TOWARDS CO-CREATION OF SCIENCES

BUILDING ON THE PLURALITY OF WORLDVIEWS, VALUES AND METHODS IN DIFFERENT KNOWLEDGE COMMUNITIES

CAPTURED I-AIM UDS UMMS

Bertus Haverkort, Freddy Delgado Burgoa,
Darshan Shankar and David Millar

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ABOUT THIS BOOK

This book is the product of two international programmes in which NGOs and universities have been working to understand, appreciate, revalue and strengthen endogenous knowledge. For more than 15 years the COMPAS programme (www.COMPASnet.org) has brought together experiences of NGOs in 12 countries across the globe concerning their initiatives to support endogenous development: development based mainly, but not exclusively, on local values, knowledge, institutions and resources. The experiences have led to a better understanding of the role of the diversity of cultures and of endogenous knowledge in development programmes. They have allowed those involved to articulate a number of basic principles underlying the support of endogenous development.

Universities were also involved in the COMPAS programme and since 2008 three universities (in Ghana, Bolivia and India) have been working together in a special programme to build their own capacities for supporting endogenous development and implementing programmes for endogenous education and research: the CAPTURED programme (www.CAPTURED-edu.org).

In the process, the participating universities have acquired more insights into the social relevance and the foundations of the specific ways of knowing in their own cultures. Despite the marginal position of endogenous knowledge, in each case endogenous knowledge has great impact on the decision making in many areas of local people's lives: farming, health practices, the ways in which communities use water, land, plants and animals, the ways in which they organise themselves, and the ways in which they express and live their spiritual life and values.

This book takes an endogenous perspective: the mainstream parameters and criteria for expressing knowledge and science are not taken as starting point. Rather endogenous worldviews, values, ways of learning, endogenous logic and ways of organising and assessing knowledge are presented. The different cases present culture-specific ways of knowing, but we have attempted to do this within one framework: a framework that regards

endogenous knowledge as an expression of an underlying science.

The objective of this book is to stimulate co-creation of sciences through an inter-cultural and inter-scientific dialogue – a dialogue in which each way of knowing expresses itself, where differences are positively and respectfully considered, and where options for complementarity (and aspects of potential incommensurability) may become clear.

The book is written for students, development workers, scientists and policy makers in different cultures who are interested in cultural diversity, the implications of international cooperation and the potential of enhancing endogenous knowledge at community level, and in colleges and universities. The authors hope to stimulate dialogues between the sciences that have emerged from and function in the different cultures.

ABOUT THE AUTHORS

The authors of the different chapters were all trained in mainstream academic traditions, and have pursued a career in formal institutions for development, education and/or research.

At the same time, the authors have made personal and professional choices that have led them to build relationships with local communities and learn with the members of these communities about their cultures, their knowledge and values. In each case this has led to programmes in which the strengthening of these traditional ways of knowing is at the core of their academic activities.

Bertus Haverkort, the lead editor of this book, was born and raised on a farm in the Netherlands. He studied agronomy and social sciences and has worked in rural development programmes in the Netherlands, Colombia and Ghana. He has travelled extensively and worked with development programmes, NGOs and universities in many countries in Africa, Latin America and Asia.

He started his international career working in top-down agricultural extension programmes. He learned that the application of Western knowledge can be important and relevant if, and only if, some basic conditions for its applicability are being met: the proposed changes should be in line with the values of the people, should build on the local ecological and socio-cultural conditions, as well as on farmers' own knowledge and available resources. Only then will people be motivated to change their way of farming in a culturally appropriate way.

The presence of a functioning commercial infrastructure with incentives for local farmers to undertake steps towards modernisation; availability of services for credit and technology; access to water resources and fertile soils; extension and education; research that address the issues and problems of rural people and policies: all are important, but they will only work if they are embedded within a culturally sensitive approach.

In many parts of the globe these conditions are not being met,

and it was this realisation that stimulated Haverkort to look for options where priority was given to building on locally available resources, local knowledge and cultures. He worked for many years in programmes run by ETC Foundation: ILEIA and COMPAS; he has also taught at the then Agricultural University in Wageningen and has written on subjects including Low External Input and Sustainable Agriculture (LEISA), Participatory Technology Development and the role of culture in development.

As an initiator of the COMPAS programme and an international advisor in CAPTURED he has extensive experience in endogenous development, endogenous education and endogenous research. He is currently involved in fieldwork, education and research in Ghana, Bolivia and India.

David Millar writes about the foundations of scientific knowledge of the Dagare and Gruni people in Northern Ghana. He belongs to the first group, and was born and raised in Genkengpe, in the heart of Dagare country. His mother was a person of great wisdom and, being a rain goddess, possessed intricate endogenous knowledge and skills.

Despite going abroad for his academic training and professional work, he has maintained intensive contacts with his brothers and sisters in his native community and has developed his ideas and insights through intensive sharing and dialogues with elders, community leaders, healers and farmers, as well as with development workers and migrants.

For more than 30 years he has lived and worked with the Gruni ethnic communities in and around Bolgatanga. From his development work, which evolved from a top-down approach in agricultural extension to participatory and endogenous development, and 'study' with local people, he has gained insight into the cultural roots of the Gruni and the knowledge upon which these are based. Millar has worked for the Ghanaian Ministry of Food and Agriculture, for the World Bank and for a church-based NGO.

He received his undergraduate degree in Ghana and his Master's

and PhD in the Netherlands. He was one of the founding partners of the COMPAS programme, and when he joined the University for Development Studies in Tamale as a professor (and where he is now pro-vice chancellor) he initiated CECIK, the centre for indigenous knowledge, an NGO that is doing pioneering grassroots work on endogenous development.

Aspects that are specific to African ways of knowing include a strong community basis, a worldview in which ancestors and ancestral spirits play important roles, the sacredness of nature, traditional institutions that regulate community affairs and knowledge development, the use of magic and supernatural forces and systems of accountability.

The weaknesses of these ways of knowing are related to Africa's marginal position, corruption of indigenous leaders and African universities' (as yet) lack of capacity to give African knowledge an appropriate place in education and research. Millar advocates inter-scientific dialogue, where African knowledges are acknowledged as science, and where complementarity rather than substitution is aimed for.

Richard Aniah, Samuel Abatey, John Dakorah and Salimah Yahya belong to the centre for cosmovision and indigenous knowledge, CECIK, a community based NGO in Bolgatanga.

Darshan Shankar presents the scientific basis of Ayurvedic medicine in India. He elaborates on its deep historical roots, describing the rich physical, biological and spiritual concepts and their application in contemporary health practices. Shankar's presentation is based on around 30 years of experience as a promoter and researcher of traditional health sciences and practices in India. As the founder of the prestigious Foundation for Revitalisation of Local Health Traditions (FRLHT), he and his team have initiated and implemented programmes to assess the effectiveness and safety of Indian health sciences and the complementarity between modern Western biomedicine, Ayurvedic medicine and folk medicine.

FRLHT is acknowledged as a national centre of excellence for the conservation of medicinal plants and Ayurvedic research,

and Shankar is respected as a practical visionary because of his success in translating his vision into inspiring action research and creating an institution that will continue long after his own lifetime. This respect is manifested in his five-year appointment as an advisor to the planning commission of the government of India, and the Padma Shri, one the highest civilian awards in his country, that he received from the Indian government.

Shankar's presentation of the interconnectedness of the manifest and intangible reality, the importance of a mind free of prejudices to be able to 'learn from within', and his insights into the scientific principles of Ayurveda represent an important contribution to inter-scientific dialogue. Shankar is known as a bridge builder between traditional knowledge and mainstream science, and is also one of his country's staunchest supporters of ecosystem-specific, community-based oral knowledge of healthcare

M.N.B. Nair is a botanist with a PhD from the University of Delhi. He is a specialist on forest plant products, in particular resins and gums. He has a special interest in ethno-veterinary care and issues related to knowledge rights.

Freddy Delgado Burgoa started his work in a period during which many elements of the endogenous cultures of Bolivia had been forced into clandestinity, having been suppressed by the political and intellectual elites in his country. His origins lie with the Kallawaya, an indigenous ethnic group that has a reputation for traditional healing and whose cosmovision has been recognised by Unesco and placed on the Intangible Cultural Heritage of Humanity.

For more than 25 years Delgado has been one of the stimulating forces behind Agroecología Universidad Cochabamba (AGRUCO), the centre for research, training and sustainable endogenous development in the faculty of Agronomy, Livestock, Forestry and Veterinarian Sciences at the University Mayor San Simon in Cochabamba, Bolivia. He has initiated and stimulated activities to re-value endogenous knowledge and to reorient educational programmes within public universities in Bolivia and Latin America.

He has experienced resistance to his ideas from his academic colleagues, and strives to be sensitive and responsive to the appreciation and guiding directions expressed by indigenous leaders and persons of wisdom among the Aymara and Quechua people. Delgado received his doctorate from the University of Cordoba in Spain (Instituto de Sociología y Estudios Campesinos) and has been an active member and leader in international movements such as the foundation for Genetic Resource Action International (GRAIN), the agro-ecology movement in Latin America (MAELA), Low External Input and Sustainable Agriculture (LEISA) and the programme for comparing and supporting endogenous development (COMPAS).

His publications not only articulate important insights about the knowledges and wisdoms of indigenous people, but also often explore the policy implications for development agencies, local and national governments and the university system. At present he is acknowledged as an important innovator in the university education system in Bolivia and Latin America and in the politics of development.

In his contribution Delgado shares the experiences of AGRUCO as a university centre and presents the insights gained into the ways of knowing of the Aymara and Quechua population, and ways to revalue and strengthen indigenous notions of living well (vivir bien), in particular the worldview based on Pachamama, community-based learning, reciprocity and spirituality.

Cesar Escobar is the coordinator for Latin America of the COMPAS programme.

Gustavo Guarachi is a PhD researcher at the University Mayor San Simon.

Dennis Ricaldi is a member of staff at the University Mayor San Simon.

Stephan Rist worked with AGRUCO for several years and earned a PhD for his study of the Andean cosmovision and ways

of knowing. He is presently professor at the University of Bern, Switzerland, and coordinator at the Centre for Development and Environment.

Anton Haverkort was born into the same farming family as Bertus Haverkort. He studied agronomy and theoretical production ecology (crop growth modelling) at Wageningen University. He worked in agricultural research and development, focusing on potato production improvement in Peru, Turkey, Rwanda and Tunisia from 1976 to 1988. Since then he has been a researcher at Plant Research International, part of Wageningen University and Research Centre in the Netherlands, where he specialises in potato research.

His main focus is the enhanced sustainability of potato production and his interests range from subsistence to commercial production systems through high-tech precision and decision-support systems. He co-initiated the organic potato research and technology transfer initiative BioImpuls and is extraordinary professor of crop science at the University of Pretoria, from where he supervises potato research in South Africa, Zimbabwe and Lesotho.

Haverkort is a frequent consultant for the Dutch and international potato industries and for institutions working on the reduction of footprints for land, water, energy and chemicals. He currently heads the DuRPh project which aims to substantially reduce the losses and costs associated with late blight, the most devastating potato disease, through cisgenic modification.

AUTHORS' POSITION

With respect to the issue at stake in this book, the co-creation of a plurality of sciences, the authors share the following position:

We acknowledge the rigour and enormous contribution of mainstream science to technological development in the globe. We are grateful for the insights and intellectual development it has provided us. Yet, we believe that injustice would be done to the diversity of cultures and knowledge systems if scientists and development professionals were to limit their attention to imported knowledge and technologies.

Understanding and enhancing culture-specific knowledge and giving it a place in education and research programmes is important if we are to do justice to the existing diversity of ways of knowing in the world, to make education culturally appropriate and to allow education and research to strengthen knowledge traditions.

We hope that we will be able to present our materials in a self-aware and self-critical way and that our position related to external sciences will be seen as a constructive contribution to the inter-science dialogue. Articulating endogenous knowledge as a science, while devoting attention to its weak and strong points, is a bold step in the CAPTURED programme.

We believe that the diversity in ways of knowing across the globe is one of humankind's greatest assets. We hope that through dialogues and mutual learning processes, each of the different ways of knowing will be encouraged to create and recreate its own science and that, in this way, global scientific development will move away from universal application and transfer of mainstream science, making way for endogenous ways of knowing and leading towards the co-creation of different sciences, where synergy and complementarity are the main characteristics of the relationships between the sciences.

The results are presented here with humility and pride. Humility because we know that the notion of a scientific basis

to endogenous ways of knowing goes against some of the conventional notions of what science is, and we realise that some of our sciences have definite weaknesses, and that we still have a lot to learn on our path to co-creation. Nevertheless we are also proud to present our ways of knowing as they reveal often-hidden and undervalued aspects of our cultures. We hope that an inter-cultural and inter-science dialogue may contribute to a better use of the diversity of sciences, for example by making appropriate use of them to address some of the pressing problems in the world: underdevelopment, poverty, ecological degradation and social disintegration, alienation of the youth from their cultural roots, marginalisation of cultures, loss of cultural diversity and the disappearance of endogenous knowledges.

SOME CONCEPTS AND DEFINITIONS

The CAPTURED programme aims to enhance endogenous development, endogenous education and endogenous research.

A central term used in this book is 'endogenous knowledges and sciences'. This refers to the knowledges and sciences of indigenous peoples, or traditional and local knowledge communities, which have their origin in these particular societies, but have been modified and enhanced by inter-scientific dialogues and co-creation with other sciences.

The central concept is endogenous, which we define as 'that which has emerged from within'; it often refers to something that has emerged in a particular system or society, but has been modified and enhanced by dialogues and co-creation with other systems.

Endogenous is the opposite of exogenous, which refers to an action or object that has emerged from outside a system.

The term is also distinguished from indigenous, which means something that has been generated by and exists within a specific cultural system. The distinction in meaning lies in the low degree of modification by interaction with other systems associated with the term indigenous.

Other terms used in this context include: aboriginal, native, first people, first nation, autochthonous, local, classical, traditional. These terms all have their specific meanings, but we consider them to be encompassed by the term endogenous.

In this book we use the following definitions:

Axiology: The study of 'what is considered as important' in terms of morality, aesthetics and values.

Co-creation of sciences: The process whereby different sciences develop their own intra-scientific dynamics and are engaged in interaction and joint learning with other sciences, in sharing research methods and results, and in response adapt their own paradigms and together create a plurality of sciences where complementarity may exist alongside incommensurability.

Endogenous development: Development based mainly, but not exclusively, on locally available resources, knowledge, culture and leadership. It has openness to integrating endogenous and exogenous knowledges and practices. It has mechanisms for local learning and experimenting, enhancing local social, material and spiritual structures, and retaining the benefits in the local area.

Endogenous learning and education: Activities to develop and transfer knowledge, skills and wisdoms undertaken by people in indigenous or local communities and which combine traditional with other indigenous and mainstream ways of learning.

Endogenous research: Research being carried out by indigenous and local knowledge communities using indigenous ways of learning, transdisciplinary methods and co-learning with other sciences, with the aim of developing endogenous sciences.

Epistemology: The study of 'what we know' and how we have organised our knowledge into theories, laws of cause and effect, and fields of subject matter.

Note: We are aware that in mainstream philosophy the term epistemology is not only related to the question 'what we know', but also to 'how we know'. In our work we make a distinction between epistemology, as the total of the products of our learning process and gnoseology, the processes involved in acquiring knowledge and insights, and ways of learning, experimenting and teaching.

Gnoseology: The study of 'how we know': the ways in which we arrive at deep knowledge, and how we learn, teach, and experiment within our own socio-cultural and scientific context.

Incommensurable sciences: Sciences lacking a common quality (concepts, methods) on the basis of which they can be compared. If sciences are incommensurable, there is no way in which one can determine which is more appropriate or accurate.

Mainstream science (sometimes also referred to as normal, Western, Eurocentric or conventional science): Sciences that generally are considered to be the most important science, and are being practised in formal education institutions and research centres in all corners of the globe. This form of science has its origin in the European Enlightenment, initially informed by a mechanistic worldview, employing positivist and quantitative methods, and is organised in specialised fields: disciplines that follow their own paradigms. Recent insights in fields such as quantum physics and internal reflections on the scope and character of mainstream science have given rise to a number of new approaches and paradigms, which attempt to include concepts such as uncertainty, chaos, self-regulation, transdisciplinarity, and to employ qualitative methods.

Ontology: The study of the nature of being, existence or reality as such, as well as of the basic categories of being (material, social and spiritual) and the relationships between these. A worldview (or cosmovision) arises from a culture-specific ontology.

Paradigm: A paradigm is a coherent approach used by a scientific community that encompasses consistent worldviews, assumptions, theories, and research methods. Paradigms generally have yielded some achievement to attract an enduring group of adherents. At the same time they are sufficiently open-ended to leave problems to be resolved.

Science: A body of knowledge formulated within a specific worldview and value system and classified under a theoretical framework. It includes the processes for producing, storing and retrieving knowledge, formulating assumptions, general principles, theories and methodologies. It involves the active role of a specific knowledge community that has reached consensus on the validity of these processes. The knowledge acquired and the resulting science is always limited and subject to modification in the light of new information and insights.

Note: The term Western (or Eurocentric) science refers to sciences developed in Western or European countries. It is often assumed to be synonymous with mainstream or conventional sciences. We prefer to use the term 'mainstream sciences' as these have not been built exclusively by European scientists and at present are being practised and enhanced all over the globe. We therefore avoid the term 'Western science' when referring to mainstream science. A similar problem occurs in the use of the term modern science. Claiming this term for mainstream science only suggests, erroneously, that endogenous sciences would not be modern in the sense that they would not adapt their stock of knowledge to present-day needs.

Worldview: A worldview is a specific view held by a person or a group, on the basis of which they understand existence. It provides the lens through which the world is seen and made sense of. In this context we often use the term cosmovision, as in different cultures the reality in which people live is not considered to be limited to the physical world, but encompasses physical, biological, social and spiritual realities.

Knowledge communities
have colourful expressions
of their diversity

Chapter 1

Relations between different knowledge communities

Rejection, substitution, complementarity and co-creation of sciences

Bertus Haverkort, David Millar, Darshan Shankar and Freddy Delgado Burgoa

1. INTRODUCTION

It is often assumed that mainstream science and technologies are universal and that they are the most reliable ways of understanding nature and providing the foundation for developing technologies. On the basis of extended periods of working with indigenous peoples, and learning about their knowledge systems, the authors of this book assert that local, endogenous and traditional ways of knowing can be considered as expressions of sciences in their own right. Their experiences have provided

important insights into the specific worldviews, values, methodologies and knowledge concepts present in India, Ghana and Bolivia, and the ways in which the indigenous knowledge communities in these countries assess their knowledge. The book also presents a specific case of mainstream research: potato breeding for pest resistance in the Netherlands. This has made it possible to compare ways of knowing that stem from different socio-cultural and historic backgrounds. In the course of the history, endogenous sciences have often been marginalised and many of them have lost some of their rigour or vitality. Yet, in many countries they are still considered important and guide the lives of people. Endogenous and mainstream sciences have both weaknesses and strengths. This book introduces the reader to initiatives that seek to strengthen endogenous development, endogenous education and endogenous research. These initiatives have helped revitalise local sciences and restore appreciation and understanding of them, within communities themselves and further afield. Ensuring inter-science dialogues can enhance complementarity of the different sciences and lead to co-creation of sciences.

The authors assert that a constructive dialogue between the representatives of different sciences has greater potential to address the multifaceted problems facing the globe than reliance on mainstream science only. They suggest that, as biodiversity is a condition for biological sustainability, cultural diversity and the diversity of sciences may become a critical issue in the progress of global civilisation. The first chapter presents two scenarios for inter-science cooperation: one that continues to marginalise local sciences and another that seeks complementarity and co-creation of sciences. Chapters 2 to 5 present the worldviews, values, methods and concepts of the four different knowledge communities. The final chapter explores the options for inter-science dialogues.

2. CULTURES, WORLDVIEWS AND SCIENCES

Today, the mainstream sciences are being taught, developed and applied in all corners of the globe and they command a very strong position because of their effectiveness, reliability, and widespread applicability. They form the basis for formal education worldwide and receive considerable amounts of public and corporate funding for their contribution to enhancing human, technological and economic development.

At the same time a wide range of different endogenous knowledge systems co-exist with these mainstream sciences. To a large extent, these endogenous ways of knowing determine how peoples in different cultures understand the world, the way they learn, the way they take decisions about their own life, and the way they use their resources and build up their livelihoods.

In the modernist scheme, not only were endogenous systems of knowing generally dismissed, they were often replaced by mainstream systems and structures. In the name of modernisation, political, educational, economic and social systems have taken Western forms. While this type of modernisation has had benefits, it has also become increasingly clear that such benefits will only yield sustainable benefits if they are effectively and strategically rooted in local cultures and traditions. In most non-Western countries, institutions of learning fail to prepare students adequately to contribute to improving their endogenous knowledge. Their education has had the effect of alienating them from their own cultural roots and thus pushing them to seek jobs elsewhere outside their communities or even abroad. Also, denigrating and marginalising endogenous knowledge systems has resulted in their failure to grow through intra-cultural learning and dialogues and has resulted in the absence of inter-science discourse. Education and research in the mainstream continues to sustain the Western bias and thus ill-prepare students for life and the world of work in non-Western cultures.

As part of the postmodern scepsis concerning universalising knowledges, several efforts have emerged that support multi-perspectival knowledges. The works of Freire, Kuhn, Popper,

Foucault, Dewey, Shiva, Derrida, Latour and Feyerabend among others, have helped in the re-interpretation of knowledge foundations in ways that allow education, research and development to respond to specific cultural and social needs of diverse populations. For countries of the Third World, this wave of change has provided its own challenges. A number of possibilities and opportunities have been presented for reclaiming and revitalising local traditions. Indigenous and local experts have written about the scientific basis of knowledge systems in New Zealand (Smith, 1999; Bishop 1998), Canada (Battiste, 2005), USA (Mishesuah & Wilson, 2004; Cajete, 2000; Barnhardt & Kawagley, 2005), South America (Delgado & Escobar, 2006), Africa (Millar et al., 2006), India (Balasubramanian & Devi, 2006) and Europe (Haverkort & Reijntjes, 2006). A large number of research and educational programmes are emerging that aim at articulating and strengthening local knowledge traditions and seek complementary relationships with other sciences.

Thus far these initiatives are relatively small in scale because of limited national funding and limited international support, but they have raised important critical insights about the relevance and status of scientific diversity. One of the leading persons in CAPTURED, Darshan Shankar, has phrased this relevance thus: 'just as biological diversity is essential to support biological evolution, cultural diversity represented by ethnic languages, traditional arts, science and technologies is essential for civilisational evolution.'

An important problem of universities throughout the world is that, even if they wish to do so, they are usually not adequately equipped to teach about and perform research on endogenous knowledges and sciences. Educational and research staff have generally been exclusively educated in mainstream modes, and standards and protocols used for educational accreditation and assessing research are generally exclusively based on the parameters and criteria of mainstream knowledge. A reorientation of the university system to accept, incorporate and improve endogenous knowledges and sciences in their community services, education and research, may require substantial redesign of the university protocols and rules. International cooperation, sharing of theories, teaching materials and student exchanges

can be an important contribution to this movement. Policy analysis, assessment and dialogues could lead to new paradigms in policy contexts for education, science and technology development at national and international levels.

