theme of this Congress be: 'Managing Soil Resources to

Meet the Challenges to Mankind'. This is the age of management—whether it is industry, engineering, or agriculture all produce remarkable results with better management of resources. For the survival of humanity, soil resource management is of great urgency. Although the developing world could borrow some of the concepts of soil science from developed countries of temperate regions, we cannot be sure of the applicability of these to tropical environments and much less of the technology of soil management suited to small farmers' conditions. Even the developed countries need to keep the concepts and technologies for soil management constantly under review to meet the challenges of the future.

In Retrospect

We feel greatly honoured that the 12th International Congress of Soil Science is being inaugurated by the President of India, Honourable Shri Neelam Sanjiva Reddy, who is well known for his love of the soil. He is a farmer himself and appreciates the relationship between soil and civilisation. We are extremely grateful to him for his encouragement and valuable advice.

It is a rare coincidence that the first International Congress was inagurated by the President of the United States of America, who emphasised the necessity of an International Congress to discuss methods to be employed in the study of soil conservation and land utilisation.

We are also elated today, because the Presidents of the fifth, ninth, tenth and eleventh Congresses are present among us.

Looking through the pages of this Society's history, I find each President's theme is in keeping with the most urgent need of the time. Sir John Russell in 1935 exhorted the soil scientists to help solve economic problems of the Depression; Richard Bradfield in 1960 emphasised the role of soil scientists in alleviating hunger and establishing peace; Gordon Hallsworth in 1968 drew attention to imbalances in research; Victor Kovda in 1974 spoke of soil and biosphere; and my immediate predecessor, Fred Bentley in 1978 took up the theme of climatic constraints to optimum utilisation of soil resources.

I have reminded you of the messages of my predecessors to bring home the point that soil scientists from the beginning have been concerned with the impact of soil management and soil policies on human society. It is unfortunate that though we have been crying ourselves hoarse, we have not yet formulated a world soils policy or a national policy aimed at rational management and efficient use of soil resources.

The world is becoming conscious of conservation of human, animal and plant resources, but there is not enough concern about the fast-disappearing fertile topsoil which supports all animal and plant life. Kovda (1974) observed that 5 to 7 million ha of good quality land is being lost every year from all over the world. If this rate continues unabated, the world will lose in 20 years a cultivated land area equivalent to the entire cultivated area of India today. Imagine the magnitude of this tragedy: 140-odd million ha of top fertile land which is to support the expected 1000 million people of India (or one-sixth of humanity) in the year 2000 A.D. disappearing—disappearing into thin air. During this period the world population will increase by more than 2000 million, an increase equivalent to the entire increase in population during the time of all the 11 Congresses. Isn't it therefore our paramount responsibility to do something about timely global conservation and imaginative, rational use of our ever-depleting soil resources?

The World Food Situation, Soil Resources and their Potential

In this Congress, Dudal from the FAO will discuss the world's soil resources and Buringh will share with you his views about the agricultural potential of these world resources. I will therefore restrict myself to a general overview. There is no doubt that world food production has not been able to keep pace with the demand in the developing countries of Asia, Africa and Latin America and future projections also show that if present trends continue, the foodgrain shortage in the coming decades will assume alarming dimensions. Some countries will of course face a problem of surpluses of food production also and lose the economic urge to increase productivity.

The core of the food deficit lies in the low-income countries and most of these are in Asia (Indian subcontinent), Africa and Latin America. It is not only the productivity of land that is low in these areas, but the use of productivity-increasing inputs such as high-yielding seed, fertiliser, water and energy and their efficiency of use is lamentably low. Even the research in soil science as compared with plant sciences is much less developed and supported in these regions, thus resulting in a big gap between the potential and actual production. Thus, there is a need for evolving strategies aimed at increasing intensity of cropping, enhancing productivity of croplands and improving the efficiency of agricultural inputs.

At the First Congress of the International Society of Soil Science in Washington, Penck (1928) observed that the world could produce food for 16 billion people. More recently Revelle (1976) projected a carrying capacity of up to 40 billion people, while Buringh and associates (1975) estimated that under optimal conditions agriculture could increase the production to a maximum of 30 times the present level. Sinha and Swaminathan (1979) estimate that in India the maximum potential of soils is 35 times the present level reached. No doubt the potential is tremendous; its realisation, however, depends on many factors, two important ones being the type of technology envisaged and the socio-economic conditions which prevail.

Of the 13 500 million ha total geographical area of the world, 78% is too cold, too dry, too steep, too shallow, too wet or too poor to sustain plant growth; hardly 22%, or 3270 million ha, is arable and of this only 1439 million ha is cultivated. Of the arable land, 60% is of low productivity, 27% of medium productivity and only 13% or approximately 400 million ha of high productivity. How much more arable land can be cultivated depends on a number of factors—technical, socio-economic and political—which are beyond the scope of this Congress.

