USING KNOWLEDGE FOR DEVELOPMENT
- towards a research policy agenda

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Note: The views expressed in this paper are those of the author and do not reflect those of the International Development Research Centre

ABSTRACT

This paper is based on the premise that humanity does not know about how knowledge in its various forms can contribute to development. The first part attempts to put research, or knowledge-production, in a broad context, starting with a concept of development that is global in scope and not confined to material progress. Secondly, the case is argued for a more holistic approach to knowledge production and use, to match the recognition that the quality of human existence is not improved by single technical or economic fixes. The third section looks at how the resources devoted to the formal research sector are distributed globally, looking particularly at the gap between the materially richest and the materially poorest countries (MPCs). Based on the issues that are raised by the confluence of considerations in the first three sections, a number of research topics are proposed that would improve understanding of how knowledge production and use can contribute more effectively to development, broadly defined.

I) RESEARCH IN CONTEXT

It is taken as a starting point that research should make a contribution to development. For present purposes, "development" is defined as

sustainable improvement in the quality of human existence:

it being recognized that "quality" is not universal and that different societies will determine what it means according to their own value systems; and that the most critical aspect of sustainability is the capacity of the natural environment to continue to support all forms of life, but that social, cultural and financial sustainability are also important.

It will be noted that, according to this definition, development becomes a matter of general concern. It does not require the classification of nation states along a continuum from least, to less and then to industrialized countries; nor regions into North and South; nor blocs into First, Second and Third. This definition accepts that the search for improvement is elusive and permanent in all societies and individuals. Politicians are elected on that basis; dictators frequently offer it up as the end to justify their means. There is also now an unprecedented measure of international agreement that the sustainable component of the definition must become a global preoccupation. Just as individuals have to suppress some actions for the good of their social group, so nations are forced to recognize that national boundaries are irrelevant to many elements of sustainability. Growing global interdependence demands an increasing degree of international sovereignty, with some sacrifice of national sovereignty.

In the context of this pervasive definition, what is the role of research? This question can be addressed by looking at the main product of research, i.e. knowledge, in the context of other determinants of the quality of human existence besides knowledge. Religious and spiritual values are rarely mentioned in discussions of development, but have affected the quality of life, positively and negatively, for considerably longer than has research; likewise have cultural activities such as music, the visual arts and drama. Human governance factors that depend, not on knowledge, but on beliefs about various forms of social organization that balance individual and community rights, have similarly ancient antecedents. These determinants will not be elaborated here, but are mentioned as a reminder that while knowledge has a powerful role to play in development as defined above, wisdom requires that we acknowledge the importance of other vital factors, particularly as they often act in various combinations together with knowledge.

The role of research should also be examined taking into consideration its interrelationship with other components of what has been called the "knowledge system".

Many terms have been used to describe the knowledge economy, usually on a country basis: "national innovations systems", "learning societies", "knowledge systems" (e.g. Dosi, Freeman et al, 1988). The purpose here is not to analyse or compare any of these notions. However, they possess the common characteristics of attempting to define a system of knowledge in action. It is unfortunate that such shorthand descriptors sound esoteric since it tends to contradict the simplicity of the subject and to militate against effective communication. Knowledge is simply an asset that is owned by every member of society, to varying degrees and in a variety of forms. It may be derived from formal education and/or practical learning experience. The Sahelian farmer knows what crop to plant in particular circumstances, mostly from informal education and trial and error (a form of research). The medical doctor knows what certain symptoms mean, mostly from formal training, frequently verified with growing confidence through practical experience.

Over the last two centuries or so, the very high levels of material consumption and comfort attained by many countries in the world have been associated with high levels of formal education in an organized system of knowledge production and use. This can be illustrated crudely by reference to the Human Development Report of the UNDP[1], which arranges 173 countries in descending order of Human Development Index (HDI). This is a compound of life expectancy, literacy, education and income; consequently it is quite heavily weighted with formal knowledge indicators. The report also contains information on real GDP per capita (adjusted for differences in purchasing power among countries). This serves reasonably well as an indicator of material wealth and consumption. Most of the top 25 countries in terms of wealth, i.e. those with real GDP per capita levels between $12 000 and $22 000[2], are also in the top 25 in terms of the composite HDI. At the other end of the spectrum, the poorest countries are mostly those with the lowest HDI levels. None of the 55 countries with the lowest HDI has a real GDP figure higher than $2500/capita, and 28 of them are below $1000/capita.

There are many components of what shall be called "the knowledge system" for the purpose of this paper. Clearly teaching is one of the most important, from the

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[1] UNDP Human Development Report, 1994 Oxford University Press, 1994.

[2] There are some anomalies, such as the oil-rich Gulf states and some tax havens like the Bahamas. These states have very high GDP levels, but are not in the top 25 in terms of the HDI.

formal primary, secondary and higher education system, including technical training colleges and adult education, to the informal transfer of knowledge in families and groups that intensifies as overall learning increases. Other elements of knowledge in use are in information and communication - increasingly facilitated by technologies whose power and potential have yet to be fully realized; production of goods and services; management and organization of enterprises, both public and private, including the formulation and implementation of policies, be they economic, social, legal, or fiscal. Last but not least is research itself, which is an essential part of the knowledge system. However the percentage of the system taken up by the research element varies, as does its composition into public: private; basic: applied; social and natural sciences; and so on. For example, the partial data available indicate quite a wide range in terms of the proportion of all scientists and engineers in certain countries actually engaged in research and development (R&D). The proportions vary from 18% of scientists (full-time equivalents) in the USA working on R&D, and 20.4% in Germany (former GDR), to 7.8% in Japan and 3.8% in the Netherlands and Canada, (UNESCO). It would appear that formal research is rarely more that one-fifth of the knowledge systems in rich countries.