Research and endogenous knowledge

Numerous studies have concluded that endogenous knowledge plays an important role in the lives of many peoples. In several countries in the South, indigenous food systems, and indigenous systems of health care and governance are built on endogenous knowledge systems. A number of different approaches are being used to deal with indigenous knowledge in research and development:

- Research from an outsider's perspective: e.g. anthropology (Haverkort, 2009), ethnosciences and donor-centred studies.

- Research that builds on endogenous knowledge and seeks complementarity between indigenous knowledge and external knowledge, as is the case in some agricultural and health programmes.[1]

- Revitalising and strengthening the endogenous knowledge base. In this approach, intra-cultural learning and endogenous development form a first step towards inter-cultural dialogue and sustainable endogenous development.

Endogenous development initiatives aim at strengthening the dynamics of endogenous knowledge systems. Such initiatives do not study endogenous knowledge from a mainstream perspective or build external knowledge on endogenous knowledge, but take the endogenous perspective as starting point, for endogenous development. They start with an understanding and appreciation of the culturally embedded worldviews, ways of learning and theoretical frameworks of peoples. Experiences show that such an approach culminates in revitalising and enhancing the endogenous knowledge and value systems.[2] They result in empowerment, enhanced self-awareness and a

1. E.g. www.ILEIA.org

2. See amongst others: COMPAS www.COMPASnet.org,online COMPAS Magazine and the COMPAS series on Worldviews and Sciences, 2006; CAPTURED www.CAPTURED-edu.org; Smith, 1999; Battiste, 2009; Rist, 2002; Coetzee and Roux, 1998; Cajete, 2000; Denzin et al., 2008; Emalgit, 2004; Wiredu, 2005.

louder voice of local population groups. In fact, support to endogenous development and revitalisation and enhancement of endogenous knowledge and values can be seen as important ways to achieve poverty reduction and to reach the Millennium Development Goals in culturally appropriate ways[3]. They can also provide a valuable contribution to meeting the objectives of the UN Declaration of the Rights of Indigenous Peoples (UNDRIP) and the UN Permanent Forum on Indigenous Issues (UNPFII), as well as those the Interagency Support Group on Indigenous Issues (IASG) in the domains of endogenous education and research.[4]

There are on-going efforts across the world to revitalise indigenous peoples' knowledges and systems, and institutions of higher learning have become important channels for this revolution although so far with marginal effects. In some North American universities and colleges, a faculty has been created to teach degree and diploma programmes in Native and Aboriginal Studies at both undergraduate and graduate levels; Teacher Education, Philosophy, Nursing and Social Work programmes have pioneered such work in Canada and the United States. In Australia and New Zealand such efforts abound, offering various qualifications at undergraduate and graduate levels where education and research are promoted. In addition, in Europe and North America, several universities have made efforts to promote studies of racial minorities with the creation of Latin American Studies, Asian Studies, African Studies and African-American studies alongside more traditional studies. Indeed, multicultural and diversity studies have become important and contribute to cross-cultural learning. However, they have largely failed to address the local development needs and own perspectives of indigenous peoples, societies and nations.

3. COMPAS Magazine 9. Endogenous Development Goals, 2005.

4. See www.un.org/esa/socdev/unpfii/en/drip.html.

3. INTERNATIONAL POLICY CONTEXT

The attention devoted to endogenous development, education and research by international and national policy bodies is rather recent. We list a few examples here:

- The International Labour Organization (ILO) Convention 169 Part VI, Articles 26-31 on Education and Means of Communication of indigenous and tribal peoples, adopted in 1989. This convention is important but so far has had little impact on the way educational and research systems have evolved across the globe.

- The Earth Summit (Rio, 1992), and the Convention on Biodiversity, in which Article 8(j) urges State Parties to 'respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities.' It recognises endogenous knowledge systems as important tools for addressing the global environmental crisis.

- Another important step forward was made in 2007 when the United Nations adopted the Declaration on the Rights of Indigenous Peoples. This recognises that indigenous knowledge, cultures and traditional practices contribute to sustainable and equitable development and proper management of the environment. Articles 14-15 refer specifically to education and knowledge:

- Article 14

    1. Indigenous peoples have the right to establish and control their educational systems and institutions providing education in their own languages, in a manner appropriate to their cultural methods of teaching and learning.

    2. Indigenous individuals, particularly children, have the right to all levels and forms of education of the State without discrimination.

    3. States shall, in conjunction with indigenous peoples,

take effective measures, in order for indigenous individuals, particularly children, including those living outside their communities, to have access, when possible, to an education in their own culture and in their own language.

- Article 15

1. Indigenous peoples have the right to the dignity and diversity of their cultures, traditions, histories and aspirations which shall be appropriately reflected in education and public information.

2. States shall take effective measures, in consultation and cooperation with the indigenous peoples concerned, to combat prejudice and eliminate discrimination and to promote tolerance, understanding and good relations among indigenous peoples and all other segments of society.

- UNESCO launched the Local and Indigenous Knowledge Systems (LINKS) project in 2002 as one of a new generation of cross-cutting projects to heighten interdisciplinary and inter-sectoral action (cf. LINKS website). Contributing to the Millennium Development Goals of poverty eradication and environmental sustainability, the project aims to empower local and indigenous peoples in biodiversity governance by advocating full recognition of their unique knowledge, know-how and practices. Aspects relevant to endogenous development, endogenous education and endogenous resources development are:

- Education programmes provide important tools for human development, but they may also compromise the transmission of indigenous knowledge.

- Progress in science requires various types of cooperation at and between the intergovernmental, governmental and non-governmental levels, such as: multilateral projects; research networks, including South-South networking; partnerships involving scientific communities of developed

and developing countries to meet the needs of all countries and facilitate their progress; fellowships and grants and promotion of joint research; programmes to facilitate the exchange of knowledge; the development of internationally recognised scientific research centres, particularly in developing countries; international agreements for the joint promotion, evaluation and funding of mega-projects and broad access to them; international panels for the scientific assessment of complex issues; and international arrangements for the promotion of postgraduate training. New initiatives are required for interdisciplinary collaboration. The international character of fundamental research should be strengthened by significantly increasing support for long-term research projects and for international collaborative projects, especially those of global interest. In this respect particular attention should be given to the need for continuity of support for research. Access to these facilities for scientists from developing countries should be actively supported and open to all on the basis of scientific merit. The use of information and communication technology, particularly through networking, should be expanded as a means of promoting the free flow of knowledge. At the same time, care must be taken to ensure that the use of these technologies does not lead to a denial or restriction of the richness of the various cultures and means of expression.

- The World Bank has a number of programmes related to Indigenous Knowledge concerning health, environmental management and agriculture. Indigenous education is addressed in IK Notes No. 87, published in 2005. It notes:

    1. Indigenous Knowledge (IK) can act as a powerful tool in a learning environment to teach students. Conventional curricula and achievement tests in many countries, however, do not support students' learning based on their IK. Learning environments need to be adapted to help students build on their indigenous communities' knowledge and by recognising students' culture and value systems. Educators can further this type of education by combining appropriate pedagogical techniques.

2. IK needs to be addressed and integrated into educational programs since the reasons for the lack of education in rural areas go beyond access to schooling, affordability, and lack of resources. When prior knowledge or IK is integrated into the classroom settings or learning environments, students better connect to material taught and can become a major knowledge source for their community's sustainable development.

- The Agenda 21 for Culture has established culture as the 5th pillar for sustainable development.

In Bolivia, where CAPTURED has concentrated its activities, the current context is proving very favourable to its intended objectives. The most salient aspects are:

- A new Political Constitution of the State acknowledging the wisdom of native indigenous nations, assuming the multi-national character of the State in all spheres (economic, social, political, cultural).

- A new education law, the Avellino Siñani Bill, grounded on intra- and inter-cultural diversity.

- A national plan outlined by the Bolivian Government that, for the first time, considers a different perspective to capitalism, that of living well, a vision shared by the country's 36 native indigenous and peasant nations.

- A native indigenous president, elected democratically by 57 % of the population; he is a representative of the social groups that, during the past 500 years of European colonisation, were among the most destitute.

- Experiences of many national social organisations, development institutions, public universities that have long sought alternative forms of development and educational systems which build on the wisdom of native, indigenous and peasant nations, who represent over 60% of the Bolivian population.

India is one of the few countries that have a major National Rural Health Mission (NRHM) that embraces the strategy of 'mainstreaming and revitalisation of local health traditions'. The NRHM is mandated to strengthen the public system of health services with 'architectural correction' so as to ensure access by all to quality care, with special focus on marginalised sections of the population. The strategy of mainstreaming traditional medicine provides for colocation of traditional practitioners and paramedics in Primary Health Centres, Community Health Centres and District Hospitals. There are diverse views regarding the primary objectives of this strategy to mainstream traditional medicine in NRHM. One view is that this policy is a strategy to deploy health care providers to rural areas at low cost where allopathic medical doctors are unwilling to serve. That notwithstanding, the NRHM serves the health needs of the excluded majorities of India.

In the context of Africa, recent efforts to revitalise African traditions in the area of development are the New Economic Partnership for African Development (NEPAD) and the African Renaissance initiative, which champions the course for an African-centred development agenda. Other initiatives include the Asmara Declaration, which has sought to promote African Language Studies, and the Pan African University, which is seeking to promote an alternative higher education in Africa. Undoubtedly there is increasing interest in exploring endogenous alternatives as can be found in the following:

- Educational Institutions (universities): African Studies programmes, African language studies and courses on African traditional religions, traditional education and specialisations such as Ethno-botany, Ethno-veterinary studies and herbal medicine in mainstream programmes in Makerere University, University of Ghana, University of Ibadan, University of Botswana and others.

- Public Departments: Plant or Herbal Medicine Councils, Regulatory Boards, Centres for National Culture and Arts, National Festival of Arts and Culture, Ministry of Chieftaincy and Culture of Ghana and Nigeria and Councils on IKS of South Africa and Botswana.

- Regional Bodies: Council for the Development of Social Science Research in Africa (CODESRIA) in Dakar, Senegal, and Centre for the Advanced Study of African Society (CASAS) and the African Gender Centre both in Cape Town, South Africa which publish research and host educational platforms.

- In August 2011, the CAPTURED project launched an African network of Endogenous Research and Education.

3. APPROACHES IN ENDOGENOUS DEVELOPMENT, RESEARCH AND EDUCATION

Endogenous development does not start from a technical or science-based position. Rather, its starting point is the daily life experiences of the communities involved: their worldviews, value systems and their endogenous knowledge base. The experiences of the COMPAS programme and of studies of indigenous scholars show that the ways in which endogenous development takes place and is supported are very diverse. Depending on the ecological, social, political, economic and cultural context and the skills, values and insights of the rural community and development agency, different practices and options exist for endogenous development. We present some guiding principles of endogenous development drawn from the experiences of COMPAS (Haverkort et al., 2003).

1. Building on local needs and local resources

Generally, economic growth or increased income is the primary objective in conventional development. For rural people in many cultures of the world, however, income is not always the major parameter in defining wellbeing or development. In endogenous development, the definition of needs may vary depending on sex, class or age differences. Therefore, the general goals for endogenous development may vary, and may include a combination of objectives such as poverty reduction, diminished ecological exploitation, increased equity and justice, or cultural and spiritual aspirations.

In every specific situation there are a host of locally available resources that could be identified and could be used for development activities. Rural people have shown a wide range of insights and practices that have enabled them to survive under difficult circumstances. The localities with their site-specific soils, plants, trees, crops, local wild and domesticated animals, the climate and the wider ecosystem provide resources that bear the potentials and limitations for development, often untapped or underestimated by outsiders. These localities differ in their social organisation, local experts and leadership. Traditional social organisations are constantly transforming, embracing risks of

erosion as well as potentials for re-valorisation and innovation. Under the surface of these transformations, traditional and spiritual leaders play an important role in daily practices and decision-making. Local economies have created mechanisms and social norms for saving, investing, income generation and marketing that have undervalued potentials. The local social systems, worldviews and economies are not always easy to understand.

2. Enhancing endogenous knowledge and practices

Endogenous development aims at enhancing in-situ development of endogenous knowledge and practices. A first activity of the development workers and researchers is to experience, understand and acknowledge the local processes, concepts and values of the society or people. In this way they gain insights into local ways of reasoning, methods of experimentation and the ways of learning and communication on which these are based. This implies that research staff participate in local activities in order to appreciate, experience and understand – and not just investigate – the concepts used, their underlying values and worldviews. A participatory diagnosis can be made about the actual situation, the changes taking place and the risks and potentials involved. This diagnosis can facilitate the process of choosing options to improve the situation and testing these options in a systematic way.

A difficulty in validating endogenous knowledge and practices is the tendency to use conventional scientific standards to measure them. While conventional scientific standards have their merits, they also have their limitations when applied in the case of unconventional knowledges. Therefore, there is a need to generate standards that complement the conventional ones and address their shortcomings. Such methodologies should be informed by the dynamics of deprived peoples in ways that do not merely accept and work with but also challenge local ways of knowing. This is research with people, not research on people. Strategies such as critical dialogue, phased assertions and emphatic learning and action have been applied in rural communities, and contribute to endogenous research. But methods that understand, articulate and enhance the ways in which local or indigenous knowledge communities are learning and experimenting need further refinement and application.

Addressing local needs was initially not seen as a problem by the CAPTURED partners, as in all stages of the development programme local leaders are involved in the planning and implementation of research. However, it has not always been easy to understand and address the intra-communal differences in power, wealth, social prestige and knowledge and the resulting differences in needs. Class, caste, gender and race can play an important role. It takes time to be able to make a gender-specific or class-neutral analysis of a cosmovision.

3. Local control of endogenous knowledge and knowledge processes

Conventional development models tend to be based on the introduction of externally developed innovations to local communities, much as conventional education introduces external knowledge to local communities. They normally translate into high dependence on external resources, actors, and power holders. Endogenous knowledge development, in contrast, aims for local control and decision-making about the way ahead. Traditional authorities play an important role in managing the internal affairs of the community such as conflict resolution, gender-based power relations, ownership and leadership succession.

The process of local control and decision-making is, of course, not limited to the socio-economic disparities and differences in interests and values among the diverse groups and sub-groups within a community or region. In some cases rural people themselves see the use of external or exogenous knowledge and practices as a threat to their already existing 'conducive' conditions, an assessment which, from the perspective of Western development, is backward progress or far from the standards of conventional development. Decades of development rhetoric and commercial influences have created a firm association in many minds that 'development' implies the use of Western style development alternatives and that the possibilities for building on local resources and leadership are limited. The role of research for endogenous development can be to facilitate the community's role in decision-making, monitoring and evaluation of the activities. Empowering local communities and local leadership may lead to problems of internal community or leadership tensions and may go against the implicit politics of national gov-

ernments. Governments and religions have often considered traditional leadership a hindrance to the development of local communities, and in many cases have consciously tried to minimise their influence or incorporate traditional leadership in a system of indirect rule. Re-valuing the role and experience of the traditional leaders is therefore an activity that requires careful negotiation and strategic choices.

4. Selective use of external resources

It is obvious that in many cases local knowledge and resources may have their limitations. Local practices, leadership, climate or biological resources usually have a better potential if combined with specific external inputs. For example, it might be possible to optimise the local system by using an external input such as cement, a bicycle, modern transport systems, electricity, fertiliser or seed. Loan facilities may be a way of financing the external inputs. External advisors, teachers or researchers can be called upon if a local community asks for specific expertise. Most rural families experiment with a combination of local and external inputs. An example is fertiliser to increase the productivity of land. However, selective use of external resources is important. In some (rain-fed) conditions fertilisers does not lead to higher yields or higher incomes. Many farmers have lost their property as a result of not being able to repay the loans provided for buying fertiliser. Chemical pesticides may show positive short-term effects, but pollute the environment and distort the food chain and local ecology over a longer period of time. A tractor without the necessary spare parts may bring more disillusion than benefits.

Therefore, in the endogenous development process, the questions to ask are: Is it possible and feasible to solve the identified problem with our own resources? What are the possible solutions from outside and how sustainable are they? What are the advantages and risks involved in external resources? What possibilities are there for building up the capacity to reproduce and maintain external technology? And can we learn from experiences of other communities, regions or cultures that are related to this problem?

5. Exchange and learning between cultures

Learning is not a neutral transfer of data. It involves conceptual frameworks that are related to worldviews and values. In many

parts of the world, a Western style of education dominates teaching and learning and has replaced traditional methods of learning and acquiring knowledge. In parts of the globe that experienced periods of Western influence or colonialism, such as in Africa, Asia and Latin America, Western concepts and values still play an important role in many areas of the academic curriculum. Western theories, concepts and methodologies are embraced from primary education level to the university level. The exchange of experiences and worldviews between different cultures is part of endogenous development. Exchange between rural people, farmers, field staff, managers and researchers can lead to fruitful cross-cultural exchange, learning and cooperation.

Exchange between different villages and population groups occurs through activities such as seed fairs, demonstrations and school competitions. This is supported by the dissemination of research results, newsletters and other publications in the local languages. Exchange also takes place with other organisations in the region and at national and international levels. This level of exchange is stimulated by learning materials such as newsletter publications and books, web-based online studies, calendars and e-learning materials such as CD-ROMs in the dominant language.

6. Training and capacity building

The highly technologised nature of learning has resulted in various critiques regarding conventional education systems and processes. In the 1970s and the 1980s in particular, Third World critics and analysts such as Paulo Freire, Everett Reimer, Donald Dore and Ivan Illich condemned the critical loss of the dynamism of schools and educational systems as agents of social change. For instance, Freire has been critical of pedagogical processes which, he argues, have lost their organicism by taking on a mechanical character, resulting in the failure to promote dialogues that lead to critical consciousness. For Dore, schools and education systems have become arenas for accumulating qualifications that have no real use value. Reimer is critical of the hidden curricula of schools that privilege particular values while denying others. Illich argued against the limitations that the institutionalisation of knowledges creates. These criticisms, and others, remain valid in topical debates about the radical transformation of the school and educational system. Indeed,

they have helped in shaping subsequent reforms in education globally, but have not been able to subdue the dominant paradigms, thus creating the need for continual work. It is in this view that capacity building and training find meaning in the endogenous development approach. The training and capacity building of organisational and community partners as well as academic champions remain critical.

A systematic training and possibly also a process of de-schooling therefore needs to be considered and carried out. In the short run this could take place for the field staff engaged in research and action for endogenous development. This can take place on the job, in service, or even during a pre-service phase.

Supporting the dynamics of local learning, teaching and experimenting, systematic design and implementation of experiments, understanding the background of local knowledge concepts, local networking: all require skills that are generally not taught in schools. A kind of de-schooling and re-training programme is therefore necessary for the professionals and field staff in partner organisations, a truly eventful learning pathway.

7. Networking and strategic partnership

Endogenous development can only thrive when a conducive policy environment exists. This can be enhanced through cooperation, advocacy and networking. Examples included: linking up with likeminded NGOs; forming strategic alliances with relevant governmental and private sector organisations; presenting experiences at different forums; attracting the attention of funding agencies. At international level scientific networks and international conferences can be useful arenas, and new communication media offer underutilised potential for communication, mobilisation of ideas and initiatives, and change.

4. A UNIVERSITY CONSORTIUM FOR ENDOGENOUS RESEARCH AND EDUCATION: CAPTURED

The endogenous development initiatives of COMPAS and CAPTURED were born out of years of experiences of community-based organisations, NGOs, educational and development agencies in working with local communities worldwide, using culturally inspired participatory techniques. Through a network of collaborations between and among Northern and Southern countries, centres of research, learning communities and development organisations have been promoted as the basis for community development and are gaining inroads into policy development processes. In areas in Latin America, Southeast Asia and Africa, where the efforts have been concentrated, there have been successes in inspiring local development organisations to reach out and work with very deprived and socially excluded groups, such as food crop farmers, migrant communities, rural women, pastoral communities, local health workers and ethnic minorities. The successes of such efforts in Bolivia, Ghana and India show that culturally and locally relevant factors are critical for obtaining real benefits from development interventions.

Since 1998, the COMPAS network has promoted that agenda mainly through a global network of NGOs. The participating NGOs[5] have worked with local communities[6] sometimes with the support of knowledge institutions[7] to develop and use strategies that are relevant to their local conditions and perspectives. As these efforts grew, it became necessary to institutionalise the partnership with educational institutions in order to create support in the areas of organisational development, research and training.

5 The NGOs are CIKOD, CECIK, SAEDP, Mviwamo, PROMETRA, CCFU, PFARD in Africa; FIOH, IDEA, CIKS, KPP, ADS, CRES and IAIM in South Asia; AGRUCO, CEPROSI, Kume Felen, SURCOS, Oxlajuj Ajpop and Pasos de Jaguar in Latin America.

6 Indigenous communities in Bolivia, Peru, Chile, Colombia, Guatemala, Ecuador, El Salvador; rural communities in Ghana, Uganda, Tanzania, Zimbabwe, South Africa, Lesotho; indigenous and local communities in India, Sri Lanka and Vietnam.

7 University for Development Studies (UDS), Ghana; Institute for Ayurveda and Integrative Medicine (I-AIM), India, University de Mayor San Simon, Bolivia.

In 2008, the partner institutions, comprising the University for Development Studies (UDS) Ghana; University de Mayor San Simon (UMSS) through the Centre for Agro-Ecological Studies (AGRUCO) of Bolivia, and the Institute for Ayurveda and Integrative Medicine (I-AIM) through the Foundation for the Revitalization of Local Health Traditions (FRLHT) of India initiated CAPTURED. With a grant from the Dutch Directorate for International Cooperation (DGIS), the Project started to implement a five-year (2008-2012) initiative. The aim of this was to build in the countries' research institutions a critical mass of scientists who can support endogenous research (both undergraduate and post-graduate) and can develop educational programmes in which there is a balance between exogenous and endogenous knowledge. Briefly, the programme aims at building capacities in the universities in the South for Endogenous Education and Endogenous Research and Development.

Furthermore, the CAPTURED project aims at developing new educational modules and modes of research involving:

- Formulating an inclusive and transcultural definition of what sciences are. The definition adopted questions the claims about the exclusive universality of mainstream science. It suggests that mainstream science and local, endogenous and traditional sciences are complementary to each other, and that this should lead to theory building on dualistic and holistic propositions, and clarify the commensurability and complementarity between different sciences.

- Supporting the processes of knowledge production within traditional knowledge communities. Intra-community learning and revitalisation of local knowledge and sciences implies recognising local sciences, understanding the mechanisms of their marginalisation and finding ways for revitalisation by addressing the weak and strong aspects of these sciences.

- Supporting inter-science dialogues and co-creation of sciences through South-South and South-North exchange. This suggests a movement away from domination, substitution and selective inclusion of local knowledge in mainstream science towards a relationship of complementarity.

> It involves a re-thinking of the implication of the diversity of worldviews, methods, epistemologies and axiologies of sciences.

For five years, the CAPTURED partners, in close cooperation with the holders of endogenous knowledge and NGOs, have studied the worldviews of peoples in their respective areas, as well as the way they gain, process and change their ways of knowing. Similarly, they have studied the theoretical background, origin and scope of the endogenous knowledge systems. The universities have started to study and to strengthen the ontologies, axiologies, gnoseologies and epistemologies of people in their respective areas and supported the local knowledge communities in furthering the dynamics of their knowledge and sciences.

Reorientation of education to endogenous knowledge, and inter- and intra-cultural learning at higher levels have led to new systems in different countries.

Research and educational programme by country

The three different partners each implement their programme in very different ways, as the programmes are a response to the specific educational and research conditions, the needs and potentials of each institution involved and the policy context of its country.