An Analysis

In my detailed address I have restricted comments to four groups of croplands: (i) tropical rice lands, (ii) irrigated semi-arid and arid lands, (iii) lands under shifting cultivation, and (iv) rainfed and dry-farming lands. They have a vast unexploited potential but its realisation depends on soil management, irrigation water management, rainwater management, efficient management of soil fertility, and fertiliser and energy management. There is no reason why rice lands of developing countries should yield only 2 tonnes/ha when some rice-growing countries are averaging more than 6 tonnes/ha. It is disappointing that the irrigated lands of developing countries are reporting hardly one-fifth to one-fourth of their potential and so are the drylands. India is no exception. From 40 million ha of net irrigated area India is capable of producing enough food to sustain twice the size of the expected population of 1 billion people by 2000 A.D. Likewise the 12 million ha of Vertisols in dependable rainfall areas, which remain uncropped during the rainy season, can produce five to six times more food without much difficulty. I need hardly emphasise that the dryland farming and shifting cultivation farming in the tropics both need greater attention from soil scientists than they have received so far. The forest lands, grasslands and range lands have been neglected even more than the croplands and with appropriate soil management they are also capable of producing many times more than their present output. Thus the key to the world food problem and environmental problem is better soil management.

Relevance of Soil Research of the Seventies

Soil scientists, irrespective of their specialisation, have been concerned with the understanding of processes and the development of techniques for improving soil environments for crop production. In my opinion, they have spent more time on the former than the latter, which obviously gave the wrong impression about their intentions. Rapid increases in demand for irrigation development, fertiliser use and intensive cropping in many countries have necessitated critical examination of the concepts and techniques of soil and water management.

The oil crisis and the escalation of prices of nitrogenous fertilisers spurred the effort to improve the efficiency of these through use of sulphur-coated urea, supergranules and nitrification inhibitors. Split application of fertilisers and use of legumes such as *Sesbania* and *Leucaena* for green manuring and biofertilisers seem to be promising in effecting savings in N bills.

Mukherjee (1922) in his pioneering researches over two decades had established the importance of Al in soils, but it is only in recent years that its full implication has been realised. In the last decade, utilisation of acid infertile soils of the low humid tropics, using aluminium-tolerant varieties, has helped make the best use of such poor soils.

Micronutrient deficiency, particularly of zinc, received the greatest attention from soil chemists and soil fertility specialists all over the developing countries. Besides correcting the deficiency through the use of zinc-containing substances, the use of genotypes tolerant to the deficiency has been found a promising approach. Indian soil scientists can rightly feel proud of their contribution in this area. The 1970s became a decade of micronutrient research in India.

Studies on degradation of pesticides, absorption of heavy metals and transformation of these chemicals in soils and the development of techniques for their detoxification and absorption gained importance during this period.

The soil microbiologists took up the challenge of improving the economy of N fertilisation by exploring the possibilities for use of algae, *Azolla* and non-symbiotic N fixation. Organic matter chemistry, through use of sophisticated instrumentation, has unravelled the mystery of the relationship between organic matter and nutrient supplies.

The last few years have witnessed great interest in the use of organic matter and agricultural wastes for supplementing fertilisers and improving soil properties. The biogas generated from animal wastes and agricultural wastes provided a new avenue for augmenting energy supplies and manurial resources for agriculture. In this area of research also India took the lead, but China has taken up the programme on an impressive scale.

The soil physicists have successfully set up models to study the behaviour and movement of water and solute in soils to predict the changes in soil environments in response to physical and biological factors. The wasteful and destructive effects of using heavy, energy-intensive tillage on soils for which it was not designed and the value of minimum or zero tillage, particularly for tropical soils, were demonstrated by IITA scientists in Nigeria. This has led to the development of a soil-management system for sustained production without detriment to the environment in the humid tropics of Africa.

Acceptance of the U.S. Soil Taxonomy of soil classification has grown during this period, particularly through the Benchmark Soils Project of the Universities of Hawaii and Puerto Rico, which indicates the possibilities of transfer of technology to the same soil families around the world.

The techniques for reclaiming saline alkali soils, acid sulphate soils, peat soils and aluminium-rich soils and for combating desertification have opened up numerous possibilities of bringing these problem soils into high productivity in the tropics and arid regions. The contribution of the Central Soil Salinity Research Institute, Karnal (India) for reclamation of alkali soils also needs to be taken note of.

The clay mineralogists have focused attention on soils of variable charges and developed understanding of behaviour and management problems of such soils.