The essential nature of research can be argued on the basis of both instinct and empiricism. If all public and private research institutions were to close down, instinct suggests that research would continue. In a sense it represents the characteristic that separates homo sapiens from other animal species, ie. that of wanting or even needing to know. When Faraday was queried about the use of his research into electro-magnetic phenomena, he replied with question: "What's the use of a baby?". He was saying that humanity's impulse of curiosity is as natural and inevitable as the procreative urge, and is not subject to utilitarian justification. He may also have been implying that the outcome is equally unpredictable; the child of knowledge produced by research may be stillborn or used for good or ill, from the eradication of smallpox to the destructive use of nuclear fission. He might even have wanted to go further, to say that some offspring have better chances that others, depending on the environment they are born into: if the teaching, production, management and information elements of the knowledge environment are rudimentary, the products of research tend to be slowly and incompletely used.

The empirical case for research is based on the argument that there are no wealthy countries that do not have strongly developed knowledge systems and no knowledge systems that do not have a formal research sector, organized in public and private institutions. Publicly-funded research provides a necessary foundation for human capital formation and this in turn constitutes the main ingredient of the other elements of the knowledge system upon which social and economic wealth creation depend. Furthermore, the human capital stock has to be continuously upgraded and maintained through, amongst other things, sustained investment in research. Beyond this general observation, the empirical evidence is inconclusive, particularly when it comes to explaining variations in economic performance. Much work has been done on the relationship between indicators such as expenditures on R&D and economic growth; on rates of return to research in general and in particular sectors, especially agriculture; on how to manage the research enterprise; and a host of other issues. However, it is fair to say that much remains to be done in terms of understanding how to optimize research performance in different circumstances. It is ironic that the very process that produces information and understanding should itself be so poorly documented and understood.

Just as research is only one part of the knowledge system, so it should be remembered that research itself classified as formal and informal. Now, in most parts of the world, the term "research" is associated with the formal structures of modern science, the mystique of intellectual achievement, and an array of establishments such as universities and institutes designed to house those engaged in this elite profession. In fact, the shift from an informal and largely unrewarded assortment of independent inventors and explorers to the current institutionalized enterprise in recognized professions is relatively recent (Salomon 1994). It is worth noting that the rise in the formal system has not meant the decline of the informal. Although the independent and occasionally persecuted or vilified figures such as Galileo and Darwin are no more, the growth of sophisticated knowledge systems has meant a corresponding increase in informal investigation, trial and error, and observation by practitioners in other parts of the system. For example, medical knowledge emanating from restricted experimentation in laboratories is complemented by and frequently at odds with clinical medical knowledge derived from professional experience. Professions such as law, medicine and engineering create and maintain reservoirs of such "cosmopolitan" knowledge, as do traditional craftspeople and rural communities (van der Meulen and Rip 1994).

Also, in materially poor countries with weakly developed formal knowledge systems, informal research takes place. Successful formal research to improve pigeon pea varieties in Kenya drew upon seed selections made by women farmers on the basis of field observations over considerable periods of time. There has also been significant growth in the non-government sector (NGOs) in the last few decades. Theses entities are usually perceived as knowledge users, but they are also knowledge gatherers - collecting information about community needs and problems - and knowledge producers, mostly through trial and error experience. Thus, a broader definition of research that embraces informal knowledge producers as well as the formal systems is likely more appropriate in an era of scarce public funds and persistent problems of material poverty. If the formal R&D system is poorly understood, the informal "system" is relatively unexplored territory. There has been some attention paid to the indigenous knowledge sector, but in general this area should have a higher position on the agenda for research on research.

The final point in this general overview of "research in context" is the subdivision of the formal sector into public and private. This is worth mentioning for a number of reasons, not the least of which is that it is often overlooked. A further reason is that the relationship between the two sectors is intimate and symbiotic. In some instances, the distinction between the two sectors is becoming blurred. For example, in a recent study of the relationship between business and the state in the energy sector in Japan, Richard Samuels discovered patterns of "reciprocal consent" between firm and government, and wrote of "a mutual accommodation of state and market" (Samuels 1987). Others talk of "neo-corporatism" and a "New Japan Incorporated" to describe the close ties between government and private enterprise in Japan.

The private sector share of total R&D activity is tending to increase globally, mostly driven by the major players. The three geographic units making up the "Triad" i.e. the USA, Japan and the 12 countries of the European Community (as of 1993) together have about three-quarters of the world potential for the production of S&T knowledge. It has been estimated that this production capacity spent $318 billion on R&D in 1990, 56% of which was financed by industry and 69% of which was implemented by industry[3]. At the international level, the public sector/public good efforts of the WHO and the International Agricultural Research Centres are parallelled by the supranational activities of multinational corporations. In different ways, both of these have significant implications for the materially poorest countries, especially those that are both small and with weakly developed knowledge systems. Their prospects for developing an indigenously owned and controlled system are greatly influenced by international activities, as well as by the comparative national giants such as Brazil, China and India. In short, any thorough examination of the role of research in development has to take both publicly and privately-funded R&D into account.