In Ghana, the University for Development Studies (UDS) is championing the course of endogenous education, research and development. As part of its regular teaching curriculum, a six-month compulsory field training is organised for students at the undergraduate level during which they investigate rural or peri-urban communities; identify developmental processes, problems and challenges facing the people, and propose workable lasting solutions to these problems. In addition, the university has graduate (MSc) and postgraduate (PhD) programmes in Endogenous Development, Research and Education. The MSc programme has produced more than 60 graduates and about 40 PhD students have enrolled to do doctoral research. Most of the studies relate to the role of indigenous institutions in the governance of natural resources, and to different aspects of endoge-

nous knowledge systems and ways to revitalise them. For a relatively young university like the UDS, CAPTURED provides the opportunity to develop its capacity in teaching and research in endogenous development, and has given a boost to its PhD programme.

In India, FRLHT is making the transition from a centre of excellence in research and development in traditional health systems to a university. Through various agreements with five universities, it has set up a PhD programme and other graduate programmes on traditional health and ethno-veterinary sciences to conduct research and training programmes related to endogenous knowledge and development. Collaboration with TANUVAS (Tamil Nadu Veterinary and Animal Sciences University) has now been undertaken to integrate into its curricula the teaching in ethno-veterinary science, medicinal plants and primary health care for community health workers and village botanists respectively. Following from this initiative, FRLHT has further supported seven transdisciplinary doctoral research students: six in India and one in Sri Lanka. In the course of its history FRLHT has influenced national policy on folk healers by motivating the IGNOU (Indira Gandhi National Open University) to certify prior learning or endogenous knowledge of folk healers gained through their own traditions of learning outside the university.

In the course of its 25 years of existence, AGRUCO in Bolivia has implemented eight cycles of Master's level training in endogenous development. The emphasis has been to redesign the academic educational system in such a way that students from indigenous communities are offered the opportunity to enter academic studies at seven different levels, from primary technical level to PhD.

One of AGRUCO's most successful experiences has been supporting the pre-graduate programme, and this has been expanded through CAPTURED to other university departments, especially in Social Sciences, Humanities and Economic Sciences in the Bolivian Amazon region. Through this AGRUCO has been able to transmit its transdisciplinary research perspective, revalue the wisdom of peasants and native indigenous nations,

and introduce this topic in other Bolivian universities. Through an agreement between UMSS University of Cochabamba and seven public universities, this system will be implemented nationwide. A concise conceptual and methodological framework translates into a PhD, Master's and diploma programmes and other specialisation programmes.

In summary, the major focus of research for scholars and researchers in endogenous knowledge is to address the following questions: What are the worldviews, basic principles, values and methods of learning which take place in different cultural environments? What are the strengths and weaknesses of different endogenous sciences and what can be done to increase the vitality or effectiveness and innovation of these ways of learning? How can marginalisation and suppression of endogenous sciences be addressed and how might complementarity of sciences be achieved?

5. DEALING WITH THE PLURALITY OF SCIENCES

In CAPTURED we have formulated the notion that endogenous knowledge is an expression of an endogenous science. It is therefore important to explore and clarify the notion of science.

The knowledge of indigenous and native people is not just a collection of unrelated pieces of information and experiences. It is the result of a culturally specific way of processing experiences and information. It is based on a particular worldview and value system, and its own knowledge community has its own way of assessing its validity. In that sense, as much as mainstream science, endogenous science complies with what Thomas Kuhn (1962) describes as a paradigm: a consistent worldview with its models, theories, values, assumptions and methods, shared by a scientific community. Karl Popper (1980) has shown that scientific certainty is an illusion and any scientific knowledge is only an approximation to the truth. Paul Feyerabend criticises Western scientific arrogance and asserts that Western science is one and only one of the possible sciences. Exporting Western sciences and technologies has not exclusively brought wellbeing to indigenous peoples. He advocates a stop to the one-way traffic and proposes instead a mutual learning process (Feyerabend, 1975).

An important step in this mutual learning process is the articulation of the different ways of knowing in such a way that they can be compared at critical points. For that reason we have chosen the following working definition of science:

Science is a body of knowledge formulated within a specific worldview and value system and classified under a theoretical framework. It includes the processes for producing, storing and retrieving knowledge, formulating assumptions, general principles, theories and methodologies, and it involves the active role of a specific knowledge community that has reached consensus on the validity of these processes. The knowledge acquired and the resulting science is always limited and subject to modification in the light of new information and insights.

This definition helps us in determining the critical elements

(science factors) that are articulated in each culture-specific way of knowing:

1. **Worldview (Ontology):** the way people see themselves and their relation with the rest of the cosmos.

2. **Values (Axiology):** the moral and aesthetic values of a people.

3. **Ways of learning (Methodology or Gnoseology):** methods for learning, teaching and innovating. It is surmised that the way of learning is directly related to the worldview and values.

4. **Existing Knowledge and theoretical framework (Epistemology):** the way knowledge is organised; its logic, theoretical frameworks, concepts and specialisations.

5. **Knowledge Community:** the experts, leaders, students and people who develop, test and apply certain knowledge and validate their worldviews, methods, theories and values and agree to accept or reject them.

In every culture people have explicitly or implicitly formulated these notions and are engaged in knowledge- related processes leading to their own science. Some of these sciences are considered to be robust in certain ways; others may be considered weak in one or more aspects. The degree to which different sciences differ from each other in each of these critical elements determines the degree of complementarity or commensurability of different sciences.

As we have seen above, the present relationships between the different sciences are not based on equity.

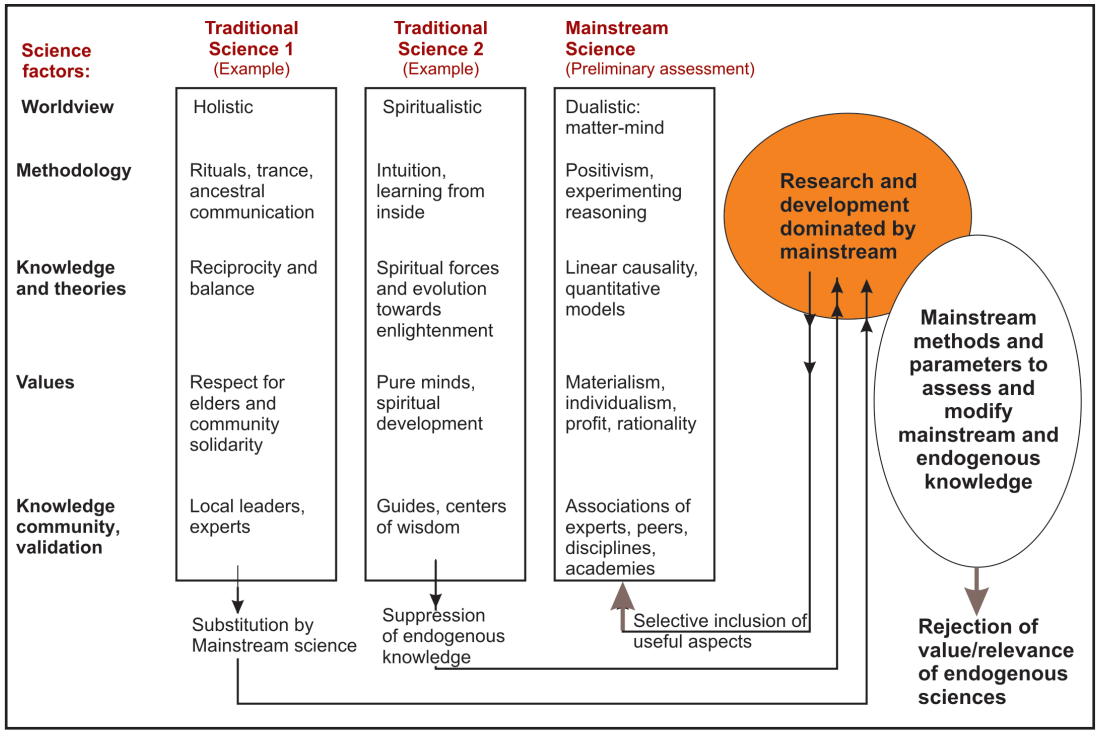
Below, two different scenarios for relationships between sciences are presented.

Scenario 1 is characterised by a dominant position of mainstream science that rejects, suppresses and substitutes endogenous sciences and selectively includes some elements of endogenous sci-

ences in its own system. This is the most common scenario of the present time. It leads to marginalisation and suppression of local sciences, to substitution by mainstream knowledge and selective inclusion of traditional knowledge in the mainstream. This may lead in turn to underground or parallel knowledge, to syncretism and/or rebellion or resistance. Scenario 2 does justice to scientific plurality and cultural diversity and leads to complementarity, synergy and co-creation of different sciences.

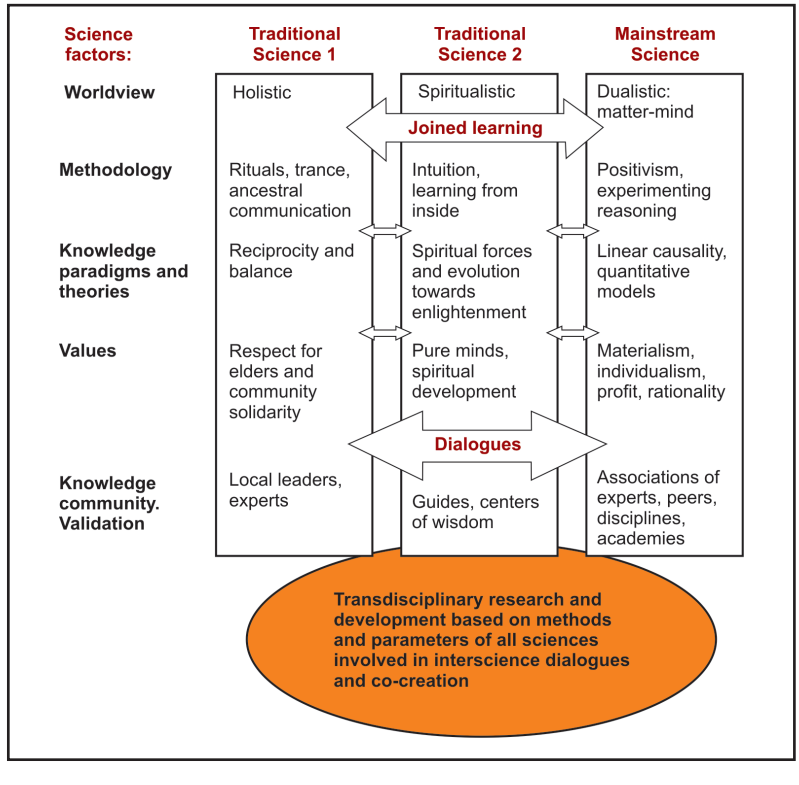
In Scenario 1 assessment of endogenous sciences is done by mainstream science in a one-way process. Mainstream research uses positivist models with mainstream parameters to assess traditional technologies. It may include those elements of endogenous knowledge in its system that are considered to fit within its own parameters. No feedback is given to endogenous sciences.

SCENARIO 1: REJECTION, SUPPRESSION, SUBSTITUTION, SELECTIVE INCLUSION BY MAINSTREAM SCIENCE



In Scenario 2, complementarity and co-creation of sciences can be obtained if the research methods and parameters used are not based on those of the dominant or on those of the endogenous science only. Research enhances the ownership, effectiveness and innovativeness of the different sciences involved and attention is paid to each of the worldviews, methods, theories, values and knowledge communities involved. All research carried out in the CAPTURED programme focuses on this scenario. Important research tools are transdisciplinary research and participatory action research and endogenous methodologies (Denzin et al., 2008). In all cases, methods and parameters of different scientific traditions are combined and included in the design, implementation and follow-up of the research.

SCENARIO 2: COMPLEMENTARITY AND CO-CREATION OF PLURALITY OF SCIENCES THROUGH DIALOGUES AND JOINT LEARNING



The following chapters of this book present different ways of knowing and different sciences as they exist today in different cultures, by describing the critical factors as they are perceived and articulated by the endogenous knowledge communities themselves: Dagare and Gruni in Ghana, Aymara and Quechua in Bolivia and the Ayurvedic knowledge traditions in India. An example of mainstream knowledge and science is also presented: the case of potato breeding in the Netherlands.

In anticipation of the conclusions expressed in Chapter 6, we present the following propositions related to science dialogue and co-creation of sciences:

- None of the four sciences can claim absolute truth or scientific certainty. Each has its own strong and weak points.

- Given the great differences in worldviews, methods and values of the different knowledge communities, we cannot justify the use of the parameters and criteria of one science to assess or falsify another science.

- Scientific enhancement and paradigm shifts within each of the scientific traditions are possible and can be stimulated by intra-science and inter-science dialogues.

- The diversity of sciences is considered an asset and a positive factor for cultural and scientific sustainability. A plurality of sciences will be better able to address the problems in this world than one mainstream science on its own.

In Chapter 6 we will address the question: How can the co-creation of a plurality of sciences be enhanced?

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A statue of Jeevika, an Ayurvedic seer, has a prominent place on FRLHT's campus. There are 1,100 indigenous medicinal plants on the campus.

Chapter 2

Indian Health Science: Ayurveda

Darshan Shankar and M.N.B. Nair, Foundation for the Revitalization of Local Health Traditions (FRLHT), Bangalore

1. INTRODUCTION

This chapter focuses on the contemporary relevance and potential of the currently marginalised, traditional health sciences of India and their relationship with mainstream or Western biomedicine.

Mainstream knowledge institutions in all modern societies are

largely mono-cultural, both in terms of the 'content' of knowledge and 'forms' of learning. This mono-cultural trait in knowledge institutions is a result of the colonial and post-colonial political history of our times, wherein most of their content and form was derived from the Western cultural and intellectual traditions imposed on them initially by colonial design and subsequently voluntarily adopted by 'colonised minds' of the native elites (with minor inclusions derived from their own cultures mostly by way of language and art forms).

The frontiers of mainstream knowledge are limited to an understanding of the physical and biological world since its methods of knowing rely exclusively on sensory data. The methodology of mainstream knowledge is reductionist since it relies on the observer-observed framework for viewing nature, on the philosophical scheme of logical positivism and Aristotelian logic. Despite its inventiveness, rigour and depth, this mono-cultural knowledge content poses a serious limitation to the capacities within knowledge institutions and societies to solve contemporary problems because it only equips them to provide mono-cultural solutions. Furthermore, because of their exotic intellectual and cultural roots, mainstream knowledge institutions are to an appreciable extent alienated from their own cultures and people.

This article is based on the experiences derived from an international collaborative programme that promotes non-Western, endogenous knowledge and development to complement, supplement and, where necessary, replace inappropriate application of mainstream knowledge. The programme is conceived in a spirit of promoting the 'co-creation' of knowledge rather than an outright rejection of mainstream knowledge.

The authors believe all forms of knowledge are valuable in general or specific contexts and every culture is also believed to be creative, innovative and inventive. Therefore, the authors hold the view that it is suicidal for any culture to give up its own knowledge traditions and embrace another. The authors believe that all cultures have a need to share and exchange because no culture has the best solutions to all societal and environmental problems.

2. MARGINALISATION OF NON-WESTERN SCIENCES

It is unfortunate but true that genuine international cooperation in 'science' scarcely exists across different world cultures. Whether Chinese, Indian, African, South American or mainstream, scientists today are all members of a mono-cultural scientific club. And while scientific institutions have been established in different geo-cultural regions, their scientific culture is largely isolated from their own endogenous sciences, which are based on very different ways of knowing nature.

To further the point of the exclusion of endogenous sciences, we cite a striking example of the fallacious conclusions that are arrived at in cross-cultural studies. In his monumental work Science and Civilization in China, no lesser authority than the reputed science historian Joseph Needham (1948) concludes that while the technological contribution of the Chinese to the world had been diverse and impressive, its 'shortcoming' lies in that it did not culminate in 'science'. The ethnocentric assumption of Needham is that Western scientific expression is the preferred, the only and the highest mode of flowering of any knowledge system. European scholars have drawn similar conclusions regarding the nature and status of Indian contributions to mathematics, medicine and astronomy (Dharampal, 2000).

Discerning observers of social change, however, point out that no single knowledge system has the best solutions to the emerging complexities of modernising societies. Yet most universities and research centres in the world use research methods and teaching materials that are exclusively based on and borrowed from mainstream sciences and technologies. This situation allows students to become part of the mainstream scientific community, which is very important, particularly for students in developing countries, and therefore should be encouraged. On the flip side, though, the exclusion of endogenous, traditional and local knowledge in education, and the absence of research programmes to uncover their contemporary potential are serious omissions because this limits the scope of innovation in knowledge institutions and reduces the role of universities as open centres of learning. Mainstream education based exclu-

sively on Western cultural and intellectual traditions also results in alienation of students and teachers in developing countries from their own cultural roots, and creates the phenomenon of 'excluded knowledge cultures' within a nation and certainly in the global context.

3. RECENT INITIATIVES FOR REVITALISING CULTURAL AND SCIENTIFIC DIVERSITY

In the last decade there have been a few pioneering efforts to revitalise endogenous knowledge in the contemporary context. These initiatives have been undertaken in universities and knowledge institutions in New Zealand, Australia, India, Thailand, Ghana, Canada and Bolivia. Thus far these initiatives appear to be of sub-critical size and scale, because of limited national funding and even more limited international support. It is important, from a national, regional and international perspective, to strengthen these nascent efforts, as they hold the key to broadening the cultural and intellectual foundations of university education. The importance of these initiatives will be better appreciated when there is wider acceptance of the idea that just as biological diversity is essential to support biological evolution, cultural diversity represented by ethnic languages, traditional arts, science and technologies is essential for civilisational evolution.

Traditional Indian healers meet to exchange knowledge and innovations

In the CAPTURED programme we use the following definition of science: science is a body of knowledge about nature and society, formulated within a specific worldview, value system and theoretical framework. It includes the processes for producing, selecting and retrieving knowledge, formulating assumptions, general principles, theories and methodologies, and it involves the active participation of a specific knowledge community that has reached consensus on the basics of its science.

In the context of this definition we present in this chapter our experiences in evaluating afresh and revitalising a classical Indian science: the traditional health science of Ayurveda.

We will outline the features of Ayurveda in terms of the various components of science as indicated in the above definition: its worldview, values, methods, theoretical framework and the way the knowledge community is organised.

4. AYURVEDA

4.1 Axiology : History and values

India has a long history and rich cultural heritage. Going back more than 3,500 years, Vedic sciences emerged initially as a rigorous oral tradition (smriti) passed on by word of mouth but with a very specialised oral learning.

Vedic sciences (upavedas) encompass in-depth knowledge in fields such as philosophy (darshana), logic (nyaya), mathematics (ganit), astronomy and astrology (jyotish), architecture (vastu), agriculture (krishi), fine arts and craft (shilp), mineralogy (rasa shastra), grammar (vyakharan) and linguistics (bhasha), political governance (artha shastra), and healthcare (ayurveda). This chapter focuses on Ayurveda, the traditional health science of India.

In the Indian tradition, knowledge of nature is regarded as sacred because it is discovered, and not created, in an unprejudiced state of mind. It was passed on free of charge, because of its sacredness, but only to worthy students who would use it unselfishly because it belonged to nature and not to particular individuals and communities. Knowledge therefore required its innovators, transmitters and carriers to adopt a highly ethical code of conduct so that the knowledge would be utilised for the

Indian classical knowledge is documented in Sanskrit and other languages on palm leaves

welfare of humanity and environmental harmony and not towards narrow ends. This code obliged knowledge holders to live in austerity so that, through their simple and basic living, they would remain independent of the influence of wealth and power.

Long after the advent of oral knowledge, came the written word and subsequently transmission of knowledge began to take place through this media. Written knowledge (shruti) is considered a fall in the evolution of knowledge, because here pure, contemplative, experiential knowledge is conditioned by words and language and becomes second-hand due as a result. This knowledge often prevents the student from gaining the essence underlying the written texts. Seasoned knowledge in Indian society is therefore always seen to be experiential (abhyas, anubhut) and not merely scholarly or theoretical. Thus wholesome knowledge also implies the teacher 'practising' what is preached.

4.2 Ontology: Ayurveda worldview

In the Ayurvedic worldview, while at one level nature is seen to be in essence a single undifferentiated phenomenon, it is viewed in practice as two interconnected and interdependent faces, like the two sides of the same coin. One face of nature is un-manifest (brahmand, purush). The second face has infinite manifestation (prakriti) on three planes, the physical, the biological and the spiritual planes.

The un-manifest world has no name, form or quality. It is not bound by time or space and is therefore experienced to be eternal and all pervading. It pervades every aspect of the manifest world. Even while being un-manifest, it is believed to be full of inherent and unlimited potential.

The manifest world is limited by forms: physical, biological and spiritual. Each form has qualities (gunas), properties (karmas) and potentials (samarthyam) within the inherent limitations of the form. All forms, however, carry the all-pervasive un-manifest principle within them at all times and cannot be sustained without it.

The Ayurvedic worldview recognises the order of creation as

having nine layers. Each of the layers are transformations and devolutions of a higher order layer into a lower one. The ordering of the nine proceeds from extremely subtle layers at the higher level to gross layers at the lower level. Genesis of the world starts with (i) the un-manifest (the subtlest, atman) which then devolves into (ii) the mind (manas) which further devolves into (iii) time (kaal) and (iv) space (dik). Then further devolution takes place into five relatively grosser forms: (v) ether (akash), (vi) wind (vayu), (vii) fire (agni), (viii) water (jal) and (ix) earth (prithvi).

In Ayurveda, in the context of the human body, the mind (manas) is seen to be distinct from the brain (mastish), although it works in conjunction with it. The mind although considered to be a substance (dravya), it is not physical or biological and therefore cannot be seen by the senses. For want of a better word, we may say that the mind-substance is spiritual or 'metaphysical' in nature. It is considered to be the 'spirit' in the physical and biological body. This is quite different from the current position of scientists who believe the mind to be a neural activity of the brain and not an independent spiritual entity that is separable from the physical and biological body.

As in mainstream science, where all physical matter is viewed as a permutation and combination of atoms and molecules, and depending on their configuration matter takes on different forms and properties, so also in Ayurveda matter is seen to be a permutation and combination of the five states of matter; ether, wind, fire, water and earth. And depending on the configuration and proportion of these five states in any material, matter takes on different forms and properties.

What is the difference between the physical worldviews of these two knowledge systems? In the mainstream scientific worldview, the world is constructed by the aggregation of its smallest particles (atoms, sub atomic particles and molecules). In Ayurveda the world is constructed by aggregation of the five fields: ether, wind, fire, water and earth. It is beyond the scope of this article to elaborate further, but suffice it to conclude that mainstream science is largely a structural theory of nature whereas Ayurveda is a systemic or field theory of nature.

Furthermore, mainstream science is focused on a vision of the world as cognised by the senses; it does not recognise non-sensory forms of nature (i.e. forms that cannot be cognised by the five senses) or by sophisticated scientific instruments (that are nothing but extensions of the five senses). It therefore does not recognise mental forms. Mainstream science does not accept the existence of the mind or spirit, but only recognises the brain as real because the brain is a sensory object whereas the mind is not. Ayurveda recognises the mind and the spiritual world consisting of metaphysical objects, by searching for it and experiencing it, not through the senses but through the mind itself.

4.3 Gnoseology: Ways of learning in Ayurveda

Learning and generation of Ayurvedic knowledge involves training the mind to achieve unprejudiced mental states (through yoga), in which profound knowledge of nature is revealed through observation, inference, experiments and contemplation of the physical, biological and spiritual worlds.