These comments indicate that soil scientists and agronomists have responded to the challenges of the time and seem to be receptive to taking greater responsibilities in the future. Expanding fertiliser technology, space-age techniques such as satellite imagery and remote sensing to assess agricultural resources, and genetic engineering are opening up new vistas in soil science research and practice as well. Let it be understood that though genetic engineering can develop genotypes with very high yield potential, it is only through soil and water management that this potential can become reality. The low yields in tropical developing countries clearly indicate this.

Soil Problems and Strategy for Meeting the Challenges of the Future

The problems which a soil scientist of today is called upon to solve are more complex and variable than ever before. Some are location-specific, others transcend political and geographical boundaries. But with the application of science and technology they can be solved. The main question is: at what cost? Special attention is needed in removing soil-related constraints from tropical soils which have the potential for expansion horizontally as well as vertically but need more location-specific research and appropriate technology. The temperate region technology cannot be directly transferred to these areas.

The challenges to soil scientists in the decades ahead can be grouped thus:

- Assessing of capability and potential of soil resources for different uses including urbanisation and recreation.
- Optimising the agricultural productivity of the land under cultivation.
- Improving the efficiency of agricultural inputs such as (i) water, (ii) fertiliser and (iii) energy, the key factors of technology based on high yielding seeds.
- Preventing and combating soil degradation and pollution caused by man's negligence and ignorance and poor management of resources.
- Restoring and improving productivity and utility of degraded lands.
- Monitoring changes in the productivity of land and developing a system of warning, treatment, care and education.

These challenges are common throughout the world; only their intensity and order of priority varies. In the industrialised countries, the problem is of maintaining high soil productivity while avoiding the harmful effects of indiscriminate use of agricultural chemicals, improving land degraded by industrial effluents and finding methods for quick, safe disposal of urban wastes.

In many developing countries, improving productivity per unit land per unit time is the goal. And the key to such improvement lies in increasing efficiency of water use—rain or irrigation and of high-cost manufactured inputs—fertilisers, pesticides and machinery. For instance, a 70% loss of N from urea applied to paddy poses both an economic loss and a health hazard. Increasing the efficiency of N from 30 to 50% in rice cultivation in India at current rates of N application (1.4 million tonnes) would amount to saving enough N to produce additional food for 46.5 million people. Likewise, increasing the efficiency of irrigation water and realising the potential of irrigated lands in India can make the country one of the biggest exporters of foodgrain and of other agricultural products.

The increasing costs and shortage of energy make it imperative to decrease the use of non-renewable energy sources in agricultural systems. Most of the energy in agriculture is used to manufacture nitrogenous fertilisers, pump water, and mechanise farm equipment. Thus, any improvement in the economy will help economise on energy, while sustaining productivity in many ecosystems, particularly in tropical areas.

I find very few soil scientists taking an interest in management of forest lands, range lands and grasslands. Unless we learn to manage these soils well we cannot combat natural disasters such as floods, droughts, siltation of water storage dams, landslides and desertification. Thus the soil scientists of today have many more demands on their expertise than the participants of the first Congress faced.

A Japanese soil scientist in the Osaka region may give high priority to problems of toxification by heavy metals; a Chinese scientist to reclamation of peat soil for rice production; an Indian scientist to moisture and nutrient stress in drylands and management of water and nitrogen-use efficiency in wetlands; an African soil scientist to management of Alfisols in the sub-humid tropics and combating desertification in the Sahel region; a Brazilian soil scientist to making the aluminium-rich acid infertile cerrado soil suitable for producing maize or beans. The priorities may vary, but the challenges are the same; the practices may differ, but the principles of soil science are the same.

Looking Ahead

It is presumptuous on my part to comment on future needs and trends of soil research because of the complexity of the problems and fast development of technology which makes all projections about the future difficult. I am sure the panels of experts on soil research will make a critical evaluation of the past achievements and the future needs.

Soil physicists are aware that we are critically short of understanding the behaviour of the soil under field conditions, particularly in the tropics. They should help change the trend from over-mechanised and energy-wasteful agriculture and improve efficiency of water, fertiliser, tillage and drainage. They should target their researches to the costly irrigation project areas, old and new, which are the hope of humanity in fighting famine. Unless efficient water management systems are developed and used in them, they are likely to become costly engineering exhibits.

There are very few soil physicists working on the soil-water relationship, nutrient availability, crop stand and soil erosion control in tropical countries and those few who are available spend much of their time in packing the soil in the lab rather than grappling with the soil and water problem in the field. The need for teamwork of interdisciplinary research can hardly be overemphasised. The soil physicists and agricultural climatologists should work together in developing a transfer of technology for different environmental situations. The Soil Science Society should also consider organising a working group on agricultural climatology to bring together scientists with common interests.