In summary, this section has looked at research in the context of an embracive definition of "development". It is proposed that the informal knowledge-producing sector should be included in the considerations of research. It is pointed out that research is but one component of a more extensive knowledge system, with a high degree of interdependence with other components. Finally, the knowledge system can be viewed in the context of a concept of development that is not confined to the materially poorest countries. Knowledge takes its place among a number of other determinants of

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[3]Note: According to the National Science Foundation, industrial R&D has been nearly stagnant in real terms in the USA since 1987.

development as a necessary but probably not often sufficient condition. Given the synergistic links among the factors that promote development and with the knowledge system itself, it is believed that this taxonomy of contexts serves as an important introduction for examining the role of research in development.

II) RESEARCH AND REDUCTIONISM

There has been considerable evolution in the understanding and practice of development over the postwar period. On January 20, 1949, President Truman of the USA, on taking office, talked about:

> "...making the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas."

On that day, although they were unaware of the fact, about two billion people became classified as "underdeveloped". The view that development was virtually synonymous with economics and economic growth had powerful adherents. Indeed, a whole branch of economics called "development economics" sprouted vigorously from the main trunk of that discipline.

But perhaps more important than this belief was the assumption that development was something to be done to people by the transfer of the fruits of scientific knowledge from rich countries. By this means, the poor underdeveloped countries would be able to catch up and an unequal world would be equalized.

Over the subsequent decades, that goal has not been achieved, although considerable progress has been made. There have been significant advances in economic growth, literacy, child health and food production, to name a few. From the lessons of experience with successes and failures, these improvements have been matched by a better understanding of the development process by Western academics and donor agencies, for whom development was something that other countries did, or had done to them. One landmark was established by the UN announcing the First Development Decade of the 1960s. It called for the integration of social, cultural and economic factors to achieve improvements in the quality of life, not just economic growth. Two decades after the end of that first decade, the UNDP issued the first Human Development Report, ranking countries according to a composite index that came closer to measuring quality of life than GNP per capita.

It should be noted that in spite of this willingness to approach development in a more integrated fashion, traditional economic thinking still tended to predominate donor policies, particularly those of the World Bank and the International Monetary Fund: and to a certain extent it still does. Yet a growing number of economists are prepared to follow the example of Schumpeter, who strove to develop an explanation of economic phenomena that was more consistent with the empirical evidence and attempted to include technical, social and institutional change into his thinking. More recently, Nobel prize winner Douglass North has pointed to one of the unrealistic assumptions of neo-classical economics, that transactions are costless. Since this is patently not the case, institutions and property rights become crucial determinants of market efficiency. Hence he proposes a school of new institutional economics "...to incorporate a theory of institutions into economics" (North 1994).

Also, one of the most comforting precepts of mainstream economics, that everything tends ultimately to a state of general equilibrium, is increasingly questioned. The idea of non-linear dynamics, i.e. that it is precisely *disequilibrium* that drives the system is gathering support.

Perhaps the most striking feature of the postwar evolution is the growing diversity of thinking. There are now the beginnings of a willingness to acknowledge that there is more to human advancement than a technological or an economic fix; that societies are complex systems of people interacting with the natural environment, with technologies, with one another in various forms of social organization that have been formed by particular historical, cultural and political factors. All these elements are connected and interdependent, such that an attempt to modify one is influenced by the others and has repercussions throughout the system. Thus there is an increasing acceptance of the holistic nature of the process. Difficult though it may be, the prudent approach for those who would presume to bring about change for the better, (or at least, in the terms of the Hippocratic oath, to do no harm) is to try to take this complicated set of interacting factors into account.

There have been many stimuli to more systemic, holistic approaches to development, but perhaps the most significant has been the accumulating evidence of the damage being done to the natural environment. Over the last two centuries, the exponential explosion of the modern industrial era, driven by the Western scientific and technological enterprise, has resulted in the economic growth and prosperity of many nations and segments of societies - and not just in the "North". There is little doubt now that this juggernaut of material consumption has had destructive effects on the natural environment and on consumers themselves. Some of these effects are known and understood, some are not. Some can be repaired, some are irreversible. Some are location-specific, like soil erosion and city pollution - although of course both of these can also have cross-border effects. Air, water and information are virtually completely disrespectful of national frontiers. Science and technology, sometimes hailed as the engine of rich modern societies, with all their unquestionable benefits have so far failed to provide definitive information about the costs of damage. But there is sufficient evidence and consensus, together with the glimmerings of collective humility about humanity's place on the planet, to spawn a growing movement of thought and action. Concepts such as the "spaceship earth", "the global village", "our common future", the "borderless world" have taken root. Citizens' movements, NGOs, and "green" political parties have sprung up in many countries. This trend has happily coincided with the growing involvement of women in social and political affairs, providing considerable impetus and often initiative to environmental action. One of the best examples is the Chipko movement in India, in which women have saved trees with their bodies. This movement originated 300 years ago, when more than 300 people in Rajasthan, led by a women called Amrita Devi, lost their lives by clinging to their sacred Kherji trees (Shiva 1989).