An unprejudiced mind is free of the six key prejudices that colour the human mind: lust (kam), greed (krodh), intoxication (madh) envy (lobh), aversion (matsar) and ego (ahankar). When the mind is free of these prejudices it is peaceful, clear and incisive, and can see nature as it is. Only constant awareness of one's impersonal, and spiritual, inner being which has no wants can remove prejudices. Mere reason or analysis does not dispel them although reason does have an important role to play in reconfirming the validity of our thoughts, words and deeds.

The way of knowing of Ayurveda is based on the sankhya philosophical school. Sankhya assumes that the manifest or objective world (vyakta) emerges from the un-manifest (avyakta) world and that there is an essential unity and continuum between the two. At a philosophical level, it implies the essential unity of the inner and outer dimensions of nature. Thus, from the Ayurvedic standpoint, the realistic way to understand nature is by becoming 'one' with it. One can do this by using our mental apparatus and the five senses that serve as instruments of sensory knowledge in a balanced way.

The senses naturally move outwards to see, hear, touch, smell

and taste. The mind can move both outwards with the senses or move inwards and experience an inner, non-sensory world. When the mind moves outwards with the senses, Ayurveda articulates three ways of knowing. These ways of knowing are similar to the epistemology of mainstream sciences. The first way is pratyakash or direct perception by one or more sense organ. The second consists of anumaman and upman which together stand for inference (induction and deduction). The third method is yukti, or experimentation to arrive at knowledge.

Ayurveda however also accepts a fourth method which relies on the testimony of the apta or seer, whose mind is perfectly unprejudiced because it has turned inwards to meditate on an unchanging self and thus lost its identification with the phenomenal sensory world of individual names and forms and the changing mental world of thoughts and emotions. A mind that is not controlled by the senses and is totally free of the six divisive mental prejudices is said to be perfectly detached and impersonal. This is called the mental state of brahma, from which the deepest insights of Ayurvedic science were originally propounded. In such a state there is oneness with the core of nature and therefore one can see nature directly 'as it is'.

At this point, it would help to demystify this mental state by pointing out that one can free the mind of the six prejudices through mental training. The training is described in yoga texts such as the Patanjali yoga sutras (Swami Vivekananda, 2006). A verse from this text of Yoga states: 'Yoga is restraining the mind-stuff (chitta) from taking various forms (vrittis).'

A good deal of explanation is necessary here. We have to understand what chitta is, and what the vrittis are. I have eyes. Eyes do not see. Take away the brain centre which is in the head, the eyes will still be there, the retinae complete, as also the pictures of objects on them, and yet the eyes will not see. So the eyes are only a secondary instrument; what is also needed is the nerve centre of the brain. The two eyes together with the brain centre are also not sufficient. Sometimes a man is asleep with his eyes open. The light is there and the picture is there, but a third thing is necessary – the mind (awareness) must be joined to the

organ. The eye is the external instrument; in addition we also need the brain centre and the agency of the mind. Now we get deeper into a unique yogic explanation of cognition. The mind takes the impression further in, and presents it to the discerning faculty (buddhi), which reacts. Along with this reaction flashes the idea of egoism. Then this mixture of action and reaction is presented to the purusha, the real soul, who perceives an object in this mixture. The organs (indriyas), together with the mind (manas), the determinative faculty (buddhi), and egoism (ahamkara), form the group called the antahkarana (the internal instrument). They are but various processes (vrittis) in the mind stuff, called chitta.

What is thought according to yoga? Thought is a force, as is gravitation or repulsion. From the infinite storehouse of the force in nature, the instrument called chitta takes hold of some, absorbs it and sends it as thought (a subtle form of force). So we see that the mind is not intelligent; yet it appears to be intelligent. Why? Because the enlightening soul is behind it; mind is only the instrument through which you grasp the external world. The perceived real universe is the occasion of the reaction of the mind. Thus we understand what is meant by chitta. It is the mind-stuff, and vrittis are the waves and ripples rising in it when external causes impinge on it. These vrittis are our universe.

We cannot see the bottom of a lake because its surface is covered with ripples. It is only possible for us to catch a glimpse of the bottom, when the ripples have subsided, and the water is calm. If the water is muddy or agitated all the time, the bottom will not be seen. If it is clear, and there are no waves, we shall see the bottom. The bottom of the lake is our own true self; the lake is the chitta and the waves the vrittis. The calm man is the one who has control over the mind waves (vrittis).

The chitta is always trying to get back to its natural pure state, but the sense organs draw it out. To restrain it, to check this outward tendency, and to start it on the return journey to the essence of one's inner being is the first step in yoga, because only in this way can the chitta come to rest. The chitta manifests itself in the following forms of vritti: scattering, darkening,

one pointed, and concentration. The scattering form is activity, and its tendency is to manifest in the form of pleasure or the pain. The darkening form is dullness. The one pointed is a special meditative state and concentration is a generally attentive state.

As soon as the waves have stopped, and the lake has become quiet, we see its bottom. So with the mind; when it is calm, we see what our own nature is; we do not mix ourselves with our reactions and perceptions, but remain our own selves.

At other times (other than that of concentration) the seer identifies with the modifications. Take the following example: someone blames me; this produces modifications, vritti, in my mind, and I identify myself with this, and the result is misery.

The next class of vritti is called sleep and dream. When we are awake, we know that we have been sleeping; we can only have a memory of the perception. That which we do not perceive we can never have any memory of. Every reaction is a wave in the lake. Now, if during sleep the mind had no waves, it would have no perceptions, positive or negative, and therefore we would not remember them. The very reason for our remembering sleep is that during sleep there was a certain class of waves in the mind.

Memory is another class of vritti and is called smriti. Memory is when the (vrittis of) perceived subjects do not slip away (and through impressions return to consciousness). Memory can come from direct perception, false knowledge, verbal delusion and sleep. For instance, you hear a word. That word is like a stone thrown into the lake of the chitta; it causes a ripple, and that ripple sets off a series of ripples; this is memory. So it is in sleep. When the peculiar kind of ripple called sleep throws the chitta into a particular kind of ripple caused by imagined or remembered or visualised thoughts, it is called a dream. Dream is another form of the ripple of which the waking state is called memory, imagination and intuition.

The direct use of mind without the aid of senses is expected to lead to cognition of the subtler non-sensory or spiritual aspects of nature. By contrast, in the mode of sensory knowing, the five

senses are used alongside the mind to help analyse the sense data, and thus one forms an intelligent understanding of the outer physical and biological world. It is the combination of the inner subtle and outer sensory reality that leads to a holistic understanding of nature.

4.4 Epistemology: The way Ayurveda knowledge is organised and expressed

The knowledge of Ayurveda, obtained through its holistic methods, is organised on three levels. The first level is that of 'principles' (tatvas). This level of knowledge is considered to be more or less complete and therefore unchanging, as long as the principles are well conceived. This is a subtle and distilled knowledge. The second level is the 'science' (shastra), which consists of the operational laws or rules derived from the principles. This level of knowledge does change but it changes slowly as new observations and their interpretation stimulate new knowledge, which is nevertheless based on the same basic principles. The third level of knowledge is 'practical skills and applications' (vyhar) of the principles and science. This level of knowledge is conditioned by time and space, and will therefore change with them.

The belief in the evolving nature of phenomenal knowledge is best expressed in the following verse, which is from an Ayurvedic text written in about 1500 BC. 'The science of life (Ayurveda) shall never attain finality. Therefore, humility and relentless industry should characterise one's endeavour and approach to knowledge. The entire world consists of teachers for the wise. Therefore, knowledge, conducive to health, longevity, fame and excellence, coming even from an unfamiliar source, should be received, assimilated and utilised with earnestness. (*Charaka Samhita Vimansthan 8/14*)

A classical Indian library

4.5 The Ayurveda knowledge community

From an Indian perspective, the entire society constitutes the knowledge community. Different sections however create and utilise different forms of knowledge. No section of society can be deemed to be ignorant. But, due to sociological and political processes different hierarchies of knowledge are formed. Some believe that codified knowledge is superior to that of folk knowledge. However, this is just a point of view and the bal-

anced understanding is that both are equally important in their own contexts and serve different purposes.

In classical Indian literature there is a theory of the four-fold, interdependent order of society (Varna Ashrama Dharma). This theory has its genesis in the observation of four dominant human psyches. The four-fold order is therefore believed to be a natural order. The theory merely articulates the natural tendencies of four psychological types of human beings in society. The Varna Ashrama Dharma theory is seen to be a formulation of natural social phenomena. It is comparable to saying physics is only an articulation of the natural laws of the physical universe. The Varna Ashrama Dharma theory also affirms the equality of roles in their own contexts. According to this, endogenous, theory of social order, at one level is a section called Brahmins who are committed to pursuing knowledge of the inner and outer nature for its own sake. The Brahmins are considered to be individuals whose natural calling is to seek knowledge and thus this group of people in Indian society are devoted to the pursuit of knowledge and become the carriers of comprehensive knowledge. At another level there is a section of society, the members of whom are psychologically oriented to govern and they are therefore nurtured into learning the theory and practice of warfare and state craft. At a third level are those wholly dedicated by virtue of their psyche to the generation of wealth and its management. Finally there is a fourth section the members of which lack ambition to peruse knowledge, power or wealth. They are fully satisfied by doing practical skills. These may be unskilled labourers and semi-skilled artisans.

Originally, the knowledge associated with each of these four sections was considered to be equally important in different contexts. It is not at all unusual for any socially constructed scheme, even if based on sound principles, to deteriorate over time. Entropy is a natural principle of nature. It applies to physical, biological and social phenomena.

Therefore, in social history there have been periods when the four forms of knowledge interacted in harmony and later periods when there was strife and conflict. Over time, the Varna Ashrama Dharma system started to deteriorate and became

expressed in the form of an inequitable caste system with a unique form of governance and distribution of social roles and responsibilities. History has not recorded the milestones in the erosion of the Varna Ashram Dharma, but we do know from Buddhist records that even in the 5th century BC, when Gautama Buddha was born, the Varna Ashrama Dharma system was already functioning imperfectly. This is what led prince Siddhartha (Gautama Buddha) to step out of his caste order and adopt a monastic life. This caste system continued to further deteriorate over the centuries, which resulted in severe social discrimination and injustices. In the 20th century, Mahatma Gandhi, a prominent national leader, worked hard to reform the caste system. The Government of India has now implemented constitutional measures as well as an active social reform policy in this regard. It is beyond the scope of this chapter, however, to outline this social history.

For the purposes of this chapter it may be helpful to briefly outline the organisation of the Ayurvedic knowledge system in contemporary India.

The traditional health sciences of India flow in two streams: a theoretically sophisticated, scholarly stream, which is codified, and an empirical, 'folk' stream. While the worldviews of both these medical traditions overlap, they both differ markedly from the worldview of mainstream bio-medicine. This difference is not surprising, as the genesis of Indian medicine, both in terms of time as well as the cultural space in which it evolved, is so different from that of mainstream medicine.

Ayurveda in the form of a codified knowledge system is expressed in thousands of medical manuscripts. These manuscripts embody a special understanding of physiology, pathogenesis, pharmacology and pharmaceuticals. Textbooks on Ayurvedic medicine cover eight broad subjects: kaya cikitsa (general medicine), bala cikitsa (paediatrics), graha cikitsa (psychiatry), urdhvanga cikitsa (ear, nose, throat and eye), salya cikitsa (surgery), damstra cikitsa (toxicology), jara cikitsa (rejuvenation) and vajikarana cikitsa (reproductive health).

The folk healthcare traditions of India constitute the second

level of Ayurveda, and are located in the villages of India. In this stream of Ayurveda, practical knowledge is transmitted by word of mouth. This stream has no written texts to support its transmission. Folk traditions are extremely diverse. They are ecosystem and ethnic community specific. The teachers in this stream are village-based healers and elders in rural households. The folk healthcare tradition also trains thousands of midwives, bonesetters, herbalists, spiritual healers and householders. Across India there are estimated to be one million specialised healers and more than 200 million knowledgeable households. There are therefore more folk healthcare practitioners than the 400,000 licensed practitioners of Ayurveda. However, folk healers have social legitimacy but no legal status.

Throughout their history, the folk and codified traditions have had a symbiotic relationship. Since the beginning of the 20th century, the Ayurveda knowledge system has gradually become institutionalised. This process of institutionalisation has occurred in all sectors of society, and is a strategy learned from the colonial experience. This strategy has destroyed oral traditions in many societies. Prior to the present scheme of institutional education, from its inception in Vedic times Ayurveda was taught for centuries, in its codified form, through an informal, non-institutionalised system of education called the guru-shishya parampara – which translates as the teacher (guru) – student (shishya) tradition (parampara). Ayurveda is codified in thousands of medical texts that were written over the period from 1500 BC to 1900 AD. Education was free. A student lived and served his teacher and perhaps even gave him voluntary gifts out of respect and love for the teacher. This system of learning and transmission prevailed until as recently as the 1950s. Today, there are around 300 medical colleges that teach a five-and-a-half-year course on Ayurveda to students who have completed high school (12th class). Only students who graduate from these colleges may obtain a medical license.

Institutionalised Ayurveda is today a legally recognised system of medical practice in India and has the same legal status in the country as Western medicine. There are in fact very few countries in the world that have legalised their endogenous health sciences. India, Sri Lanka, Nepal and China are forerunners in this regard.

5. OUR RESEARCH METHODOLOGY IN CAPTURED

The ways of knowing in different societies, cultures and sub-cultures are evidently diverse. What is common to all cultures is that all human communities use the five senses and the mind, which are the only human tools available for knowing, although they may use them in different ways. A particular culture or sub-culture may actively use only one or the other sense or a combination of the five senses with particular intensity and similarly use the mind in one or the other of its several complex states, and thus arrive at a particular way of knowing with its associated worldview. These ways of knowing may be called artistic, scientific, spiritual, superstitious, practical and so on, depending on the way in which one or more of the five senses and the mind is used.

The ways of knowing in mainstream research are based on the 'the scientific method'. In order to broaden its outlook, science adopts the interdisciplinary and multidisciplinary framework for research. One should however distinguish the terms inter-disciplinary and multidisciplinary from the transdisciplinary. The first two terms, inter and multi, endeavour to integrate disciplines that share the same worldview, even if their domains be different, whereas transdisciplinary refers to the relationship between knowledge systems that have different worldviews, foundations, concepts, categories, logic and methods of knowing. In the Indian context, transdisciplinary research tries to bridge Indian shastras and mainstream science, which have different ways of knowing. The central problem underlying trans-disciplinary research is the problem of correlating endogenous science concepts, categories, principles and methods with corresponding concepts in mainstream science.

The difficulty in establishing tenable correlations is due to the fact that endogenous science and mainstream science have entirely different perspectives on nature. Indian Ayurvedic science views nature and natural phenomena and entities 'as a whole', whereas mainstream science breaks up the whole into its constituent parts and studies nature part by part. The former is therefore inherently holistic in outlook whereas the latter is

reductionist. The whole and the parts are evidently related, but the relationship is not one to one. A part is not equal to the whole or vice versa, yet, common sense informs us that the parts and the whole are organically related. How to establish correlation between them is, therefore, the first step and the central challenge of transdisciplinary research.

Transdisciplinarity involves an attempt to interpret the traditional practices, procedures, concepts, logic, parameters and therapy with the aid of scientific (mainstream knowledge) tools, methods and parameters by recognising and identifying the limitations and scope of the exercise and leaving room for future bridging research.

5.1 Our PhD programme

As part of the CAPTURED project in 2008, the I-AIM PhD programme was initiated in the Bangalore institute. This programme offers fellowships to students who had completed a Master's degree and wished to do doctoral research on a subject that would attempt to build a bridge between endogenous knowledge and mainstream science.

Offices, classrooms and laboratories on the FRLHT campus in Bangalore

The source of inspiration in the case of all PhD topics selected by I-AIM scholars is a topic derived from Indian endogenous health knowledge and practice. This knowledge may be a traditional practice (e.g. storing water in copper vessels), a recommendation (e.g. the herb Cyperus rotundus can replace Aconitum heterophyllum), a concept (e.g. the definition of mind and emotion in traditional performing arts and music, Ayurveda and Yoga text), a procedure (e.g. the way to assess the health status of one individual by identifying his/her unique phenotype constitution and quality of body tissues), or the aetiology and therapy for specific diseases (e.g. for anaemia or malaria).

Since traditional knowledge is the starting point, as well as being an essential and core part of the research, the first step for the PhD researchers is to describe in detail the nature of the traditional knowledge (ontology), its genesis and its own internal logic (epistemology), with appropriate references from the traditional texts and practices.

As a second step, the PhD research design, in all cases, involves validation of the traditional knowledge. The approach adopted for this step is transdisciplinary. To assess the traditional practices, procedures, concepts, recommendations and therapy, the PhD students are required to use scientific (mainstream knowledge) tools and parameters along with those tools and parameters that may be available in the Indian knowledge systems.

The topics of our PhD students are listed in the table below:

- Traditional knowledge based on contemporary methods using copper for enhancing the quality of drinking water.
- Pre-clinical validation of plant based remedy for prevention of malaria.
- Study of abhava and abhava prathinidhi dravyas.
- Comparative studies on a Master Health Check-up integrating allopathic and Ayurveda systems.
- Evaluation of the traditional conservative management of pelvic organ prolapse.
- Pharmacological efficacy and biodynamic practices used in the preparation of local (deshiya) medicinal formulation (naigal/snake stones) for adsorption of snake venom from site of attack.
- Development of appropriate in-vitro and in-vivo bioassays to study rasayana products (Ayurvedic Nutraceuticals) with particular focus on iron deficiency anaemia.
- Comparative studies, using conventional and traditional

approaches, on propagation of selected medicinal plants.

- A study on the raw drug markets in southern India with particular reference to adulterants and substitutes of highly traded medicinal plant species.

Research on effectiveness and safety of traditional treatments of malaria involves village meetings

The I-AIM-CAPTURED research programme is directly related to assessing traditional knowledge in the light of mainstream science. Since traditional knowledge is the starting point and is an essential and core part of the research, the first step for the PhD students describe in detail the nature of the traditional knowledge (ontology), its genesis and its own internal logic (epistemology), with appropriate references from the traditional texts and practices.

As a second step the PhD research design, in all cases, involves validation of traditional knowledge. The approach adopted for this step is transdisciplinary. To assess the traditional practices, procedures, concepts, recommendations and therapy, it requires PhD students to use scientific (mainstream knowledge) tools and parameters along with those tools and parameters that may be available in the Indian knowledge systems.

6. AYURVEDA AND MAINSTREAM PHARMACEUTICAL APPROACHES

I-AIM laboratory in Bangalore

There are a number of basic conceptual differences between Ayurveda and 'mainstream' pharmacology. In Ayurvedic pharmacology, which is called 'Dravyaguna shastra', the entire plant and/or its parts – the leaves, stem, seeds, root, bark, fruit and flowers – are studied as a whole in terms of their overall 'systemic' effects. There are four parameters that help the scientist to predict and assess the systemic effect of a substance:

RASA: Taste, of which there are six, each suggestive of the com position, properties and biological activity of the substance.

VIRYA: The potency (hot or cold) of a substance immediately after ingestion.

VIPAKA: The post-digestive state of a substance.

PRABHAVA: The overriding biological outcome of a substance.

Mainstream pharmacology, on the other hand, isolates an active chemical entity from the plant or its parts and studies its effects,

in vitro and in vivo, on limited biological models, such as micro-organisms or body tissues. It does not have models to assess the overall systemic effect of a substance.

Both approaches undoubtedly have their uses as they yield different understandings of the properties of materials. The difference lies primarily in the fact that in Ayurveda the biological evaluation of whole substances (not molecules) is done on the whole human biological system, whereas in mainstream medicine 'molecules' are studied for their effect on individual biological processes and structures (bio-assays). Thus, in endogenous pharmacology, the category of knowledge known as chemistry (breaking a whole into its constituents) is absent; instead a holistic category is used called dravyaguna shastra. This subsumes both chemistry and biology, and determines the effect of whole substances (chemists call them crude extracts or fractions) on the entire human system.

In both the folk and codified traditions of Ayurveda, properties of materials are expressed in terms of the five material states dominant in them. Thus, the bitter gourd causes wind-air (vayu), and the bitter taste is a characteristic of substances that agitate the wind. Chillies, on the other hand, have a high proportion of fire (agni) as the dominant state; the thinner the chilli, the spicier it is likely to be, as fire in a fat chilli is balanced by its content of water. Again, the cucumber has relatively more water (ap) in proportion to its volume and weight, and water is its dominant state and can thus boast of cooling properties. All sweet substances are usually heavy because they are dominated by the earthy or solid state (prithvi) and astringent tasting substances, which are usually light and hollow like the stem of lotus flower or the mineral alum, are dominated by the ethereal state (akash) in them

Diseases are also seen as an imbalance (vikrti) in the normal proportions of the five states in the human body. Parkinson's disease or paralysis, where limbs tremble or become frozen, is due to an imbalance of wind (vayu) in the body, which affects motion. Hyperacidity is caused by an imbalance of fire (agni) and wind (vayu). Obesity represents an imbalance of solid and liquid (prithvi and ap) states.

In mainstream pharmacology biological changes are observed as structural changes. By structural changes we mean changes which can be detected in body structures like cells, tissues, arteries, blood cells, urine residues, organs etc. Systemic changes as described in Ayurveda are, however, physiological changes that are not confined to changes in specific structures, but occur across the entire physiology. Ayurveda detects and classifies systemic changes through a very elaborate scheme of clinical symptoms. It has neither the instruments nor the knowledge to detect and measure structural changes. According to Ayurvedic theory, structural changes may happen as a result of systemic imbalances, but Ayurveda holds the view that, structural changes themselves, while they are significant indicators, are nevertheless only visible symptoms which have underlying systemic causes. Correction of these should therefore be done through systemic interventions. It is only in acute conditions (for example a blockage in the respiratory or cardiac region or a haemorrhage) that direct intervention at the structural level may be necessary. Sustainable correction can only take place when the underlying systemic cause is understood.

Ayurveda, does have methods of verification, sophisticated schemes for diagnosis, descriptions of the evolution of diseases, as well as criteria for admitting a therapeutic substance into the materia-medica, all of them are based on its own holistic (systemic) perspective, which is different from that of the mainstream sciences.

The advantage of the scientific approach in pharmacology is that it provides incredible details about the structure and functions of parts, but has little idea of the principles that govern the whole or even about the complex inter-relationship between the parts. The advantage of the Ayurvedic approach is that it has deep insights into the workings of whole systems but has no tools to see or detect the effect of systemic changes on microscopic structures and parts.

The two sciences working together can contribute to new holistic, integrative science about the biology of natural products.

7. THE CHALLENGES OF TRANSDISCIPLINARY RESEARCH

Every research problem addressed by the I-AIM PhD students consists of two basic dimensions: firstly documenting and explaining traditional knowledge in its own light, and secondly interpreting traditional knowledge in the language of mainstream science. We call the latter a 'transdisciplinary research' methodology. This raises the question, why adopt a transdisciplinary approach, why not explain, describe and reassess the traditional knowledge in terms of its own theoretical and experimental methods?

The answer to this question is that firstly this form of endogenous knowledge is understood only by endogenous communities. Its concepts and categories are today not universally understood or known. Therefore if one is to communicate the value of endogenous knowledge to a global audience, one has to try and explain the relevance and usefulness of the knowledge in terms of Western science, which is much more widely known to the global knowledge community.