The energy crisis has revived interest in supplementing chemical fertilisers with biofertilisers and phosphate release from unavailable forms to improve soil productivity. Thus, the pendulum of research in the future should swing to soil chemists and microbiologists working together rather than separately. More sophisticated techniques should help in resolving many controversies and changing old dogmas.

In the field of soil fertility, the necessity of intensive research on controlled nutrient release and improved efficiency of nitrogenous fertilisers for drylands and wetlands, in the tropics and arid and semi-arid areas of the world needs highest priority. Isn't it strange that in case of nitrogen which is a costly fertiliser we are losing 50 to 70% in rice lands and making our waters polluted. Phosphate, which is a non-renewable resource, we are using wastefully and in case of K we are behaving as if its supply is inexhaustible. Judging from Indian experience I can say that if the decade of the 1950s was one of N deficiency, 1960s of P, 1970s of Zn, 1980s will be of multinutrient deficiency, K included. With exploitive agriculture and about two to three times the present level of N, P and K consumption, by the year 2000 we should be prepared for many unexpected problems of nutrient imbalances.

It is high time that soil fertility specialists work together with plant geneticists in adapting the plant and with fertiliser technologists in modifying the fertiliser, to suit the soil environment. Despite the large number of papers on soil fertility we still do not have a satisfactory method of predicting fertiliser needs precisely. Most disappointing is the story of N. The problem of toxification from heavy metals and crop residue management will demand more attention from soil scientists as these are unavoidable products of industrial and agricultural development.

No doubt the pedologists have come a long way in developing a soil classification system; however, they still need more information about tropical soils. I feel the best tribute to all the eminent pedologists from Dokuchaev to Guy Smith would be for the pedologists to agree on one uniform system of soil classification. I would like to emphasise that the pedologists have looked at the pedon too long; let them now use their knowledge for the transfer of technology of soil management.

The soil technologists should be aware of the limitations of high-energy technology and develop alternative approaches compatible with the socio-economic conditions of the situation.

The clay mineralogists may rightly lament the inadequacy of research in clay mineralogy but they should be concerned about the lack of utilisation of already available knowledge of the subject for soil management technology. I am sure the panelists of all the commissions have a number of suggestions for researchers for meeting the challenges to soil scientists in the decades to come. However, unless the education programmes prepare the scientists to make use of advances in knowledge of the related sciences and use of instrumentation, including remote-sensing technology, we may not be able to progress fast.

Concluding Comments

This is the year of the 10th anniversary of the UN Conference on Environment. It is a good occasion for us to remind ourselves that soil is the base of all we produce and reproduce and it needs attention. We hear the slogan '*Save the Oil*' but I have yet to hear the words '*Save the Soil*'. Unless we do it now it will be too late, as it was for the philosopher who at the time of his death read the inscription 'GOD IS NO WHERE' as 'GOD IS NOW HERE'. I am confident that this Congress will lead to formulation of a world soils policy.

A number of international agricultural research institutes have been set up in the world for crops and animal research but there is none for soil and water research, though its need has been recognised particularly in the tropical regions. I need hardly emphasise that embryo culture and genetic engineering may offer many new genotypes with high yield potential but you need a soil and water management system to realise their potential and make the technology viable.

The Consultative Group on International Agricultural Research has proposals for an International Soil Science Research Institute (ISSRI), for an International Board for Soil Research and Management (IBSRM) and an International Water Management Center (IWMC). All are claimants for scarce financial resources. I suggest these could be combined together into one international research effort which may be called International Soil and Water Research Institute (ISWRI), with a network of centres in different tropical regions.

We find ourselves at the crossroads where the good agricultural lands are slipping out of our hands into nonfarm uses and the energy crisis, rising costs of mechanised farming and land reclamation and increasing land degradation prevent us from expanding agriculture to new areas. We realise that there is vast scope for increasing productivity of the land for which we need water, fertilisers, energy and pesticides. Their high prices, low efficiency of use and environmental hazards -real and imaginary—place a serious limitation on their use. We realise that poverty, hunger and malnutrition are an even greater threat to the environment and the only way of alleviating them is through increase in productivity of land and water. Hence our major task is how to manage our soil resources to meet human aspirations and challenges of the future. The third world, especially, needs more soil management technology than it is using today.

With today's technology we can certainly modify soils to man's advantage. We can predict the changes and improvements if we know our soil well. We could computerise irrigation schedules, fertiliser needs and likely response of soils to management.

Whether there are disasters like floods or droughts, food or water famines, energy crises or health hazards, poor soil management is the cause. We have the capacity to improve the situation but we need the will to do it and a national and world soils policy to accomplish it.

Now I request the Chief Guest to inaugurate this International Congress.

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