Popular movements do not always find equivalent enthusiasm or commitment at the political level. In this case, some grounds for optimism can be found in the two UN conferences that have been held on the environment and development in 1972 and 1992. The second, held in Brazil and labelled the "Earth Summit", was attended by 185 nations and 118 heads of state. An action program was adopted, called "Agenda 21". This event gave further credence to the belief that, whatever else development must mean, it must also be sustainable. Hence, to the quality of life concept proposed by the UN in 1960, must be added the necessity of achieving improvements without damage to the ecosystem. The Brundtland Commission of 1987 articulated this imperative as follows:

> "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (Our Common Future, 1987)

Of equal importance to the inter-generational aspect of sustainability is the dimension of global interdependence. However, this is not now confined to the shared reliance of all humanity on the natural environment. Activities and phenomena related to economics, capital markers, epidemiology, informatics and technology are occurring more and more without heed to national frontiers, i.e. they are increasingly global. They interact with one another and, in various ways to varying degrees, with the natural environment.

All these refinements and imperatives add up to the definition of development proposed at the beginning of this paper: a sustainable improvement in the quality of human existence. The characteristic of the definition which is highlighted for present purposes is that it is holistic. The various factors that contribute to development are interactive, and any theoretical or practical approach must remain cognizant of that fact. In terms of the role that research can play in the development process, the question can be posed about the degree to which it is moving in the same direction. That is - how holistic are approaches to research?

The evolution of the modern (Western) scientific enterprise has been dominated by the phenomena of fragmentation and depth. Simply because of the vast complexity of the natural and social universe, science has approached the task of trying to understand it by breaking it up into manageable pieces and creating increasingly narrow fields of specialization. This allows strength in depth of enquiry. Human ingenuity cannot yet cope with breadth and depth simultaneously. This rational approach of dividing exploration into separate lines of enquiry or disciplines, has been called "reductionism".

Of course, a divided structure of higher education, research, review and publication has evolved to support the reductionist model. Judgements about the value of research done in each discipline are normally made by peers within that same group. Specialization has evolved to the point where this is the only possible procedure, since each discipline has necessarily developed its own language, which becomes more esoteric as the research becomes more basic. With respect to economics, J.K. Galbraith has likened the prestige structure of that subject to a hollow cone,

> "...the sides of which... become increasingly opaque and impermeable as one proceeds to the apex. Positions near the apex are fully protected from external communications. ...Questions of practical application are excluded as also the influence of other disciplines." (Galbraith 1971).

The benefits of the Western approach to science are unquestioned and will not be elaborated or debated here. But given the need to approach development in a more holistic way, the profoundly fragmented nature of research and science deserves a critical appraisal. To a large extent, the reductionist model that has evolved in the rich industrialized nations has been replicated in most parts of the world, even in the materially poorest and smallest countries, where its suitability can be most seriously questioned.

It can be argued that holistic thinking about development is in its infancy and is indeed fiercely resisted in some quarters. The reasons are obvious. Development practitioners are trained in the reductionist school and try to understand the world through the lens of their disciplines. Each individual inevitably constructs a model that is described in the language of their discipline(s) and functions in those terms. Collectively, some models accumulate considerable influence and only accept new elements by addition, rather than creative integration. It becomes a form of sculpture by accretion[4]: a partly formed body is created, a vital part is recognized as missing and is added on, leaving the original deficient form intact. Ideally the missing element should be integrated by remixing all the clay and beginning the sculpture again. However this is not a simple step for the reductionist, rational school. It would virtually require reschooling in a radically different approach to the pursuit of knowledge. F. Kapra expresses the challenge as follows:

> "Rational thinking is linear, focused and analytic. It belongs to the realm of the intellect, whose function it is to discriminate, measure and categorise. Thus rational knowledge tends to be fragmented. Intuitive knowledge, on the other hand, is based on a direct, non-intellectual experience of reality arising in an expanded state of awareness. It tends to be holistic and non-linear." (Kapra 1987).

Despite the intellectual and practical challenges that it imposes, the sanctity of development models based on "sculpture by accretion" must be questioned. The trend

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[4] Note: "accretion = adhesion of extraneous matter to anything" (The Oxford Concise Dictionary)

towards more holistic development thinking can only be strengthened and transformed into more effective practice by a shift from reductionism to holism in the knowledge system, and in research in particular. It should be clear that this is not an anti-reductionist position. The strength and rewards of the system have been acknowledged. However, it is apparent that the downside of the approach is considerable and in some respects may be reaching a critical point of no return. Human ingenuity must be pushed to the limit, to find ways in which the strengths and advantages of the specialist depths of reductionism can be enhanced and complemented by greater holism and integration.