However, there is another reason to dialogue with Science. While the traditional knowledge is indeed available and is experienced positively by its community of users, not enough is understood about the details of the traditional methods of knowing (epistemology and ontology) through which the knowledge was established. We have a detailed description of the results and how to apply them, but not enough on how the results were achieved. We do not know what experiments were done and how they were designed to establish the pharmacology (dravyaguna shastra) of plants. We know they were not laboratory experiments because laboratories and instrumentation did not exist during that period. Yet the results are sound and this is testified by thousands of physicians who have applied the properties of plants given in the Ayurvedic texts.

However, it is difficult to reconstruct the way of knowing and revalidate it using the traditional methodology. Let us take an example of the difficulty in context of the PhD topic on 'sub-

stitute drugs'. It is evident from Ayurvedic literature that substitute herbs are suggested e.g. Cyperus rotundus can be used as a substitute for Aconitum heterophyllum. Clinically they are seen to be effective substitutes for one another. However, one has to accept the fact that the logic that ancient seers used to search for alternative herbs has been lost. The methodology used to search for and validate the substitutes is untraceable. At least in the initial phases (where we are now), we propose to validate the substitutes that have been put forward by using tools of mainstream science (chemistry and biology).

Similarly, in the case of malaria management, clinical observation seems to indicate that the traditionally suggested herbs may indeed be capable of preventing the disease. But traditional knowledge does not have tools to satisfy the questions of present-day scientists, in particular about the detailed mode of action of plants and how they prevent malaria. Nor do we have statistical data on efficacy. Here we need the support of mainstream science, which can evaluate for example, whether the drugs are active in pre-hepatic stages of malaria, when parasites are present in the body in a dormant state. Thus, the preventive action of herbs on parasites can be studied in minute detail on a hepatic model. Subsequently, statistically valid population trials will need to be designed and implemented to establish the efficacy.

The example of the logic of using copper to store drinking water presents the same difficulty, namely that we do not know what traditional methods of validation, if any, were used. Communities have been using copper vessels for storing water for centuries. No one knew the precise reason, but millions believed it to be good practice. Surmising that copper may act on micro-organisms present in unhygienic water, the PhD researcher undertook a study on the antimicrobial effects of copper ions released in water. Scientific studies demonstrate remarkable antimicrobial activity, even when the amount (PPM) of copper dissolved in water is well within safety limits. While the scientific explanation for storing water in copper vessels is becoming clear, we still do not have enough clarity on the traditional logic for the practice. The research methodology for this work currently involves valida-

tion of the traditional practice using conventional mainstream science. We pursue this path because there is no clear traditional hypothesis to evaluate the logic of copper's action on water given in traditional texts. We only have a widely used practice based on belief that storing water in copper vessels is good. The present PhD work therefore undertakes collection and analysis of relevant antimicrobial data in an attempt to justify the traditional practice that uses copper as a water purification agent. The research references in the Ayurvedic literature to the biological properties of copper may perhaps give us leads to understanding the role of copper for enhancing the quality of water in contexts other than microbes. And these leads may inspire further research on copper.

Thus, today, it is actually easier to establish a relation between the traditional and mainstream concepts, even though there is no one-to-one correspondence, and subsequently attempt validation of the traditional knowledge within the parameters of mainstream science using well-established methods of mainstream science.

The first challenge for transdisciplinary research in the context of the Indian CAPTURED programme is to uncover the traditional logic and method of traditional research that led to such remarkably important findings. The second challenge is to correlate traditional concepts with mainstream scientific equivalents, even when there is no one-to-one correspondence. The final challenge is to validate the efficacy of or make comparisons between traditional and scientific parameters, if both are available. Where there are no traditional knowledge parameters, the strategy is to assess a traditional practice, procedure, therapy or concept using only mainstream scientific parameters, while documenting the traditional knowledge and literature as comprehensively as possible and suggesting key topics, issues and subjects for future investigation. When mainstream scientific parameters are used for validating traditional knowledge, care is taken not to underestimate the traditional knowledge or reduce its holistic, qualitative intuitive and cultural values.

Identification of community-based stakeholders for every piece of research is an important step and challenge in our research programmes. Mutual exchange of knowledge with relevant communities is a key activity between the researcher and community stakeholders to ensure that the outcome of research is acceptable and hopefully beneficial to the community.

Community-based dialogues on endogenous and mainstream health practices

8. CORRELATING DIFFERENT SCIENCES

In any comparative study of the two sciences it is imperative to have an appropriate terminology and language for a dialogue. Conceptual correlations between the two medical systems are, however, poorly established at present. There are three key biological terms used in Ayurveda. These are vata, pitta and kapha. It is very difficult to establish equivalent terms in Western medicine. These terms refer to three biological functions that regulate anabolic, metabolic and neurological functions. Even this correlation of vata, pitta and kapha to anabolic, metabolic and neurological functions is very tentative.

Conceptual terms like these understood in one particular way by one medical system may be used by the other to mean something different. For instance, vata, a systemic physiological function that implies 'transmission' of nutrients and neurological impulses is often equated by mainstream scientists with the nervous system or nerve force, and pitta, another systemic metabolic function, is equated with the activities of the digestive system, enzymes, hormones and the heat-regulating mechanisms.

While such equations may work at one level, they often break down at other levels. For example, in Ayurveda, the intellect is a function of pitta, representing a preponderance of sattva guna (a term that refers to a quality of the mind). In mainstream physiology, however, the intellect falls within the domain of the nervous system and should therefore be equated with vata. Such equations therefore tend to be untenable because the principles of classification in mainstream medicine (derived from a structural theory) and Ayurveda (based upon a holistic and systemic theory) belong to radically different orders. When mainstream physiology speaks of nervous tissue, muscular tissue or epithelial tissue, the principles of classification are anatomical, based on structural differentiations. In the Ayurvedic triadic classification of vata, pitta, and kapha, the basis is biological and based on systemic functions.

To cite another example of incompatibility, the essence of the mainstream laboratory method is to first isolate an object or

aspect from its environment, eliminate temporarily its real links with other diverse factors in nature, and then artificially reduce its relationships to engage the minimum possible number of measurable and controllable parameters. These parameters are then varied (usually one at a time) and their effects on the object studied. Finally, there is an attempt made to integrate the findings arising out of the 'disintegrated' studies. In contrast, the Ayurvedic approach attempts to solve a problem by considering it in its entirety, including its interlinks and outside connections. This method of solving problems in their natural setting (yukti) seems to be efficient in providing balanced and realistic solutions.

Indian systems seek to study nature by systematising natural phenomena, and to make them rigorous rather than destroy their essential unity and multifaceted character. Thus, according to the Caraka Samhita[1], Ayurvedic science is dependent upon a method that perceives phenomena brought into existence by the coming together of a multiplicity of causes. Having perceived this multiplicity of causes, it uses yukti (solving problems in their natural setting by experiments) to bring about holistic understanding and design appropriate actions and material at the appropriate time and place. Thus, the traditional system, even in its theoretical formulation, seeks to find a holistic strategy for healthy living rather than dissecting life and then trying to string it together again. It appears, then, that while traditional sciences are built upon a stupendous amount of detailed and minute observations, they do not support a disintegrated scheme of experimentation in the modern laboratory sense of the term.

To elaborate further on the differences in approach: the Ayurvedic analysis of matter is done in terms of panchabhutas (the five states of nature), which are cognised by the five sense organs resulting from their contact with material states. For example, sound is an attribute of space and is cognised by the ear; touch an attribute of air cognised by the skin; form an attribute of fire cognised by the eye; taste an attribute of water cognised by the tongue; and smell an attribute of particulate

1. Caraka Samhita, an Ayurvedic text dating from 1500 BC that is still extensively used by all students of Ayurveda.

matter, earth, cognised by the nose. Mainstream scientific methods, on the other hand, analyse matter by investigating only its chemical constituents and their impact on biological activity, and assuming that its active constituents represent the whole, or only relevant, substance.

Although measurement and quantification are an important part of endogenous systems of medicine, they differ in form from their mainstream counterparts. Most measurements in the traditional sciences are made using units that are 'normalised' for an individual. In yoga for instance, a matra (unit) of time is defined as the time taken by a sleeping individual to complete one cycle of breath; one inhalation and one exhalation. Although measurement and quantification have their place in Indian Systems of Medicine (ISM), their role is different from that found in mainstream systems. In India, it is not the geometry of Euclid but the grammar (astadhyayi) of Panini that is considered the supreme example of the construction of theory. Indian sciences are based on the understanding that numbers and symbols are not essential to achieve scientific rigour. Rather, the technical use of natural language, such as Sanskrit, has sufficed, even in highly abstract and technical topics like logic, mathematics and Vedanta. Indeed, Panini has been described by many as the Indian Euclid for his context-sensitive grammar and ability to solve complex problems.

8. CONCLUSIONS

Health-seeking behaviour trends over the last decade suggest that medical pluralism, also referred to in recent literature as complementary and alternative medicine (CAM), will increasingly govern healthcare delivery systems in modern societies. According to the recently published WHO Global Atlas of Traditional, Complementary and Alternative Medicine, up to 42% of the population in USA, 48% in Australia, 70% in Canada and 77% in Germany used CAM at least once during the decade 1990-2000. Europe and the Scandinavian countries, foreseeing the future, have already taken the lead by establishing national institutes for complementary medicine. The US has been a pioneer: its National Institutes of Health (NIH) as well as several of its leading medical schools established centres for CAM almost two decades ago. Similar institutional initiatives are evident in Australia and Japan. This shift from singularity to plurality is taking place in urban settlements worldwide because it is becoming increasingly evident that no single system of healthcare has the capacity to solve all of society's health needs. In rural areas in Asia, Africa and Latin America, traditional medicine (the oral stream) meets 70-80% of the population's primary healthcare needs alongside mainstream biomedicine, which plays a smaller role.

India has a comparative advantage and can perhaps be regarded a world leader in the area of complementary medicine and medical pluralism. This is because of its strong foundations in mainstream medical sciences and an immensely rich and mature endogenous medical heritage of its own. It is the only country which has given legal status to five non-mainstream systems of medicine, namely Ayurveda, Unani, Siddha, Sowa Rigpa and homeopathy, alongside its recognition of mainstream biomedicine (allopathy). But at present all these six systems plus the folk stream function in India as parallel streams with very little interaction between each other.

One reason for limited interaction between different systems of healthcare is the confusion regarding the relevance of traditional knowledge. There are still scientists in India and other countries who believe that traditional knowledge is obsolete and irrelevant for contemporary needs. This clouded view probably has its origin in colonial and post-colonial history when deliberate attempts

were made to distort the value of non-European endogenous knowledge systems as part of a political strategy of domination.

In early 20th century sociological literature, 'traditional knowledge' tended to be depicted as backward and unchanging. Modernity on the other hand was characterised by attributes such as growth, dynamism and change. This characterisation continues to be reflected in social science school textbooks in Indian schools. This tends to create a divide between tradition and modernity, the former being regarded as generally retrogressive and the latter as progressive. In our view, however, just as the present flows from the past, so also there is a natural and an inherent connection between tradition and modernity. In essence, the modern may be described as 'evolving tradition'.

How did this misunderstanding about the nature of traditional knowledge come about? During the last three centuries, in which Europe was politically dominant on the world stage, a strange social phenomenon occurred in many parts of the world, particularly in countries in Africa, Asia, Australia and North and South America. In these countries, the colonising Europeans succeeded in creating a huge disruption in the social evolution of these societies by imposing a European tradition on the indigenous cultures. Western politicians and scholars committed what contemporary history will judge to be a civilisational wrong and a gigantic cultural blunder by misleading the indigenous intelligentsia and their countries into believing that modernity was no longer to be a natural evolution from their own past into their present, but it had to be imported from the advanced West. Thus, a cultural divide was created between an evolving endogenous tradition that was seeking to come to terms with the present, and an alien superimposition from the West decrying the indigenous effort as orthodoxy and imposing, for hegemonic purposes, its own modern cultural constructs as a strategy for modernisation of all societies. It would however be wrong to place the entire blame for disruption in the endogenous development process, solely at the door of colonialism. A part of the blame must perhaps be shared by the native leadership and attributed to some inherent temporal weakness in the endogenous cultures that allowed them to succumb.

Scientists concerned with modernisation need to understand that

while all societies can share and learn from each other, the core of their modernity must derive from their own roots. In fact, no single social culture has balanced solutions to all the contemporary social and environmental problems, and therefore modernisation should not be accepted as a mono-cultural process. Modernisation can be compared in essence to biological diversity: an inherently diverse variety of social ecosystems, each with a culturally specific process.

The challenge today for bridging traditional knowledge and mainstream science is to design a transdisciplinary or inter-cultural research framework. This is certainly possible and desirable. It is possible because both the traditional Indian health sciences and the mainstream biomedical sciences have bodies of theory and practice for managing human health. It is only their approaches that differ. In mainstream sciences, one investigates nature within the observer-observed framework. In this framework when the scientist takes the position of an 'observer' with nature being the 'observed', the epistemological question that creeps in is, how does a part of nature (the scientist), observe the whole? Evidently a part of a whole can only observe another part and can never observe the whole. Mainstream sciences therefore inevitably achieve a reduced or partial view of nature. By contrast, in the traditional Indian health sciences such as Ayurveda and yoga, one studies nature not by standing apart from it (as an observer) but by becoming one with it and thus achieving a holistic perspective. Achieving oneness is a function of a rigorously trained mind as described in the Yogasutra of Patanjali.

The design of the research framework for bridging mainstream and Indian health sciences, therefore, has to essentially address the relationship between the holistic and reductionist perspectives of Ayurveda and yoga on one hand and that of mainstream biomedicine on the other. The whole and its parts are obviously related, but the key is to appreciate that they do not have a one to one relationship because the whole is not equal to a part or parts, and even the sum of the parts does not add up to the whole. Yet they are related and are obviously complementary, if one knows how to combine them. One should therefore not be seeking equivalence in developing the relationship between Ayurveda and mainstream sciences. Otherwise, one will either reduce the whole to a part, or

assume that the part represents the whole, and thus develop a distorted understanding. Exploring ways to integrate holistic and reductionist perspectives is one of the most serious epistemological challenges of the 21st century in the field of medicine.

Collaboration between Ayurveda and biomedical sciences can be very fruitful. Mainstream science has uncovered certain fascinating and intricate details of parts that can enrich our understanding of the whole. Similarly there are new perceptions and insights that are revealed through a holistic perspective that can fundamentally alter the partial view. At a practical level, one can identify several areas for exploring integrative approaches centred round Ayurveda. These include:

- Integrative approaches for documenting clinical history.
- Integrative physical and mental examination protocols.
- Design of new forms of investigation to generate transdisciplinary evidence.
- Interpretation of diagnostic reports.
- Integrative treatment strategies.
- New outcome parameters and their measurement.
- Preventive health care strategies.
- Research into metabolic and immunological implications of Ayurvedic detoxification procedures (panchakarma).
- New designs for transdisciplinary pharmacological studies.
- Design of statistically tenable whole system clinical trials.
- Development of innovative educational modules on Ayurveda and integrative medicine.

On a more practical plane and within a more immediate time frame, integrative medical care can be implemented by establish-

ing multi-knowledge-based polyclinics and hospitals, which can provide a multi-cuisine cafeteria approach to health services, located under one roof. This strategy for functional integration will require mutual respect and understanding and the creation of an environment for cross referrals amongst medical professionals trained in different systems. It will involve an appreciation of the strengths and limitations of different medical systems and, based on this appreciation, a carefully worked out code of ethics for referrals. Such a plan for functional integration would immediately provide better options and informed choices to millions of healthcare seekers and one need not wait for the more complex, research-led epistemological integration to be completed.

In the light of contemporary health-seeking behaviour trends, the challenges and opportunities provided by good integrative medical research and good integrative clinical practice are staring us in the face. We anticipate that the outcomes of such transdisciplinary research will be very rewarding. They have the potential to result in the creation of new, multi-cultural knowledge products that can perhaps make original contributions to the world of medicine. Judicious and urgent action is called for, however, as not all health knowledge workers have the sensitivity to see the writing on the wall.

An Ayurvedic doctor and his patients

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Traditional leaders and experts in Bongo, Northern Ghana

Chapter 3

Endogenous Knowledge in Northern Ghana

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1. INTRODUCTION

This article presents the ways of knowing among the Gruni and Dagara communities of Northern Ghana. These ways of knowing have been handed down over generations and are at present being used by people of the communities in their daily lives.

The information presented here is based on an interactive and mutual learning with members of the Gruni community in the Bongo and Kalbion areas in the Upper East Region and and the Dagara community in the Gengenkpe and Tangne areas in the Upper West Region of Ghana. The stakeholders in the provision of these insights include the development staff of an NGO, the Centre for Cosmovision and Indigenous Knowledge (CECIK), the University for Development Studies (UDS) in Northern Ghana and the communities mentioned earlier. The joint learning has taken place through intensive cooperation over 15 years. The writers is a Dagara who has lived among and worked with the Gruni for 20 years.

Researchers and development staff have bonded closely with the two communities. Community elders have consulted ancestral beings about the justification and conditions for the cooperation. Joint learning took place through numerous interactions, participation in village festivals, rituals, funerals and socio-cultural experiments.

Participatory action research on themes including reforestation of sacred growths, development of threatened indigenous crop varieties, indigenous livestock development, grass development for natural resource management made the actors aware of and led to insights in the ways of indigenous knowing, and their dynamics and sense making.

Focus group discussions, participant observations and phased assertion interviews were held and the results have been documented and fed back to the communities. Exchanges between local knowledge holders and with persons from outside the community took place in the form of intra- and inter-scientific dialogues, cross-visits and peer reviews. Through these process-

es, the communities got a deeper understanding of their own ways of knowing, experimented with ways to improve on these and were encouraged to articulate their ways of knowing in a systematic way. They were able to determine their own strong and weak points.

This chapter presents a reconstruction of the knowledges of the two tribes and articulates our understanding of how this serves our communities and the values involved. We are aware of our limitations and possible biases. We nevertheless dare to present it to our readers and invite all to join in the efforts to come to a better formulation of our science.

Some weaknesses of our sciences

The endogenous knowledge of our people is important as it provides the basis for livelihoods. And we consider endogenous worldviews, values and knowledge communities as the most important factors that allow change to take place in a culture-specific way. But our sciences are not without weakness.

Our knowledge emerges in an oral culture and has never been written down systematically. Exchange mechanisms and intracultural methods for its validation are weak. As a result, perpetuation of some aspects of the sciences that are outmoded or have outlived their usefulness still continues as unhealthy baggage. This, combined with a marginal position in the Ghanain mainstream knowledge framework, limits the growth and consolidation of our sciences.

There is more subjectivity in our sciences than objectivity in the ways we build up our knowledge. This provides problems for generalisation, replicability and upscaling. There is the problem of doing research in a uniform manner, thus giving rise to possibility of a degree of error.

The aspect of insensitivity to gender and generational voices and interests has long been identified with African knowledge systems. Although there is a danger of stereotyping, the fact remains that there are elements of unfair opportunities and gender and generational discrimination that require redress.

For some knowledge there is a monopoly of knowledge, power imbalances in knowledge holders, and hence limited access to information for further development. There is also a limitation in passing on accurate knowledge and information to other users and to the younger generations.

The weaknesses in our endogenous knowledge are also related to our material poverty, social disintegration and unsustainble use of our natural resources. Infrastructure such as roads is lacking. Much remains to be done for improving government services in health and drinking water access. Traditional community-based economies are being destroyed by unregulated privatisation and unfair free trade. Community-based moral leadership, solidarity and reciprocity are breaking down. Corruption and large-scale accumulation of resources allow some African leaders to be far richer than the nations they govern.

Our education system does not reach all and is skewed. It neglects and often rejects the culture of the people. Research gives very little attention to our own knowledge and hardly contributes to its enhancement. Instead, it tends to replace it.

The University for Development Studies takes a different stance. It exposes all of its students to the real life situation in Northern Ghana. The university has for the past 10 years offered an MSc degree in Endogenous Development, Research and Education . Four years ago it started a PhD programme in this field. At present are about 40 PhD students and their research relates to the role of indigenous institutions in agriculture, health, informal economies and the governance of natural resources. They focus on understanding and articulating different aspects of endogenous knowledge systems and ways to revitalise them through transdisciplinary and participatory action research. This research will strengthen the ties between local knowledge holders and researchers and enhance our understanding of our endogenous knowledge.

This chapter cannot build on the results of PhD research as yet. In fact, this paper should be seen as a baseline presentation on the Dagare and Gruni knowledge communities. We hope to improve the presentation in the course of the time. We have

chosen to report some of the results 'raw', as derived from the discussions, and others as the author's own understanding of information collected. Hence the writer is both 'the researcher' and 'the researched', which brings with it a set of strengths but also weaknesses.

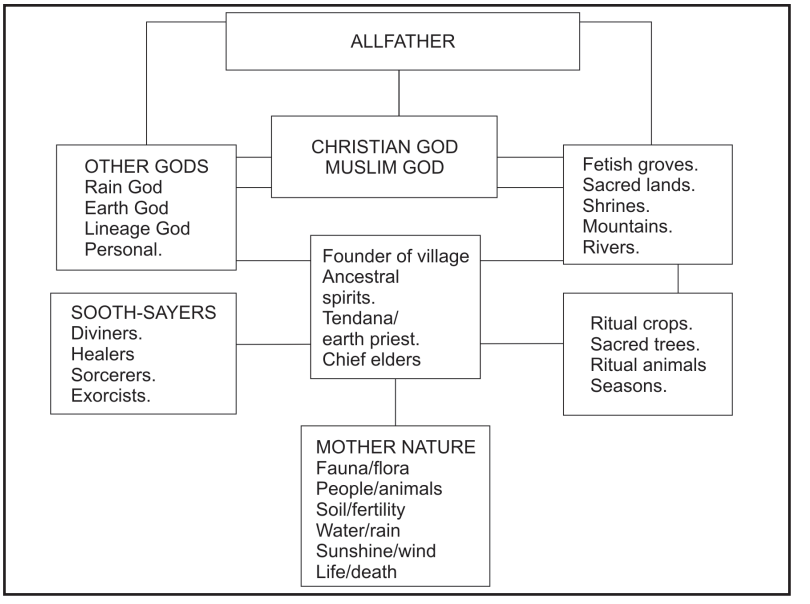
Focus group discussion with an Earth Priest or Tindana and elders in Bongo

2. ONTOLOGY: OUR WORLDVIEW

We see our existence as humans as part and parcel of the cosmic reality that consists of the social, the natural and spiritual worlds. These three worlds are inseparable and need each other so that the whole can express itself in its full richness. But, if we look at this holistic reality part by part, we can see that each of these worlds is composed of different elements, and is engaged in different processes of exchange. Interrelationships between all entities, and flows and exchange of energies are of paramount importance.

The social world, the natural world and the spiritual world are linked in the sense that the natural world provides the habitat for the spirits and sends messages from the spiritual world to the human world. The spiritual world provides guidance, sanctions and blessings to the social world. People therefore have to relate to both the natural and the spiritual world in such a way that the laws of nature and of the spirits are respected. In an effort to present the most important entities that make up our cosmos and their interconnectedness, the diagram below was constructed from the various dialogues.

FIG. 3.1 – EXISTENCE AS PERCEIVED BY GRUNI AND DAGARA PEOPLE



2.1 The spiritual world

The spiritual world is the most powerful of the three worlds and spiritual forces express themselves in human beings as well as in animals, plants, trees, waters and other parts of the living and non-living world. Our main spiritual entity is what we variously refer to as the Allfather/Allchief/The Father of All/Ultimate King/Creator/Total Owner or Naa-mwin. This is the creator of mankind and the universe. Then we have deities of different types: e.g. family gods, water gods, land gods. Further, there are parts of the natural world that have important spiritual significance: sacred places, shrines, groves, trees, waters and sacred plants and animals.

Some persons, animals, plants and locations lend themselves more prominently to spiritual expression than others. Therefore, we can make a distinction between normal lay people and people with a special spiritual position or disposition. We also distinguish between plants and animals that may serve as our food and animals that have spiritual significance and can be used to make sacrifices.

The spiritual beings ensure that life emerges and continues. Energies and vital forces determine the degree to which living beings grow, are healthy and/or sick, may die and/or may sprout up or be born again. In this context we differentiate between magical powers: 'white magic' and 'black magic'; Black Tendana (Tendaan Sobligu) or Red Tendana (Tindaan Mulgu).

A sacred grove in Bongo: place for worship and refuge for wildlife

2.2 The social world

The social world is made up of our ancestors, the living and the yet unborn. The cycle of being born, dying and rebirth is continuous and provides the opportunity for humankind to build up experiences and, in so doing, come closer to the ancestors. Our human ancestors have lived their lives in our villages, and through their learning experiences and dedication to the gods and spirits have accumulated wisdom and knowledges which they share with us. In order to be open to their guidance we have to be respectful to them and consult them through our rituals and sacrifices.

Some of our ancestors have lived long and wisely and thus have achieved a high position in the spiritual domain of the ancestors. They are in a good position to guide us. The ancestors, as spirits, also have the capacity to communicate with the living as well as with the gods and other spiritual entities. In this way they can advise us and influence our fate and lives. Some of the recipients of ancestral guidance may use their spiritual wisdom that has been conferred on them for the benefit of their families and communities, whereas others may make misuse of their position or may be possessed by negative spiritual powers.

Communities make mention of the following persons with special powers or functionaries who are able to marshal and master special energies:

- **Tindanas:** These are sons of the first settler and considered to be the son of the spirit of the land, as the first settler made a covenant with the spirit of the land conferring the right to use the land and in return to make sacrifices and pay respect to the gods. For this reason land use is governed by the Tindana.

- **Healers:** Persons with skills to cure and heal. This entails the use of spiritual, social and material forces. Healers may combine trance, magic sacrifices and the use of herbs.

- **Spirit-mediums and soothsayers:** Persons who have the capacity to see beyond the natural and social reality. They can see the reasons why things are happening and are thus often consulted to find out why a person has died.

- **Village elders and chiefs:** Historically, leadership was mainly in the hands of the Tindanas. During the colonial period, the British needed local leaders to be able to implement indirect rule. These chiefs now preside over a council of elders and rule the community in matters related to family affairs, receiving visitors, peace and conflict management.

Village chief with elders at Sirigu

- **Gender:** In our community, the men are the heads of the households. A man can marry a woman by paying a dowry to his in-laws. Married women live in the house of the husband and their children belong to the household of the man. Most of the traditional functionaries are men, but certain women can also be chosen for these positions, such as first wives, very old women, female heads of households, women who have experience outside the community and women who are considered role models for the leadership or other affirmative skills they have demonstrated. Women may also acquire special spiritual powers that enable them to perform the functionaries' roles identified above. In such circumstances these women occupy special positions within their communities, and have similar status to, or sometimes are even more powerful than, their male counterparts.

Women in the Gruni village of Sirigu traditionally paint houses with symbols and animal totems

Consulting the ancestors is generally done by men (sons, husbands and brothers do this for their mothers, wives and sisters). The consultation generally takes place by first sprinkling water and then sacrificing an animal. It ends with sprinkling of flour. The animal sacrificed depends on the type of consultation and may be a chicken, goat, cow or a dog. A soothsayer plays an important role in reading the signs of the ancestors.

In our society we have high respect for the elderly people in the community. The oldest male is the head of the household. He takes the decisions on important issues such as sacrifices and marriages, farming and social relations. At village level, a Council of Elders advises the local leaders (section heads, sub-chiefs, chiefs, paramount chiefs) on matters of local governance, local issues of justice, land use and peace enforcement activities.

We attach special importance to funerals. A funeral ceremony is carried out by a community to help a soul make the transition from human life to the life of the ancestors. Our sense of destiny means that we believe one has to live this life on earth in such a way that you first reach your ancestor after this life. Your return or otherwise is determined by the ancestral world and is based on parameters that may be good or evil, depending on the purpose of your reincarnation.

Funeral of Gengenkpe Chief

The aspect of time introduces another dimension to this discourse. For us, time is not a linear process, but a cyclical one – what goes round comes round. The past and the future are linked by the present. The dead and the yet unborn are linked by the living. For us, it is not the uncertain future, but the present time and the (ancestral) past that is considered most important. We do not have a clear vision on what the future is, or how you can anticipate the future. We do not control time or our future. Destiny controls it.

The sun is our guide in the dimension of time. Hence we have sunrise (also before sunrise), the time at which the sun is overhead (mid day) and when it sets (when the sun goes to rest). These are the major coordinates of our life. It is this worldview that largely influences what is called 'time' – hence our genuine inability to keep to Western time frames. Time is a period, not a specific event with a locus.

2.3 The natural world

Nature includes all living beings such as plants and animals and 'non-living' entities such as rocks, soils, waters and clouds. We do not speak of dead entities but of 'non-living beings'. We believe that all elements of nature are an expression of the spiritual world and are thus part of the vital force that permeates nature. For us, land is of special significance. Land provides food, provides the

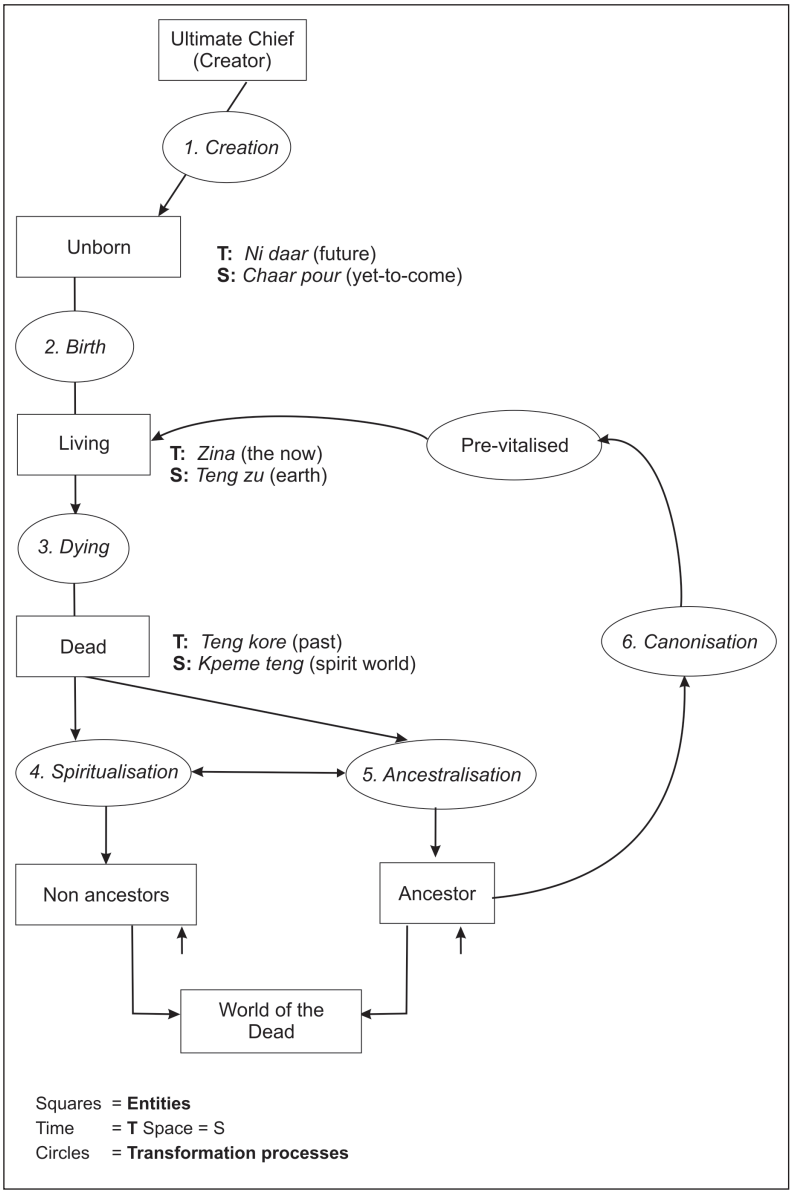
shelter for our deceased in the form of graves and constitutes a space or habitat for the spiritual beings. We believe that land belongs to the spiritual world, but has been given in custody to humans, plants and animals. Humans have been allowed to use land, plants and animals in covenants between the gods and our ancestors. Our Tindanas represent the intermediaries between the gods and the living persons who regulate the usufruct of the lands. For us, place and space with all the energies involved, are more important than matter and time as an ordering concept of reality.

Also, water is very vital for us. Water is life! Aside from the everyday uses of water, it is water that precedes every sacrifice and spiritual performance. Water also plays an extremely important role in the resolution of conflicts between two parties. A calabash of water is used to rinse the mouth and is spat out as a sign of cleansing. During naming ceremonies water plays a very important role. We also have certain water-bodies that are spiritual in character. They manifest themselves in various life-forms, provide protection or are called upon during spiritual activities. They are sacrificed to and there are several dos and don'ts associated with some of these water-bodies.

The natural world (plants and animals, even rocks, stones and mountains) exhibits similar duality – the mundane and spiritual. They have their material forms but also have spiritual forms, and may be pure or impure for sacrifices. They can also have good or bad spiritual manifestations.

Our landscape: scattered trees, farmland, grazing areas, fallow areas and homesteads

FIG. 3.2 – THE CYCLE OF EXISTENCE IN DAGABA ONTOLOGY



2.4 Life and death

In our context, the discourse about the ancestral spirits (ancestor-centrism) almost invariably makes a link between the living, the dead, and the yet-unborn. This leads to the following construct.

The world of the dead (Kpeme-teng)

It is important to state that not all the dead are regarded as ancestors. The operational definitions restricting the qualification to (a man or woman) include the following categories:

- The founder of the community or village.
- The first settlers of the clan or lineage.
- A person who has lived a special or spectacular life and has made a unique contribution to the community and has hence been 'canonised'.

Hence, in the World of the Dead (Kpeme-teng) we have, through an unknown process of spiritualisation, a category of the general spirits of Non-ancestors. By a similarly unknown process of ancestralisation, another special category is referred to as Ancestors or Saakumine. The Dagaaba believe that only those in the category of Saakumine have the ability to will their own reincarnation.

Hence some of the Ancestors, through a process referred to here as pre-vitalisation, manifest themselves in unborn pre-vitalised forms. Then, through reincarnation, they are born into the world of the living.

Kpeme-teng is a space. The time element that coincides with this space is referred to as Teng-kore (the Ancient World).

The world of the yet-unborn (Chaa-pour)

The world of the yet-unborn, from the cosmovision of the Dagaaba, comprises the un-born pre-vitalised (of the Ancestors) and the un-born created (of God). In this world of the un-borns, the space it occupies is referred to as Chaa-pour and the time dimension is Nidaar or future.

Hence the ontology of the Dagaaba has the following elements with their definitions of time and space:

- Entities: unborn created and unborn pre-vitalised (Nidaar and Chaa-pour), the living (Zina and Teng-zou), the dead

(Teng-kore and Kpime-teng) – consisting of non-ancestors and ancestors.

- The processes of transition towards existence include: creation through the Allfather, birth, dying, spiritualisation, ancestralisation, pre-vitalisation, and reincarnation.

- To keep the wheel of existence turning, the Dagaaba identify the following institutions or functionaries:

    1. Birth attendants (women, young and old)

    2. Dying attendants (very elderly women)

    3. Undertakers (largely men)

    4. Special visionaries for reincarnation (fortune tellers and sorcerers: 'gifted' men and women)

- Functionaries for pre-vitalisation and creation are not human but purely spiritual and communicate with specialised soothsayers who are human (men and women 'with the second eye').

Ancestor-centrism is key to our systems of knowing. Variously called Saakumnu, Nyaba-Itgo, Amaamere, or Ubuntu, ancestor-centrism is central to understanding the persistence of our knowledge and belief systems despite having undergone several persecutions and attempts to stifle this body of knowledge.

3.0 AXIOLOGY: OUR VALUES AND ETHICS

Our community values bind us together and keep us going. Our values and ethics are spiritual, human and natural in their manifestations. Adhering to values leads to the attainment of purity. The ultimate reward is admission to the ancestral world. It is this belief in values that gives our resilience during periods of persecution by the West and its onslaught on our knowledges.

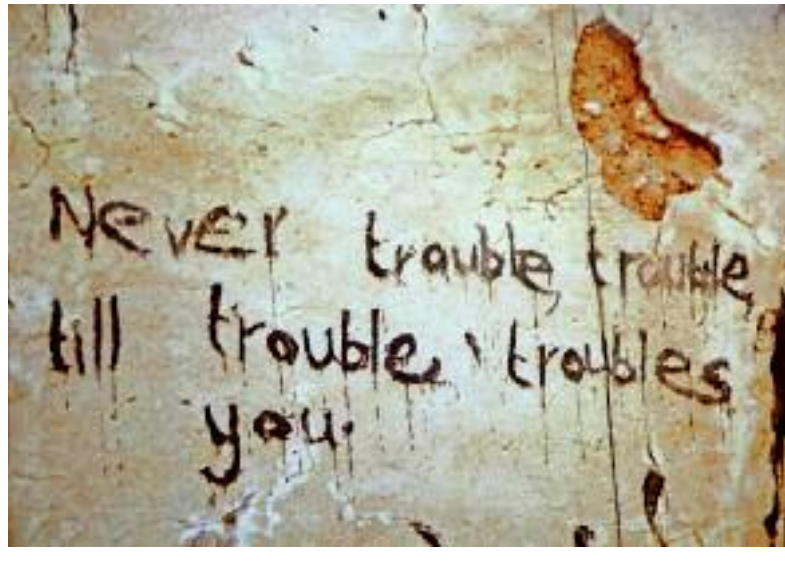
Below is an attempt to come to terms with what our ethics and values are and differentiate then from mere concepts or activities. This mechanistic separation has been difficult to apply throughout my investigations because the axiology of our people tends to derive from a holistic perspective. My interactions show that in some cases what might appear to be a cultural rule underpinning an action or inaction for a Gruni is seen as the value placed on the same by a Dagara. Also, what might be of spiritual consequence for the Dagara will be considered a human and/or material expression for the Gruni. Hence, the presentation below is a 'mixed bag' and is a write-up of the expressions as collected for the inventory that I made. This difficulty is further compounded by the fact that I could not identify one vocabulary in the local languages for ethics and/or for values (or for concepts) to facilitate this discourse, but rather had to rely on a group of words or sentences that might mean different things to different knowledge providers.

For us, the most important thing to achieve in this life is 'to be received – deb-vela – by the ancestral world when you die'. Hence, what we do or do not do is underpinned by this goal in life. We hope that our soul will become part of the spiritual domain and, therefore, we attach great value to funerals, having children, building relationships among ourselves and with our own ancestors. Women also identify with male ancestors and refer to as their 'great grandfathers'. They aspire to reach them and be well received. Seldom are female ancestors referred to unless during praise and dirge singing, when women of quality and leadership are mentioned as Zendaa Ma. During our life on earth we all (men and women) strive to develop our physical

and spiritual strengths that will reconnect us with our ancestors when we die. Our axiology provides inputs to attain this 'perfection' or 'ultimate goal'.

Hence we value qualities such as:

- Generosity: the capacity to share wealth and power, especially within extended families, clans and villages. We also share in our poverty.
- The wisdom to speak the truth and defend justice.
- Respect for ownership, marital status and the elderly.
- Friendship and kindness, especially when it is directed to persons in our own family, kin and ethnic group.



People's wisdom expressed on walls

Our interpretation of beauty and joy:

- Our sense of beauty is expressed in our clothes, our architecture, our music and dances.
- We like bright colours and our basic colours are white, black and red. The dresses of our women express the wealth and spiritual wellbeing of the families. The men wear their

smocks with pride. The primary colours used for them are white and black.

- The Chief's compound is the object of community pride.

- Our music is very rhythmic. Our drums have the capacity to bridge the gaps between the spiritual and material worlds. Through our dances we can cross the boundaries of reality by reaching a state of trance. Our music has energising and mobilising effects as well.

- We use drums and dance during festivals for rainmaking, harvesting, funerals and other auspicious occasions. Different instruments have different expressions and functions (also spiritual in nature).

Exercising spiritual activities, rituals and related knowledge are more important than technical activities, skill and knowledge, and material gains. Good humour and joking relationships are important. Our jokes allow us to say the truth in a way that is not offensive. In fact, our life is something we should celebrate. It is not the problems that dominate our minds, but the vital forces, the joy of the moment and gratitude for receiving the gifts of Mother Nature. Our enemies are those who threaten our livelihood system.

For us, our own traditional systems of governance and landuse are more important than those brought to us from outside, including those for ruling the community, for making peace and reconciliation, for enforcing justice and correcting criminal behaviour, and for offensive and defensive purposes. We still see our national system of governance as an extension of the colonial system that was brought to us by force. Therefore, paying taxes, going to elections, going to court, accepting the authority of the police and complying with the rules of the administration of the republic of Ghana, to name a few, are activities we find difficult to accept and understand but we just have to live with and tolerate.

In our notion of justice and our concepts of law, we value authority as an expression of ancestral powers; common owner-

ship of land, water and even knowledge; family solidarity in taking care of our brothers and sisters. We have our notions of equality and democracy and human rights, but they differ from the Western or republican notions in the sense that they are more based on loyalty and accountability within the ethnic structure than on individual choices and are governed by our ethics and values.

With our notion of time, we like to live in the present and do not place a premium to the future. Hence we find it not necessarily important to save money or to invest only in activities that may yield material gain in the future but rather in those that are a response to spiritual considerations. We are generally very spiritual people. Beyond our ancestral religion, we are happy to have the possibility to also relate to the gods and spirits of Christianity, Islam and other belief systems. Religious freedom and tolerance of differences are highly valued.

Violence is also part of our reality, but in general we do not accept violence against women, children and elders or violence against persons in our own clans. But if our ethnic identity or sovereignty is threatened, we may defend ourselves vigorously: ethnic conflicts and chieftaincy disputes sometimes lead to violent clashes. We have our own mechanisms for dealing with criminality: reconciliation and restoring relationships is more important than punishment. If our lands and livelihoods are being threatened, our people can be mobilised easily. In case of wars, men are the fighters. Women provide the logistics. We have a number of taboos that regulate and guide our behaviour. These are intended not to disturb the vital forces and harmony in nature. We have totemic relationships with plants and/or animals with which we have established a spiritual and ancestral relationship.

3.1 Our notions of poverty and of living well

Our notions of poverty, wealth, and living well are regarded as aspects of spirituality and are captured in expressions like Ubuntu, Mma-mere, Saakumnu and Nyaba Itgo. Hence the cosmovision of our people appears to be the basis of our worldview on poverty. We place more value on people than on things (material and mundane). A person's wealth is measured by his

following – how many people he feeds and how many he can influence. It is one's social capital that matters. The question is often asked: 'How much do you take to your grave when you die?' This reminds us of the limits on how many material things you can take and how much goodwill, good deeds and blessings you can take with you. A direct expression of this position is how well attended one's funeral has been. It is the belief that the measures of these values are predictive of the likelihood of one reaching one's ancestors when one dies.

Wealth and money are caught in these dialectics of cosmovisions and hence on debates about poverty. We make a distinction between money and wealth. Money is a medium of exchange and wealth is about relationship building. A good man is a man who has and shares his wealth with others – someone who has money, but most importantly has social capital. The socio-cul-

Cattle are an expression of wealth

tural underpinnings of wealth, and hence poverty, provide partial pointers as to why livestock is not necessarily sold for cash when in need – livestock is not seen as money but as wealth – in the form of cash, material and spiritual depositories.

Some attributes of wealth are:

- Type of job (or combinations of jobs)
- Household size and number of wives and children
- Type of house and furnishings (beds, bedding, chairs, etc)
- Ownership of transport, travel behaviour
- Type of clothes and ornaments
- Food consumption: how many times a day and what quality cash holdings and cash reserves
- Ability to lend money to those in need
- Education and level of exposure
- Health and handicaps
- Performance of funerals and rituals
- Specific festivities and festivals performed
- Kindness and generosity
- Mode of obtaining and use of profits
- Sympathy and likeability
- Friendliness and approachability
- Empathy and reciprocity

Based on these attributes, our communities strive for wellbe-

ing that is measured in terms of happiness (this entails a paradigm shift from Gross National Product (GNP) as a measure of prosperity in the Western knowledge system to a measurement of Gross National Happiness (GNH) in the context of Africa.

The above sets the stage for the ensuing discussion on the concept of living well. The perception and notion of poverty of the African people is therefore more holistic than that identified by Western science and development agendas.

4.0 GNOSEOLOGY: THE WAY WE LEARN, TEACH AND ADAPT OUR KNOWLEDGE

We consider our knowledge as ancestral knowledge. Ancestors are our 'library'. Any innovation or deviation in the use of our ancestral knowledge can only be carried out after consulting our ancestors. The 'owners' and developers of this knowledge are referred to as the knowledge community. We have tried in the subsequent paragraphs to present the complexities of our knowledge system.

4.1 Forms of learning and knowing

The family homestead is the nerve centre of all learning. It is here that primary (self-generated) learning occurs and it is here that secondary (externally induced) learning is refined. Most socio-cultural and religious (spiritual) learning takes place here. The family tree's roots are in the homestead. It is here that an apprentice learns the family trade and secrets and gets an understanding of the strengths and weaknesses of each member of the family.

The family unit is surrounded by an active environment referred to as the immediate environment, which is a combination of locations such as markets and drinking bars, farms. It includes functions such as hunting, water/fuel wood fetching, marriages and sacrifices. Interactions between people and their immediate environment for purposes of learning are more aggressive and spontaneous than those with the 'distant environment'.

The second level of knowing, which is referred to here as the 'distant environment', involves locations such as government institutions, external religious institutions. It includes migration and travel. Migration is often generally described as a wage and a labour activity but it is also important for the exposure it offers, in particular providing a milieu for learning.

There is a constant interaction between what the people generate themselves using their indigenous knowledge and the influences of 'external knowledge'. The various environments identi-

fied in this study reinforce the interactions and overlaps between the two knowledge bases. Beyond this, the 'knowing environment' deals with the difference in degrees of interactions of two bodies of knowledge: showing the differential emphasis within a socially constructed relationship.

4.2 The 'learning distance'

Social distances that are not geographic but socially constructed are discernible among families within the communities. These distances affect the learning among members of the community and this is what I refer to as 'learning distance'. Basically 'learning distance' is an expression of the extent to which learning interactions occur or to what extent family 'trade secrets' can be or are actually shared. It shows the heterogeneity in learning within one family and between families. Thus within one family, the relative social distances depict the intensities of the heterogeneity of what is learnt as a result of interactions.