It will be of primary importance to develop approaches that meld the natural sciences and "hard" technology with the social sciences. The division is perhaps the most detrimental to development and is becoming increasingly accepted even when the rich countries attempt to understand their own development. For example, the OECD recently declared an "...understanding that... technological change is fundamentally a social process" (OECD 1992). Also, a major work on technical change and economic theory concluded that "... indeed it will be the broad societal context, including economic, but also social and ethical factors which will set the conditions within which technological change will be adapted, even selected" (Dosi, Freeman et al, 1988). The capacity of humanity to innovate technically has grown exponentially in the last two centuries and shows little sign of relenting; but the equivalent capacity to devise effective forms of social innovation lags far behind. Few societies are able to construct viable systems of organization that permit the attainment of social goals, particularly those related to equity. Much is made of scientific and technological (S&T) innovation, but the social science element in this term tends to be overlooked in favour of the glamour of technology. It can be argued that it would be more appropriate to redefine "S&T" as Social and Technical innovation. Unless the two are approached together, with major efforts made to redress the imbalance between the social and the technical and to ensure that technical change is subordinate to societal goals, the deficiencies of the status quo will continue to prevail and may become irrevocably damaging. As already intimated, this is not an intellectual preoccupation for a Western elite in its deliberations on how to run other societies: this is a general challenge of global concern, although the paths forward will be shaped by different social, cultural and economic circumstances.

III) RESEARCH DISTRIBUTED

As proposed above, development in terms of the quality of human existence is of universal concern to all societies and nations; and global interdependence has grown to an extent that reinforces that universality. However, in term of material wealth, there is a gap between rich and poor nations that is staggering in its proportions. The majority of the world's population lives in a state of extreme material poverty relative to the minority, and for more than a billion people, the quality of existence is abysmal. As stated in the 1994 Human Development Report, these people live "...at such a margin of human existence that words simply fail to describe it." Hence, although development in the broad sense of quality of existence is the concern of all and distinctions such as North/South; "less developed" "pays en voie de développement" may be close to obsolescence, in terms of material poverty, the difference is very real. Rather than "LDCs", or "developing countries", such countries will be described as Materially Poorest Countries or MPCs, for future purposes in this paper. Whatever their wealth in other terms, their levels of income are unequivocally far below average levels in the rich countries.

The champagne glass of the Human Development Report (1993) shows vividly how the distribution of the world's wealth is highly skewed: 84% of global GDP is enjoyed by only 23% of the world population. Is the level of development of different knowledge systems skewed? Unfortunately, there are no internationally applied standards and indicators to measure this: general science and technology (S&T) indicators are partially available, mostly for OECD countries. In terms of the ability to generate knowledge, inconsistent data are available on levels of spending on formal R&D and on numbers of people engaged in R&D, by country. The World Science Report 1993, prepared by UNESCO, can be used to provide a general picture of the global totals for these two indicators and how they are distributed among countries, groups of countries, or regions.

The UNESCO Report estimates a world total of $426 billion (1990) spent on formal R&D (public and private), of which $405 billion or 95% is spent in those countries that receive 84% of global GDP. Hence only $25 billion, or 5% of formal global R&D is pent in the MPCs[5]. Yet 3.9 billion people reside in these countries, i.e. 76% of the world population, together with most of the world's poverty. R&D spending per scientist ranges from $115 000 in Japan and Canada, to $20 000 in Africa. R&D spending per head of population

[5]MPCs in this case are defined as Latin America, North and Sub-Saharan Africa, Middle and Near East (except Israel), the NICs (Korea, Malaysia, Hong Kong, Singapore, Taiwan), China, India and other countries in the Far East. (Data derived from the World Science Report, UNESCO, 1993)

ranges even wider, from over $500 per person in Japan to $1.40 per person in the countries of Sub-Saharan Africa. This is a ratio of 380:1. Therefore, in terms of formal research resources, the UNESCO data indicates a even more lop-sided distribution than world income.

Even allowing for imperfections in the data, there also appears to be great differences within the developing regions, i.e. among the MPCs. Table 1 illustrates the extent of skewedness using some broad indicators of intensity of R&D effort.

Measuring effort against wealth, the world spends about 2.2% of global GNP on R&D. Within the MPCs, China and India spend 0.8%; the Asian average is 0.64%; Latin America is 0.4%; and Sub-Saharan Africa is less than half of the Asian level at 0.3%. (Japan is top of this league table at 3.1%).

Effort can also be measured in terms of the resources available on average to each scientist. Compared to a global average of US $85 000, Latin America spends close to US $18 000 per scientist; Africa $20 000; and Asia $10 500. The scientists of the European Community lead with respect to this indicator, at US $167 000 per scientist.

It can be argued that there will tend to be some correlation between the need for scientific effort and the population of a country. The ratio of scientific personnel to population is frequently used as an indicator. On average, there are 976 "R&D scientist and engineers" (UNESCO) for every million people in the world. Around this average is a range from 4720 in Japan to 71 in Sub-Saharan Africa. The ratio for Latin America is 549; the Asia average is 244, (perhaps against expectations, the level is 361 in China, and much lower in India at 139).

Another obvious measure of intensity is R&D spending per unit of population. Compared to the global average of $83.40 per capita, $10/head is spent in Latin America; $2.60 in Asia; and $1.42 in Africa.

It is worth noting that the values of the "intensity indicators" given for the NICs in Table 1 are quite close to the average global values. Leaving aside the valid questions about the desirability or need for any country to obtain those levels, and simply using them to illustrate the gaps, it is clear that the MPCs are several orders of magnitude below the levels of R&D intensity found in the NICs (or the world averages, if those are preferred). For example, for Sub-Saharan Africa to reach the same level of R&D spending in proportion to population as the NICs would require of a 64-fold increase. The equivalent figure for Asia would be 36, and for Latin America a less dramatic but still significant 9-fold increase.