Within our communities there are family lines that have been endowed with special skills by their ancestors. It is only people within a particular family line who are recognised as being appropriate to perform particular functions. One example is of the blacksmiths who make farm tools. Since the secrets of the trade are a spiritual gift, they have to be processed and protected in a special way by the family line. From this perspective, the 'knowing environment' depicts the fact that the closer you are to the centre, the higher the chance that you will be exposed to the family secrets, and the further you are away from the centre the less are the opportunities for you to be exposed to the family or trade secrets or skills (the centre being the ancestry with those special spiritual gifts).

4.3 Wulu: tutelage or apprenticeship

Wulu simply means showing, which also doubles for teaching. Wulu covers all ages and therefore spans an unlimited period. It has no time and space restrictions. The end of a wulu cycle is marked by certain social practices, in particular the commencement of individualisation as expressed in the allocation of productive resources.

Cognitive forms of wulu are dominated by experiential learn-

ing. This includes the conscious educational process the young go through at the hands of the elderly by way of following the footprints that the elderly have left behind for them. Modern development polemics have confused this with child labour exploitation. What it implies, however, is instructing and observing the performance of the instructed, demonstrating and giving the task to try out, or sometimes doing the task together with the apprentice. This form, therefore, involves giving a set of instructions and a body of information, and demanding an output in the form of fulfilling a task. Another form is demonstrating an action and asking that it be repeated. These are often not events but processes that are repeated over and over until skills are properly mastered. Redundancy or superfluity is therefore one of the techniques we use to ensure that effective wulu is attained. It is similar to formal schooling, where a set of instructions is administered before performance and accompanied by supervision and support during performance.

Non-cognitive forms of wulu: indigenous ways of learning consist of using images and symbol, rituals and ceremonies, proverbs, riddles, stories and songs to teach and to learn. There are histories narrated in connection with these occasions, culture is evoked and knowledge so acquired is exhibited in both content and processes. In addition to 'schooling' in culture, history, and geography, the occasion serves to perpetuate religious ideas and pass them on to succeeding generations. An example of this includes reflex actions related to the occasions listed above, which result in the young trying to mimic or imitate what the auspicious events communicate to them.

Imagery and symbols are very active learning tools that are utilised by rural communities for performing rituals and the young learn from them. Among other forms, songs are a very powerful way of communicating.

The art to communicate skillfully using songs has to be learnt. The message is in the words of the songs. For example, songs are composed about pupils who are very good at farming. Similarly, there are songs about students who are poor at farming. There are also songs about good hunters and good hunting.

Proverbs and wise sayings are the prerogative of the elders. This is an advanced form of tutelage and one that best expresses the wisdom of old age. It is a value-laden way of teaching the young. Although it is the elderly who most frequently teach in proverbs, a measure of an excellent student is the ability to translate the teacher's proverbs, or even to speak in proverbs to peers and subordinates, but not to superiors. It is very common to have a riddle/proverb session during moonlit evenings in rural communities, a little like a quiz competition. Proverbs test knowledge, convey learning and perpetuate skills. There are occasions when competitions are organised between communities on proverbs and the richest community in terms of both the number and quality of their proverbs (with respect to the learnings that they generate) is identified and hailed.

Establishing proof of knowledge: bangfu

Bangfu is experiential learning that often occurs simultaneously with wulu. It means establishing proof of the knowledge and skills that have been acquired. The challenge is to apply the experiences acquired so far to new sets of information. The common form of this is similar to the Western notion of an examination. However, since general testing is done as knowledge is being acquired, bangfu is only additional. Often during bangfu live situations are used (unlike the use of prototypes in wulu) and therefore risks have to be minimised. Similarly, the pupil is aware that what he is doing is contributing to actual production and therefore the challenge to do his or her best is greater. The combined action of these 'push and pull forces' in learning gives a basis for bangfu which sometimes runs concurrently with wulu.

Graduation: oogfu

Oogfu is the final expression of formalised bangfu and is a type of graduation or passing out. Literally it means to ostracise, but it is more like weaning. In practice it means that some factors of production and consumption are given to the graduating pupil.

This is the signal of individualisation within the community. Additional sacrifices are done to signify that this is happening. The sacrifices are intended to inform the gods that part of the ancestral property is being passed on to a member of the clan,

and their secondary purpose is to ask for the gods' blessings so that the skills the young person has acquired become productive.

Showing off: gandaalu

Gandaalu is the sort of learning that is generated by social or peer pressure. It is both horizontal and vertical learning for the young and exists also among the old. The young on their own provide tutelage for themselves, based on that which they have acquired vertically; set tasks and challenges and realise them judged by their own standards. Gandaalu means showing off, and gandaa stands for excellence. Through gandaalu, learning that has resulted from showing prowess and excelling is appreciated and rewarded. It is an indication of a distinction in learning – a cum laude. It is every young man's aspiration to attain these heights among his peers by showing what he has acquired from his master. Gandaalu is, therefore, more of a learning mode among peers, and has its own internal rules, regulations and dynamics, with the accompanying rewards and punishments.

Knowledge markets and networks

In the wider sphere of horizontal learning, most knowledge is largely family owned. That which is acquired in common on the 'open market' is further processed and transformed within families to perfect it for their comparative advantage. The adage that 'knowledge is power' is closely adhered to and exhibited, especially among the elderly. After making additional efforts to perfect knowledge, it is patented as family secrets, and such special skills are jealously guarded. That knowledge which does not belong to the category of family secrets is traded for payments of some sort. This accounts for the 'partial commoditisation of learning'.

Very often in horizontal learning, knowledge is traded for knowledge, either paid for immediately in cash, in the form of a tool, in kind (harvest), or deferred as a form of indebtedness against the future. There are also knowledge networks (learning networks) that are built on confidence, dependence and trust. There is a mental value put on traded knowledge, which is used in determining what should be traded-off, and the magnitude

of the expected payment. All these, when pulled together, often result in some form of social network.

Elder with his grandson and ancestral shrines in Bongo

4.4 Organised learning

Learning types discussed here are less discrete, most common, and are dynamic in their inter-role changes. I identified three forms of learning. These I categorise as pro-active, inter-active and reactive.

Pro-active learning

Farmers' experimentation types are often categorised as curiosity, problem solving and adaptive experimentation. All three forms describe farmers' experimentation in its reactive forms – responses based on an earlier action. In my work on the same subject I discovered peer/social pressure experimentation, which is more spontaneous and thus closer to proactive forms of learning in the sense that it is an action preempting future actions – gandaalu as influenced by people's cosmovisions. In a quest to learn, people might be seen deconstructing apparently strong structures just to rebuild them as a test of prowess. This activity sometimes results in re-inventions in preparation for an uncertain future. The person is often using his own generative capacities. Basically proactive learning is intended to be preemptive or to stay ahead of others and maintain one's lead over one's peers.

Interactive learning

In interactive learning there are role-reversals: on one occasion the learner becomes the teacher and vice versa. There is also constant switching between the subject and object of learning. Here issues are discussed both bottom-up and top-down. For example, if there is a cultural problem to be resolved, the elders compromise their position of authority and allow for views from the youth and the women as well. The advantage here is to allow for maximising institutional memory. Also information from 'the outside' is allowed to be brought into the learning (almost invariably this outside information is from travellers or from the markets – the youth are often the most travelled in the community and the women are believed to be the most gossip-rich). Other forms of interactive learning are found in experiential learning as well.

Among the Dagaabas, it is rare to find girls being encouraged to do 'male farming activities', such as land preparation, mounding and some aspects of weeding. However, it is common to find younger boys doing reproductive jobs that are meant for girls. Boys fetch water and fuelwood, cook on the farm and wash the dishes. As they grow up, part of their adulthood is expressed in graduating out of these reproductive activities. On the other hand, the reverse occurs for women. A girl would only

go through tutelage in farming under her father if she is either the only child or the man has no sons. Otherwise the farming activities involving girls are limited to sowing and harvesting.

Reactive learning

This is learning that is purposeful, where the purpose may just be to satisfy one's curiosity or to prepare oneself for some future uncertainty as informed by the present. Reactiveness may be confined to one spot or there may be ripples of reactiveness that are ultimately far removed from the causes of learning. Because of the unpredictability of our environment there is the need to learn and share, and support one another in our preparedness towards dealing with risks. Hence, every farmer is involved in reactive-learning at all times and in all stages of his farm operations. This is done both as an individual and jointly with others.

5.0 EPISTEMOLOGY: HOW WE ORGANISE OUR KNOWLEDGE

One way to understand how our people are organising and building their knowledge is addressing the what, how, why, who, where and when. The 'who' is discussed under the 'knowledge community' and concerns the actors engaged in knowledge production, development and use. They include local experts, gatekeepers, specialists, learners and the ancestors. The 'where' is within the household or the community or common property (on sacred sites or in purely mundane areas). 'When' refers to normal times or auspicious moments that capture the present, the past and the future in a cyclical manner. These aspects, though relevant, are not the focus of the analysis here because they provide very limited insights into my work. I obtained a deeper understanding of our knowing (epistemology) through an in-depth study of the what, why, and how and their interactions, which I share below.

5.1 The why, the what and the how

The ensuing discourse brings to the fore the complexity and the holistic nature of our knowledges and sciences. The understanding, constructions and narrations are all the author's own way of unravelling this complexity.

We have developed our own notion of cause and effect: things in the natural and human worlds do not happen by biological, physical or social process only, or by chance. There is also spiritual force behind material processes. A climatic condition, health problems, social conflicts and even birth and death are guided or controlled by spiritual forces. The Allfather, deities, ancestors and other spiritual beings interact with the natural and social worlds and, therefore, humans have the opportunity to appease these forces through good conduct as well as through sacrifices and rituals.

We do not have only a mechanistic or linear way of explaining things as we are taught in school. An event may have several causes: physical, biological, social, moral or spiritual. The wise way to pre-empt a situation is to address the different forces. Therefore, any activity of healing, farming or family-related

rites of passage involve the combination of biophysical, social, and spiritual or ceremonial activities and allow for multiple (and possibly even mutually inconsistent or contradictory) explanations of why the events take place. We do not believe that there is only one truth, and that we have the capacity to come to grips with this one and only truth, but we believe in a multiplicity of truths.

A rainmaking ceremony involves dancing, drumming, drinking and eating as much as it involves sacrifices and praying. Healing may involve the use of herbs, sacrifices of chickens, invocation of magical forces and consultation of ancestors. Farming involves land preparation, sowing and weeding, as much as sacrifices for the spirit of the land and family- or community-based labour, with drumming, drinking and meals.

We do not believe that there is only one truth or one logic, but many different truths. These truths can exist together. Different persons may have a different explanation for a certain thing or event. Therefore, for deciding what the best decision is, consultation of the ancestors and interpreting the responses of the ancestors requires the mobilisation of our best advisors in the community. Our chiefs have councils of elders, and different soothsayers may be consulted in important matters (the knowledge of the 'whiteman' and of our educated children can also be used for validation and cross-validation).

As part of the logic, one is also expected to establish the 'what' of events. This dimension spans spirituality, humanity and nature. Through the lenses of our cosmovision, sense or meaning is attributed or given to a 'what' of an action or inaction or an event.

5.2 The spiritual level

Ancestors or Saakumine are the first grandfather of a lineage, the founder of the village, and similar elders of the lineage who have distinguished themselves in leadership roles. However, a grandmother in the same category is not called an ancestor because she came from another lineage. There can be many ancestors or a group of grandfathers in the same lineage. Saakumine are, therefore, dead male parents at the remote end of the lineage who the living beings or people can still remem-

ber very well. They are a point of reference for those alive when it comes to family, household or lineage matters. The Ancestors are at the apex of the ontological ladder. All knowledges and wisdoms emanate from them and are created and recreated by them. There is an array of spiritual institutions that safeguard the interest of the Ancestors and that are in constant dialogue with the ancestral world – forming a vital link (inter- and intra-connectedness) with the Mwin (Allfather).

Dagara believe that all living things have sie or vuru - this is Mwin's (God's) gift to all His creation on earth. If this is extinguished, there is no life or the living thing is dead. In the tree kingdom, for example, the Dagara believe that the sie of a tree can do harm to a person who kills it. There is a popular saying: 'a tie nyogu na', meaning the sie or soul of the tree has harmed the person who killed it.

5.3 African technical knowledge and practices

Below, I give a brief summary of some literature on various forms of African indigenous technical knowledge: soil and water management, crops and trees, animal production, medicine, food processing, metallurgy and building techniques. (Goduka 2000, Emeagwali 2003, and Wiredu 2005). Note that this information goes beyond the Dagare and Gruni communities at stake here, but in most cases the knowledge and practices presented here do apply to our communities.

Soil and water management: One of the common characteristics of the African cultures is the perception that the earth is associated with the concept of the mother, or womb. It is often considered to be a deity, the property of the gods, and the founders of a clan or tribe who were the first settlers in the area. Traditional functionaries, such as the Earth Priest, exercise spiritual control over the land. A wealth of information exists about agricultural traditional knowledge, especially on soil classification and practices of soil and water management. Mulching, use of water pockets in plant holes, soil conservation, traditional erosion control, water harvesting and irrigation are all examples of effective practices, which are still widespread and to a large extent explain the food productivity in areas considered marginal by conventional standards.

Crops and trees: An overview of literature on traditional management of crops and trees reveals that the subjects most frequently dealt with are sacred groves, agro-forestry, plant breeding and crop cultivation. Again, the literature gives more information about the biophysical aspects of traditional use of trees and crops than about the cultural and spiritual dimensions, with the exception of studies on sacred groves. Several studies stress the importance of sacred groves in relation to the efforts of the rural people to appease the spirits related to rainmaking, good crops or health. Traditional spiritual leaders play an important role in the management of these important patches of high biodiversity. Several authors (Fairhead 1993, Millar 1999) also indicate that sacred groves can be an important starting point for development and rehabilitation of savannah areas, forests and wetlands.

Indigenous agro-forestry is widespread and several systems are described in the literature. Farmers know the qualities of trees, what they can be used for, and the possibilities and limitations of combining trees with crops. Some tree species have a spiritual significance, which is reflected in taboos and rituals associated with them. Many studies on the traditional cultivation practices of crops, including traditional food crops and wild plants, can be found.

Livestock keeping: Livestock systems in Africa are extremely complex. In a broad sense we can distinguish between two major livestock systems, which are the extremes of a continuum: livestock systems associated with settled farmers and pastoral husbandry systems. The role of animals in the spiritual life of African rural people is quite unique and has been the subject of several studies. These describe beliefs and practices related to livestock on aspects such as feeding, breeding, animal health, small stock and wild animals.

The literature also shows the immense changes that African livestock production systems are undergoing currently, especially the pastoral systems, due to modernisation, population growth and government policies. It is necessary to look at indigenous knowledge related to livestock in the context of the culture of the people involved. In many ethno-veterinary and animal hus-

bandry studies, this aspect has been overlooked, focusing mainly on the use of medicinal plants for curing diseases. There is much potential in activities that combine ethno-veterinary aspects with village-based animal health care. There is an imbalance in the extent to which the different animal species are studied, and the use and importance of the species in rural peoples' lives. For example, most literature on fowl deals with chicken, though many families use a combination of species including guinea fowl, ducks, turkeys and pigeons. There is potential for working with rural people, especially women, by focusing on these 'non-traditional' species.

The role of women in relation to livestock is subject to many changes. In some cases they have become more involved in livestock, in others less; the effect on their social position and status is also very varied. In the past few decades there has been a decline in 'conventional' livestock projects, due to disappointing results, especially the range development projects, and the projects based on the import of exogenous breeds. Meanwhile, the number of 'innovative' projects, for example on ethno-veterinary medicine and village-based animal health care, has increased. In Africa, there has been a sharp decline in the number of traditional breeds which are integral to local culture, ecological circumstances and social structures. It is necessary to look at these breeds not only in terms of the conventional productive role of livestock (like meat, milk and traction) but also in the context of manure, risk management, transportation and society and culture.

Medicine: According to Emiagwali (2003), African traditional medicine is holistic and attempts to go beyond the boundaries of the physical body into the spiritual. This is in contrast to Western biomedicine, which views the body mechanistically in terms of individual parts, and is derived from the germ theory of disease. African traditional medicine can be described as mind-body medicine. Some common medical principles have emerged over time in various African regions. These include several scientifically proven techniques and strategies, some of which are culturally specific and of psychological importance. Among the common principles and procedures utilised in African traditional medicine are hydrotherapy, heat therapy,

spinal manipulation, quarantine, bone-setting and surgery. Incantations and other devices of psychotherapeutic dimension are often applied. Western-based pharmaceutical companies often send agents to tap the knowledge of traditional African pharmacologists. Treatment for cancer, obesity, drug addiction, diabetes and other ailments have benefited directly and indirectly from traditional African pharmacologists through plants such as the African willow (South Africa), the hoodoo plant (Namibia), iboga (Gabon and Cameroon) and other botanicals. Carlson (2002) acknowledged that Shaman Pharmaceuticals collaborated with 58 traditional doctors from 7 provinces and 42 communities in Guinea, West Africa, between 1994 and 1998. As a result of this collaborative venture, 145 plant species were identified as useful for the treatment of type-2 diabetes.

Food-processing: Indigenous fermented foods in Africa are usually derived from cassava tubers, cereal legumes, oilseeds, palm tree sap, milk and various other local products. Common to various parts of the continent are dehydrated granular food products which involve fermentation, frying and de-juicing; or products such as sorghum, maize or other cereal fermented and made into alcoholic beverages.

African civilisation may be associated with specific methods of preparing and even consuming food items in ways which reflect some measure of relative uniformity throughout the continent. Fast-food items range from couscous to gari or cassava granules; various types of cereal-based flour, pulverised tubers of various kinds and a wide variety of vegetable-based soups have given African culinary traditions a distinct character.

Metallurgy: Schmidt (1997) carried out extensive research on steel production in ancient East Africa. Africans have used various types of metal products over time, including gold, tin, silver, bronze, brass and iron/steel. The Sudanic empires of West Africa emerged in the context of various commercial routes and activities involving the gold trade. In the north and east of the continent, Ethiopia and Nubia were the major suppliers of gold, with Egypt being a major importer. In Southern Africa the Kingdom of Monomotapa reigned supreme as a major gold producer. In the various spheres of metal production specific

techniques and scientific principles were applied. These included excavation and ore identification; the separation of ore from the non-ore bearing rocks; smelting using bellows and heated furnaces; and smithing and further refinement.

The use of multishaft and open-shaft systems facilitated the circulation of air in intense heating processes whilst the bellows principle produced strong currents of air in the context of an air chamber expanded to draw in air through a valve or to expel it. Note that the various metal products were used for a wide range of purposes including armour as in the case of some Northern Nigerian city states; gold, silver, iron, copper and brass jewellery; currency including circular and non-circular coins; pots and cooking utensils; cloth dyeing, sculpture and agricultural implements. The technical know-how and expertise associated with blacksmiths helped to enhance their status, although they were also often associated with supernatural and psychic powers as well.

Building technology: Emeagwali (2003) describes how, in various parts of ancient, medieval and contemporary Africa, building constructions of various dimensions, shapes and types emerged, reflecting various concepts, techniques and decorative principles and specific raw material preferences. Builders integrated the concepts of arch, dome, column and aisle in their construction. The underground vaults and passages and rock-hewn churches of ancient Ethiopia are matched in Nubia and Egypt with pyramids of various dimensions. In the Sahelian region, adobe or dried clay was preferred in the context of moulded contours at times integrated with overall moulded sculpture. Permanent scaffolding made of protruding planks characterised the Malian region. The principle of evaporative cooling was integrated into the building activity. Mats were utilised as part of the décor and were also wetted repeatedly, to cool a room.

6.0 OUR KNOWLEDGE COMMUNITY

Education and socialisation take place through living together and, among others, mimicking existing activities and skills of the adults. They are also supported by correcting activities, recognition, ceremonies and story-telling. Teaching is done by everyone in the community although there are also 'knowledge experts': parents, grandparents, neighbours and elders are all engaged in teaching. Education is a collective responsibility. Education takes place in the local language. Our language is rich and has many words, and we have ways to describe the processes we see in our worldview or cosmovision (proverbs, wise sayings and parables are critical modes of advanced communication). Members of this knowledge community also include the family, the community, the old and the young, local experts, spirit mediums, skilled experts and certain relevant 'external actors'. Hence it is not a closed system.

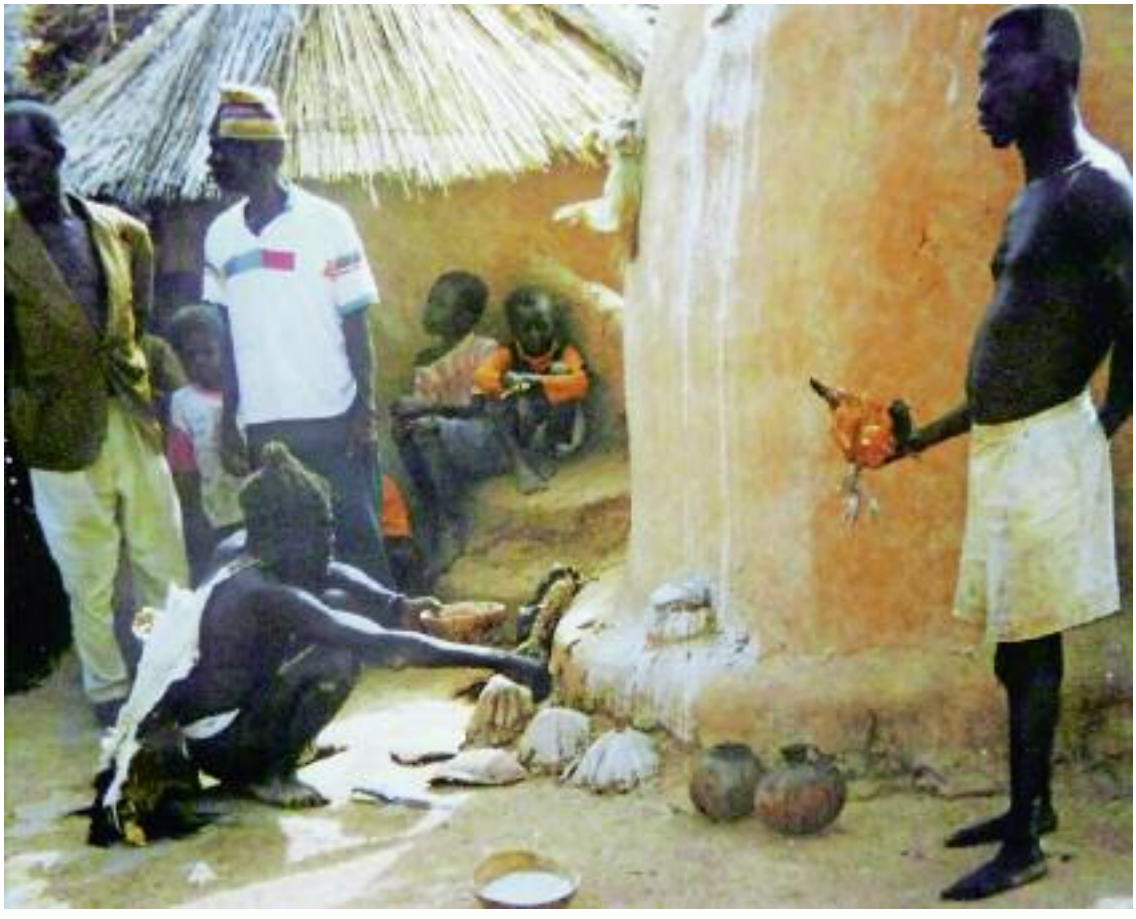
The gatekeepers of knowledge are the 'knowing institutions' – spiritual, social and material institutions. The perpetuation of knowledge among the community is a gift from the Allfather, transmitted through individual experts, community experts or family heirlooms. The way knowledge is built up and shared has been discussed above.