The use of such indicators to make international comparisons clearly begs a number of questions. To venture beyond comparisons towards policy analysis and prescription would require much more detailed considerations and much better data.

For example, more detailed data on agricultural research in countries of Sub-Saharan Africa is being painstakingly assembled by ISNAR[6]. The information now available for about 20 countries reveals potential for policy insights at the national and regional level, and the dangers of going much beyond broad country comparisons using global R&D statistics. For example, agricultural R&D in 16 countries in Africa

TABLE 1: Some indicators of "intensity of R&D effort"

[6] ISNAR = International Service for National Agriculture Research

Country of Region	GERD/GNP (%)	GERD per scientist (US$)	Scientists/mn population (No.)	GERD per mn population (US $ 1000)
China	0.8	8 770	361	3 166
India	0.8	21 000	139	2 919
Rest of Asia	0.2	5 015	170	853
Asia Total	0.64	10 490	244	2560
Sub-Saharan Africa	0.3	20 000	71	1 420
Latin America	0.4	17 802	549	9 773
World total	2.2	85 430	976	83 380
Canada	1.4	115 200	2 350	270 000
				91505
NICs	1.6	88 840	1 030	

Notes:

1. Monetary units are 1990 US dollars, calculated on parity purchasing power for the countries of the OECD and on current exchange rates for the other countries.
2. GERD = Gross Expenditures on R&D, in each national territory, from all sources of finance, including overseas.
3. Asia excludes the Newly Industrialized Countries (NICs)
4. Sub-Saharan Africa excludes South Africa.

SOURCE: World Science Report, UNESCO, 1993 stands at about 0.6% of agricultural GDP, about twice the overall R&D/GNP ratio of 0.3% shown in Table 1. However, it is still a fraction of the level prevailing in a country like Canada (about 2.5%). It can be argued that, given the state of development of the food sector and the severity of Africa's food problems, the intensity of the effort should in fact be much higher than those in wealthier parts of the world. The ISNAR data also reveal considerable growth in the stock of human agricultural R&D capital in Sub-Saharan Africa over the last 30 years, but the corresponding impoverishment of these scientists. Overall spending per scientist has fallen by 2.6% per annum on average between 1961 and 1991. Another source shows that total spending per scientist has fallen from $113 000 to $75 000 between the 1960s and the 1980s (in real terms, see Anderson et al. 1994).

However this paper is primarily concerned with broad international comparisons. Even allowing for statistical deficiencies, it would appear that the global distribution of resources available for formal R&D is significantly skewed both between the rich countries and the MPCs, and among the MPCs themselves. Further, the data on literacy and education would suggest that the distribution of resources in other components of the knowledge system is similarly skewed. There are very little data available on the informal research sector, or even agreement on how to measure it: this becomes a research question itself. Overall the evidence points to a difference in formal knowledge resources between MPCs and the rich countries that by some standards would be described as a gulf, not just a gap.

With respect to the private sector component of formal R&D, the issue is not so much the imbalance in the distribution but who controls it and how. It is likely that the degree of skewedness is also extreme, possibly more so, since private sector investment in the smallest and poorest of the MPCs is usually confined to the branch plant operations, in which very little R&D takes place, if any. In the three dominating regions of the world economy - East Asia and Japan; North America; Western Europe - about 1000 major corporations control more than half of the worlds manufacturing and two-thirds of international trade. Not only is the distribution of private R&D likely to follow a similar pattern, but to the extent that the corporate sector does invest in R&D in other parts of the world, the scope and direction of the research often remains largely in the control of the main headquarters. A recent survey of research on the internationalization of R&D confirms this, but also points to a number of forces working in favour of geographic decentralization, such as proximity to markets and availability of skills at low cost. The survey also points to new evidence of a trend of many Multi National Corporations (MNCs) performing increasing amounts of R&D abroad (Granstand et al. 1993). Again, information is limited, but it appears that this is an issue of concern to all countries, not just to the MPCs and touches on the broader question of the integrity of nation states in controlling their own economies.

We can conclude, therefore, that there is a long "tail" - in terms of numbers of countries - to the distribution of global knowledge resources. Along this tail are up to 100 countries with very low levels of knowledge resources in general and formal R&D resources in particular; they are materially poor; they usually have a relatively low share of manufacturing in total production; and for the most part they are small economies, in terms of population and resource base. If these characteristics are combined with a number of other factors, a case begins to emerge for a radically different approach to the kind of knowledge system that is appropriate for these countries and to the ways in which knowledge can be produced, appropriated and used for development. The first factor relates to the use - or rather misuse- of the term knowledge "system" when referring to this group of countries. The word implies a degree of coherence and an evolution that has been at least influenced, if not guided, by a sense of national purpose, indigenously controlled. In reality, the knowledge infrastructures of many MPCs resemble another set of examples of sculpture by accretion, rather than "systems". They have been constructed over the decades often first by occupying colonial powers and then subsequently by the usually uncoordinated efforts of donor agencies, whose good intentions have rarely extended to a willingness to subordinate the sanctity of their own programs and policies to those of the nation states that they were assisting. (They also have usually been reluctant to collaborate with each other.) These external influences have frequently been accompanied by domestic factors, ranging from civil war and other manifestations of political upheaval to unwillingness and/or inability to give much priority to science or research policy and related matters. Consequently the characteristics of internal coherence, indigenous control and relation to a national purpose are often deficient and in some cases conspicuously absent in many MPCs and the term knowledge "infrastructures" is probably more apt than knowledge systems.

Secondly, there is a complex of factors surrounding the current state of science and technology themselves and their effect on knowledge production, appropriation and use. The three most important are power, pervasiveness and speed of change. The potential power of recent scientific developments in fields such as informatics, telecommunications, materials science and biotechnology needs no elaboration here. The fruits of such advances pervade the international community to an extent and at a speed of change, especially on the technological front, such that what A. Toffler called "Future Shock" in the 1960s is now virtually built into the present expectations of many. Research is now as much driven by and dependent upon these phenomena as it is a producer of them. MPCs with rudimentary knowledge infrastructures risk being at the mercy of the power and speed of change in S&T, without at least a minimal level of capability to discriminate, choose, adopt and adapt. For better or worse, it is now scarcely conceivable that any society can opt out and remain immune from the pervasiveness. Clearly the potential costs in terms of loss of national identity and global cultural diversity are high.

A third factor relates to the question of scale and critical mass. It has been remarked that many of the MPCs along the tail of the skewed distribution of knowledge resources are small countries. Assuming that the knowledge system gap (or gulf) could be bridged and numbers of scientists, levels of spending on R&D, literacy rates, institutional infrastructure and so on could attain levels equivalent to (say) the NICs at the present time, would the resulting "systems" be workable? The implicit assumption is usually made that a small MPC like Honduras with a population of 4.8 million should develop a knowledge system to that of a rich industrialized nation, albeit a scaled down to size - one-tenth that of France, one-fiftieth that of the USA. At those levels, how many of the components would reach a sufficient size to function effectively? Little work has been done on this, but one study of animal research indicated that programs in a number of small countries were below productive levels of a reasonable model with respect to a number of measures of size

(Daniels and Nestel 1993). This question is clearly related to those of the appropriate balance among the various components of the knowledge system; regional cooperation and national sovereignty; the composition and health of the economy; and a host of others.

If only one of these factors is prevalent, it is reasonable to expect that a functioning knowledge system could evolve: there are several examples of small countries with healthy economies and flourishing systems. However, in cases where all or most of them prevail at the same time: - current poverty; rudimentary knowledge infrastructure, with colonial and/or donor-dominated origins; below critical mass and subject to the power, pervasiveness and speed of change of external S&T, it becomes difficult to see how the evolutionary path and destination in terms of the knowledge systems of the large, rich nations are in any way relevant to such countries. It has also been claimed that, because of the major impact of the complex structural adjustment efforts of the 1970s and 1980s in many MPCs including the larger ones, the models that can explain the technological and innovation performance of "late industrializing" countries in the 1960s and 1970s are irrelevant to current circumstances (Katz 1994). In short there is a strong case for avoiding the assumption that the Western model is valid and adjusting it piecemeal as each factor that differentiates the small MPCs from the large rich countries becomes apparent. Rather, these arguments point strongly to a need to approach the development of appropriate knowledge systems in MPCs from a fresh perspective, with no prior assumptions about a generally applicable model. Above all, the perspective should be indigenously inspired, so that to the greatest extent possible, further evolution of each national system is demand driven.

IV. A RESEARCH AGENDA

The first three sections of this paper have attempted a very broad look at some aspects of the place of research and knowledge in the development process. The main ideas upon which the examination has been based are: first, the importance of placing the formal research activity in the context of the broader knowledge system in society and of keeping knowledge itself in context, as one of a number of determinants of development; second, the fragmented approach to Western science has enormous power and undoubted advantages, but must be increasingly combined with more holistic, integrated thought and action to address the dilemmas of human existence more effectively; third, given the hugely skewed distribution of the worlds knowledge resources, at least in the formal sense, and the indecent imbalances in terms of wealth and economic sovereignty, there is a need for a fresh, indigenously inspired approach to knowledge production and use, especially in the smallest and materially poorest nations.

Arising from this brief study of the "big picture", a number of further ideas begin to emerge of areas of enquiry for those concerned with development and the role of knowledge. A few of these are outlined below as items for a research policy agenda.

(1) Exploring the Contextual Links

Taking knowledge in the context of being one factor that contributes to development, the links between it and other factors become worthy of investigation.

- Under what circumstances can knowledge make an independent contribution to development?

- How can knowledge be combined with cultural and/or spiritual factors to promote development, beyond the practice of participatory research techniques?
- What forms of governance provide the most hospitable environment to the effective use of knowledge? To what extent are they culture specific?

The relationship between research and the other components of the knowledge system also raises a number of questions.

- What is the appropriate balance among the various parts of a knowledge system and does it vary according to the stage of development?
- Is there ever a stage when the research component should be zero and the emphasis placed on (say) communication, production and management?
- How should the links between research and the other components of the knowledge system be managed, particularly those with education and policy?

With research itself, the relationship between informal and formal research is relatively unexplored and challenging. How are the two linked in different social settings? Is the relationship positive or negative, ie. does a strong formal system erode the informal by undervaluing it? Has the imported formal Western system harmed informal research in MPCs?

Finally, the links between private and public R&D offer a host of questions.

- Given that private sector research orients a range of disciplines towards a common purpose, are there management techniques that the public sector could learn from it to promote more holistic, problem-solving research?

- How effective in social terms is the "market" for researcher? E.g. is the price paid by the private sector for a scientist trained at public expense matched by an equivalent contribution to the public good?
- What mechanisms can be devised to orient private sector innovation to "win-win-win", i.e. to create employment, to protect the environment and to make a profit?

(2) Tailoring National Knowledge Systems

The case for a fresh approach to the development of indigenous[7] knowledge systems, that goes beyond the usual scope of science and technology policy, has already been made. The particular case of the smallest and materially poorest countries has been highlighted. It is proposed that such initiatives could entail the following:

- they should be initiated and driven by the countries concerned, yet based on full intellectual partnership with external institutions and individuals:
- a complete inventory of all knowledge resources: public and private, formal and informal, NGOs, community groups, with particular attention paid to knowledge producing and using institution, and the relationships between them;
- a form of inclusive, multi-stakeholder process to confirm initial data and analysis,

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[7] As applied here, the term means native to the countries concerned. It does not refer to the original natives people of a country, although they would be part of any study.

to generate improved understanding, to create and enhance partnerships and to prepare and agenda for action.

The initiatives would need to be supported by studies and analysis of issues such as economic development opportunities, local governance structures, social service requirements, composition and size of research institutions, and the fiscal outlook. The initial premise of each initiative would be that there is no generic model and that the object would be to tailor a knowledge system to the special circumstances of each country.

(3) Knowledge system innovations in large and/or rich countries

The array of potential innovations in the development of knowledge systems and the understanding of how they work could be enhanced by further study of policy and practice in large, rich countries. The financing of research and other components of the knowledge system, such as schools and universities, is becoming more difficult in many countries. Related to this is the balance and relationship between basic and applied research and how they are managed. University-industry linkages are promoted in various ways, but need to be seen in the context of incentives away from peer review and publication and towards practical application and public profit. The explosive growth in computer assisted access to sources of information and to an infinitely wider community of individuals and institutions itself constitutes a field ripe for innovation. It also of course provides a mechanism for debate and exchange of information about other forms of innovation. A final example of the many possibilities would be an examination of the various experiments with disciplinary integration, both in teaching and research, including the vertical integration with policymakers and users.

(4) Internationalization of research

This phenomenon provides both a promise and a threat, or a classic opportunity for the two handed economist. On the one hand, the global nature of some of these threats to human existence, the interdependencies that give force to the concept of a borderless world, and the power of information and communication technologies to foster effective transnational dialogue and action combine to provide an unprecedented opportunity for effective development initiatives by the world community. On the other hand, the international financial markets and the major multi-national corporations (MNCs) operate without allegiance to any particular national entity or reference to any community of nations. To the extent that private sector research follows the same independent path, it poses a threat to national sovereignty and minimizes the possibility of orienting a significant proportion of global knowledge resources towards dealing with issues, mostly related to the natural environment, but also including increasingly pressing social questions such as employment. If it is accepted that the main deficiency is not in technical but in social innovation, then problem-solving research must be location specific, ie. real solutions have to be tailored to - and by - the societies concerned. This raises questions such as - what kind of research can be usefully performed at the international level? How should/can it be linked to research that is specific to particular nations, locations and communities?

It can be argued that the problems of development are sufficiently severe and the knowledge resources to deal with them sufficiently scarce that a division of labour between a private sector pursuing corporate profit and a public sector dealing with the consequences is ineffective and untenable. It is also an increasingly inaccurate stereotype, as the private sector exhibits a growing and tangible interest in the public good, and the wisdom of public investments in terms of social profit is more frequently called into question.

As the need for international action grows, so it appears that the will to invest in public sector international research is dwindling. One of the best known examples, the Consultative Group on International Agricultural Research, is attempting to redefine its future role. This and other sectors require much more research policy work, including relationships and linkages with private sector research.

CONCLUSION

These four broad items:

- exploring the contextual links
- tailoring knowledge systems for small, poor locations
- studying policy and practice in larger rich countries
- examining the internationalization of research

provide the beginnings of an agenda for research on research. It is hoped that they will stimulate others to amplify, amend, add and act. It should also be emphasized that these are not put forward as potential preoccupations for the intellectual elites in one part of the world, as they muse in comfort over prescriptions for the less fortunate. The imperatives of global interdependence and the shared vulnerability of humanity are such that the solutions must be sought on a common front. Just as air, water and financial markets transcend national boundaries, so to a degree does knowledge. The old North-South, us-them vocabulary signifies an increasingly sterile and irrelevant debate. Joint ventures, shared ideas and knowledge, based on mutual respect, are required more than ever. They must also transcend a perhaps even more pernicious boundary, that between the formally schooled and the untutored; between those whose business is in specialized fields of knowledge and who are sometimes called experts, and those who are too often presumed to know little or nothing and who are traditionally considered as pawns rather than players. Knowledge resources permeate all parts of all societies. Unless we recognize this and until our standards of social innovation can catch up with our beguiling brilliance in technical innovation, the gap between the practice and the aspirations of humankind will remain.

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