Since our knowledge community is holistic, it does not exclude external modes of learning – it takes advantage of relevant portions of external knowledge, through an endogenous development approach. The school system, external religions, science and development interventions, 'modern' forms of communication, critical arenas such as funerals, markets and festivals, and various networks all contribute towards the development and growth of our knowledge communities. Hence our knowledge community is formal, informal and non-formal in nature.

Common knowledge and secret knowledge

As indicated above, we have different knowledge communities for different subjects. Within each of these communities, some knowledge may be openly shared and taught to anybody interested, but access to other parts of that knowledge may be limited to those who are selected, and involves specific modes of dis-

tribution as well. Considerations include who is teaching whom, who can be a teacher, who can be taught, what makes good knowledge, and who determines what is good and acceptable new knowledge. All are addressed as ethical issues guiding these communities. This is an area that requires more in-depth research. Some of our knowledge is secret, because of its sacred nature and its powerful character; it could be misused if applied by a person not properly initiated.



Sacrificing a chicken during ancestral consultation in Bongo

6.1 Our libraries

We do not have libraries with books and computers. But we do have our own ways of producing, codifying, storing and retrieving our knowledge and information. These include written and non-written forms; another area for further investigation.

- We produce knowledge through our learning experiences, by observing the three worlds and cosmic reality. We learn together with our ancestors and deities.

- We codify our knowledge not only in specific words, metaphors, expressions, but also in sacred objects, sacred places and rituals.

- Our information is also stored in stories, myths and histories. Remembering and repeating these stories is an important skill that ensures the proper storage and retrieval of this knowledge.

- Retrieval of our knowledge and sharing of our knowledge is subject to rules, initiations and rites, funerals, rituals and festivals.

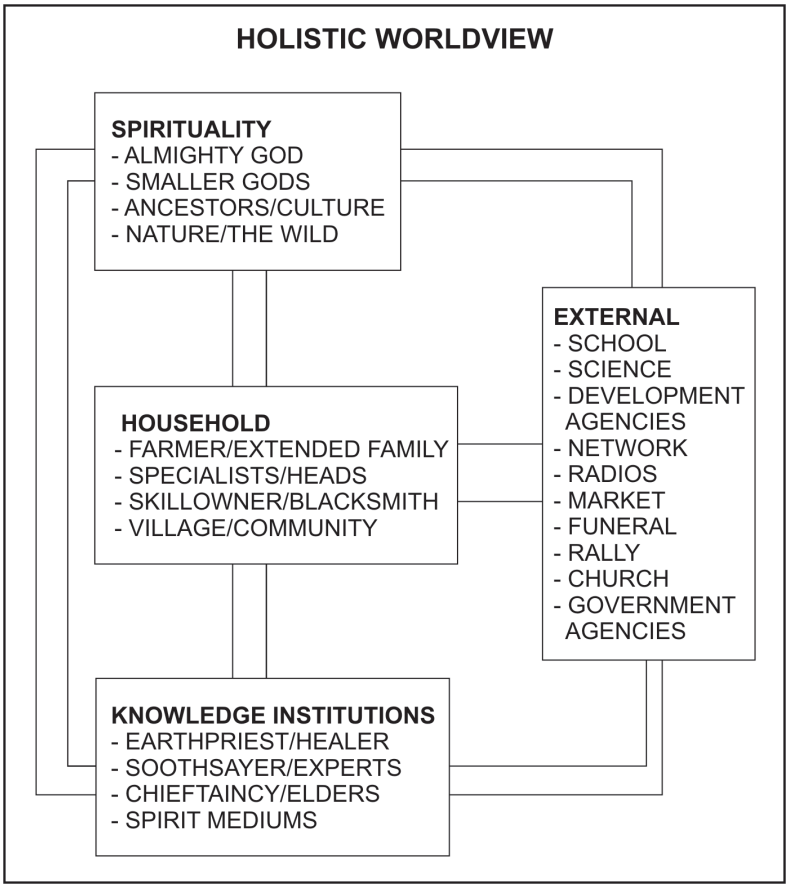
- Potential for revitalisation and complementarity with outside knowledge holders is a strong aspect of our knowledge.

- Dreams, revelations and visions provide a way to retrieve wisdoms from the ancestral world. Hence this is a window for humans to tap knowledge from the ancestors.

- The ancestors ensure that critical (spiritual) knowledge is not lost by the choice of successors and reincarnation. (Reincarnation is partly seen as a way of completing an unfinished job.)

- The ethics, code of conduct and conditions under which external knowledge holders may interfere help regulate exploitation of our knowledge with the spiritual world, and are foreseen in rituals, sacrifices, performances and consultations in the spiritual realm.

FIG. 3.3 – CONSTRUCTION OF OUR KNOWLEDGE COMMUNITY



Thanks to our ancestors we have accumulated a wide variety of knowledge that has allowed our people to live, survive and prosper, to become wise and die with accumulated experience and wisdom which they in turn make available to the living and the yet unborn; either during their lifetime or in spirit when they die.

We use this knowledge to relate to our ancestral spirits, to produce our food, to heal the sick and to govern our society. We have organised our knowledge in different fields. In that of health we have knowledge specialists such as bonesetters, traditional birth attendants, snakebite healers, healers for mental

health problems. In the field of agriculture people are knowledgeable on animal rearing, animal health, herbal use for food and curing, tree husbandry or crop production, water management, blacksmithing and landuse systems.

7.0 HOW WE ORGANISE OUR RESEARCH AND VALIDATE OUR KNOWLEDGES

The methods for testing and validating and the criteria being used for validation overlap. Process evaluation, content evaluation, outcome evaluation and impact evaluation are not as straightforward as they are in mainstream science. The holistic nature of our body of knowledge and the complexities therein result in complex variables and criteria for validation.

The actors of the knowledge community are the determiners of valuable outcomes and hence positive impact. The indications are that validations and cross-validations regularly take place, hence certification and quality assurance are also going on within indigenous knowledge communities, which my works (and those of others) still have to unearth. The ensuing notes are based on the limited insights I have thus far gathered in respect of how testing and validation is done.

7.1 How we validate our human and material knowledges

The figure below provides an illustration of how we organise our sciences. The table is divided into the relevant institutions, the experimentation itself and the environment (proof and dissemination). The framework is adopted only to show the parallel between the two bodies of science.

The institutional aspects are covered by the categories: institutions, linkage, gender, motivation and abstraction. Holism is again demonstrated here in the mix, in integration, and in the self. All this is within the paradigm of our cosmovision. The experimentation proper is covered by the experimental modes, research agenda, problem or issue identification, questions and hypothesis.

Results are proven individually, by the family, and by the community at large. Process, content and spiritual acceptability are all measured, as is dissemination. Verification and validation are a continuous process and acceptance or rejection are also a continuum. The 'knowledge owners' are the final decision makers. No matter how good, successful or productive a result is, if it is contrary to the wish of the ancestors, it will be totally rejected.

PARALLELS BETWEEN FARMERS' RESEARCH AND MODERN SCIENTIFIC RESEARCH

ASPECTS	RURAL RESEARCH	MODERN RESEARCH
Institutions	Research, dissemination and user are all mixed. Fluid task distribution.	Research, dissemination and user are separate according to the linear model.
Linkage	Research, dissemination and user integrated in one person.	Three institutions listed above are separate professional domains.
Gender	Specific and distinct according to activities, yet integrated into the whole.	Fractioned and separated in processing and later sometimes integrated as an afterthought.
Motivation	Self-motivated objective often not clear to outsider, hence experiments cannot be conducted, continued or replicated by others precisely.	Externally motivated objective but clear to others; experiments can be conducted, continued or replicated by others precisely.
Abstraction	Spiritual world is a component of experimentation; experiments have more immediate and practical relevance.	Devoid of spirituality; practical or immediate use of the result is often not too obvious.
Experimental parameters	Criteria, indicators and impact are mixed and heterogeneous. Process and content validation are mixed and done simultaneously sometimes. Validations are done by self, peers, knowledge holders, local experts and spirit mediums.	Criteria, indicators and impact are identified separately and are homogeneous. Process and content validation are separate and often done at different times. Validations are done by teams of researchers or peers.
Experimental modes	Continuous experimentation which combines curiosity, adaptiveness, problem solving and social pressure.	Seasonal experimentation (specified periods or time frame) combines basic, applied and adaptive research.
Research agenda	Multiple agenda resulting from multiple objectives integrated into one. Hence complex.	Single or few objectives hence less complex agenda. Few variables to measure at a time.
Problem identification	By self and family based on observed or heard of situation.	Researcher interest, external or client request.
Research question or hypothesis formulation	Through discussion with family and colleagues, multiple hypotheses arrived at through mental screening. Reformed later during experimentation, others can be added on or abandoned. More of a research question than a hypothesis with continuous modifications.	Through the use of secondary data or physical screening one or a couple of hypotheses are formulated for testing. Choice is made quite easily and early, and is maintained throughout experimental period. Research question and hypothesis have equal emphasis.

ASPECTS	RURAL RESEARCH	MODERN RESEARCH
Research question or hypothesis execution	Test sequencing starts from small-scale home gardens (rural laboratories).	Starts from laboratories, research stations to farmers' plots.
	Experimental layouts have no clear boundaries and may be immediately integrated into whole farm.	Clearly demarcated layout to meet specified criteria. With specific boundaries and locations.
	Often one layout with interested neighbours as a replication; thus multi-location.	Several replications in the same location; and then multiplied in several sites.
	Control is normally some information in the farmer's head, his own farm or a neighbour's plot.	Control is designed as part of lay-out; under the same environment could be primary/secondary.
	Several variables to be observed at the same time.	Variables to be measured are few and identified early.
	Results are mentally recorded.	Results are written down.
	Validation is done based on mental records and is done throughout the entire period. It is based on physical as well as spiritual measures. Done individually or in consultation with neighbours.	Validation relies on physical data gathered over experimental period and analysed at the end. Devoid of spirituality, and specific instruments are used which are universal in their application.
	Execution, analysis and the use of results are iterative; content and method evaluation are inseparable. Knowledge generation, spread and use are done simultaneously.	Results use is distinct from execution and analysis; content and methods are evaluated separately. Knowledge generation, propagation and utilisation are separate functions.
Proof of results	By self, family and peers; by community through users and soothsayer/sacrifices and cosmovision. Both as technology and how it fits into the sociocultural context. Verification and validation are a continuous process.	By professional peer group and by reference to existing logic. By fellow generators as technology. Social suitability and user view are seen as separate processes. Validation and verification are separate phases.
Research environment	Primary, risk prone, limited and in fragile equilibrium	Secondary, manipulative and re-creative.

8.0 WHY WE WRITE AND SHARE OUR SCIENCES

Having presented our science, we would like to clarify: who is going to benefit from this sharing? Our problem in presenting our science is that, one way or another, our forefathers and mothers were made to believe that our ancestral knowledge and belief system is not a real science but a superstitious way of knowing.

In the course of the colonial history European visitors came and took over our governance, our religions and ways of knowing and brought us a colonialist administration that became a republican nation state. They also brought Christianity, made a taboo of our ancestral beliefs, and set up numerous schools and colleges. We were taught in English; we learned about European ways of farming and health care.

Radio, television and Internet have exposed us to Western lifestyles: Western clothing, diets, consumer goods. And all the time the signals were: substitute your traditions for modern ones because yours is against development, illogical, irrational, superstitious and satanic.

The most intelligent of our sons and daughters in our communities went to school and reinforced the idea that their newly acquired knowledge was superior. They acquired jobs as teachers, as government workers and some became Christian reverend fathers. So, the members of our new elite were no longer on the side of our own cultrure. Our soothsayers and healers were no longer respected and performed their activities in what was considered to be the margins of our society, even though this involved the majority of our people.

Until the present day, schools continue to educate our youth in ways that replace our ancestral knowledge and, although we want our youth to become educated, we feel that it might be much better if education were given in our own language and built on our own knowledge. Of course we have also benefited from the use of this European-based knowledge and technologies. But we feel that the one-sided focus on the material world and materialistic values is a serious omission. Therefore, we wonder, what use is it for us

to share our sciences with the mainstream? Who would benefit from this type of exchange? What benefits could we have from it and what benefits could outsiders have?

We have generally steered away from sharing our intimate knowledge with outsiders as we have experienced that we are often not understood, not respected and not even allowed to practise what we believe. In fact, keeping our sciences for ourselves has been a fairly effective defence mechanism against Eurocentric aggression. So, sharing these notions now confronts us with the vulnerability of our science. But, in the process, we have also become aware that we are not the only people whose endogenous sciences have become marginalised.

We are prepared to share our science with the outside world as we hope that we can share more with likeminded people in other parts of the globe and together focus on further improving our ways of knowing, by sharing and joint learning. We even believe that our science can make a humble contribution to addressing the problems that the earth and humankind face. Our globe has produced many kinds of knowledge and science and we feel that it is wise to make use of these in a balanced way.

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Ronald Hutten, breeder of the DuRPh team, observing his plants in the field

Chapter 4

Agricultural science and potato research in the Netherlands

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1. INTRODUCTION

This chapter highlights some aspects of plant science at Wageningen University and Research Centre in the Netherlands. It presents the historical and socio-cultural roots of agricultural science and sketches the contemporary place of agriculture and agricultural science with particular reference to potato breeding.

Agricultural development has been a concern of the Netherlands governments since the international food and agricultural crisis in 1880. A state committee concluded that the two most pressing problems in Dutch agriculture were the lack of education among farmers about modern production methods and the credit facilities. It was decided to improve agricultural production through development in three areas: research, extension advice and education. This knowledge triangle became the backbone of prosperous agricultural development. Cooperative banks and cooperatives of famers for supply of inputs such as fertilisers and foddera and the sale and processing of farm products played an important role in building the rural economy. The Netherlands government also invested heavily in improving infrastructure: water and roads. It reclaimed and consolidated land.

The Netherlands was one of the founding nations of the European Union (EU) in 1958, and from the start agricultural development was a keystone of the common European agricultural policy. Initially, up to the 1960s the focus of this policy was on providing enough food for a Europe that had been faced with a decade of war-induced shortages. This included subsidising production and supporting prices for farmers through

export subsidies, import levies and buying up and storing agricultural surpluses. These methods gave an enormous boost to productivity, but became too expensive for the European taxpayer and at times have led to substantial surpluses at European level for certain commodities such as butter.

Today, EU agricultural policy aims to enable producers of food to:

- Produce sufficient quantities of safe, high-quality food for European consumers and for export.

- Make a full contribution to diversified economic development in rural areas.

- Meet very high standards of environmental care and animal welfare.

With consumers becoming ever more quality conscious about food, voluntary EU quality labels now help them make educated choices. These labels – indicating geographic origin, use of traditional ingredients or methods, including organic – also help make EU farm products competitive on world markets.

The Netherlands, with a population of 17 million people, only has 2.5 million hectares of arable and pasture land and yet, agriculture is very important for the Dutch economy. The country has about 15,000 ha of greenhouses, about 100 million chickens, 13 million pigs, 3.9 million cows and 1.2 million sheep. About 80 % of all agricultural produce is exported and the agriculture and food industry is responsible for 17 % of total national exports. These figures make the Netherlands the second largest exporter of agricultural produce in the world, after the United States of America. The animals are largely fed on imported feed, conveniently imported through the port of Rotterdam. The eggs, dairy products and meat are mainly exported and the residue – manure and slurry – helps make the soils in the country some of the most mineral rich in the world. To control the environmental impact of intensive agriculture, the government has set rules for growers in order to keep flows of nutrients (nitrogen and phosphorus) in balance. Much of the

industry's income is created through the use of genetic resources. The Friesian-Holstein cows are exported worldwide, as is pig semen and flowers such as tulips and roses and vegetables like cucumber, sweet peppers and tomatoes. Seeds of vegetables and potatoes are exported in great quantities by breeding and seed companies that are world leaders: one kg of tomato seed of certain varieties costs more than one kg of gold.

Together with agricultural education and extension services, agricultural research has greatly contributed to this knowledge-intensive sector. What is now called the Wageningen University and Research Centre, WUR, started almost one hundred years ago. But other Dutch universities and the food industry itself also have centres of excellence for research in the field.

This chapter focuses on the Wageningen research: its worldview, methodology and results, and explores how it contributed to the triple Ps of sustainability: well-being of People, sustained food production on our Planet, and a Profitable competitive agricultural sector in the country. Its slogan is Science for Impact.

This chapter will highlight the Wageningen endeavours to rid an important global food crop (potato) of its most devastating disease, late blight, caused by a fungus-like organism the oomycete Phytophthora infestans. This pest was responsible for the Great Famine in Ireland in the nineteenth century, and at present still is a major cause of losses in productivity and a driver of use of fungicide in potato production. This research is regarded as a successful example of a culmination of the long tradition of the reductionist or positivist research and development approach, yet taking societal concerns into consideration.

2. ONTOLOGY: WESTERN SCIENTIFIC WORLDVIEWS

2.1 Introduction

The roots of modern Western science go back to the ancient Greeks. Socrates, Plato, Pythagoras and especially Aristotle laid the foundations of a way of knowing that is involves understanding reality based on observation, common sense and logical reasoning. The Greeks believed in a pantheon of gods, and in an individual human soul that exists before birth and after death. Plato formulated the dualistic notion of the world in which spiritual reality is superior to material reality. Aristotle developed logic: the study of the principles and criteria of valid inference and reasoning about possibilities and necessities. In Aristotelian logic, arguments are investigated on the basis of paradoxes, fallacies, probability and causality. This logic and science was itself the beginning of efforts to secularise, disembody and compartmentalise meanings. The search for rationality, universalities and absolutes resulted in the alienation and rejection of particular and mythical knowledge and meaning. The ancient Greeks formulated metaphysical laws about the material and the spiritual world, the way to organise society and ethics.

The Greek/Christian worldview spread widely through Europe during what is known as the era of Christianisation (approximately 800-1300), replacing the indigenous animistic European worldviews, belief systems and ways of knowing of the peoples such as the Celts and Germanic tribes. During their first phase of growth and expansion (roughly 1450-1640), the transformed European countries subsequently expanded and entrenched their control over other parts of the globe through an integrated system in which churches, political powers and scientists worked together and complemented each other to further imperial interests. In this process, they also learned and borrowed from the colonised peoples. Selected elements of Arabic, Vedic and Chinese knowledge systems and technologies, among others, were incorporated into the emerging science of Europe.

This scientific development accelerated during the scientific revolution in Europe, which took place during the

Enlightenment between 1600 and 1800 AD. This era was marked by a period of economic growth and colonial and political expansionism in which the Netherlands was a prominent participant. The methods for scientific discovery and even recovery were refined. The classical idea that valid knowledge would emerge from observation, common sense and from logical interpretation of the observable world was replaced by a rational, mathematical-analytical and empirical approach.

During this period, the dominant worldviews were modified as the result of new discoveries and insights, especially from physics and mathematics. In 1543, Copernicus (1473-1543) presented a revolutionary model of the planetary system, stating that it was not the earth but the sun that was the centre of the universe. Later the Italian Galileo (1564-1642) took up Copernicus' theory of heliocentrism and published his own work confirming it. His work was violently opposed, especially by the Catholic Church, which condemned him to lifelong house arrest. During the same period Keppler (1571-1630) and Newton (1642-1727) also moved from the geocentric view to the heliocentric perspective (Drake, 1971, Bienkowska, 1973, Bechler, 1991).

Francis Bacon formulated a clear theory that laid the foundation for experimental science: Well-designed experiments could force nature to reveal its secrets. Isaac Newton formulated the laws of gravity, which enabled him to explain why the sun, planets and satellites are kept in place by these laws. He developed the prism and discovered the spectrum of light. He formulated the mechanistic worldview in which the forces of gravity and the laws of movement play a central role.

Rene Descartes believed in the possibility of reaching absolute truth through scientific knowledge. His method was reductionist, involving breaking up thoughts and problems into pieces and arranging them in their logical order. This approach is based on the belief that all aspects of a complex phenomenon can be understood by reducing them to their constituent parts. He made a clear distinction between mind and matter and replaced the notion of the divine plan of the Creator by a mathematical order of nature.

For Descartes (1596-1650) the material universe was comparable to a machine. There is no purpose, life or spirituality in matter. Nature works according to mechanical laws and everything in the material world could be explained in terms of the arrangement and movement of its parts. This mechanical picture of nature became the dominant paradigm of science, labelled as positivism. For a long period it guided all scientific methods, observation and formulation of theories. Bacon and Descartes agreed on the idea that the aim of science was the domination and control of nature, and assumed that scientific knowledge could be used to render humankind the masters and possessors of nature. To make it possible for scientists to describe nature mathematically, they had to restrict themselves to studying the essential properties of matter: those that can be quantified by their shapes, weights, numbers and movement. Other properties such as colour, taste or smell, and particularly emotions or spiritual values, were considered to be subjective and/or mental projections and were therefore excluded from the scientific domain.

2.2 Life processes and biology

The world is originally a physical entity, part of an immense cosmic reality, that in the course of its 4.5 billion years of existence (after the big bang that took place almost 14 billion years ago) has created the conditions for life to emerge. Under the influence of sunlight and with the presence of elements such as hydrogen and carbon, organic molecules emerged that organised themselves and differentiated into living cells. As a result of their capacity to divide, these cells were able to reproduce themselves, and thus life emerged. The living entities initially were composed of one cell, but in the course of history they became differentiated into more complex plants and animals. Photosynthesis is some 3 billion years old and this process led to an atmosphere rich in oxygen, which allowed organisms that depend on this element to evolve. The first primates appeared almost 90 million years ago and only 50,000 years ago did modern humans emerge. Agriculture as a practice where food is deliberately grown has only been in existence for some 10,000 years.

Biology studies the reality of living entities, and through the use

of rational reasoning, systematic observation, and quantitative measuring, and with the support of mathematics, physics and chemistry, biologists have been able to discover important laws about life processes. Amongst others they have discovered the structures and processes in cells, micro-organisms and genes as well as ecological principles about the role of sunlight in plant growth, competition and symbiosis. Important mechanisms in this evolutionary process are genes. All living entities, however different they may seem, are very similar in their basic components, the most fundamental of which is the gene.

Wageningen University and Research centre applies the insights of the life sciences in the field of agriculture and this chapter is devoted to an elaboration of this university's approach to crop ecology and gene technology. The latter is exemplified in this paper by a new development in plant breeding and genetics: cisgenesis.

2.3 The basic building blocks of life: genes

Many Wageningen scientists involved in plant sciences view the world from a Cartesian perspective; a plant is considered as a machine that can be used and altered to feed the world and not necessarily as a created living organism. Some are inspired by or would readily agree with the British biologist Richard Dawkins and the ideas he presents in his book, The Selfish Gene (1976). This book addresses the repercussions of Darwin's theory of evolution and his vision on important aspects of human society: egoism and altruism.

Genetic information of living organisms is stored in deoxyribonucleic acid (DNA) molecules, long strands of nucleotides bound to each other by phosphate groups. DNA contains four bases: adenine, cytosine, guanine and thymine (A, C, G and T). Each gene has a fixed combination of these bases, which forms the code for the production of proteins, which are made up of 20 different amino acids. The proteins regulate all processes in a living cell, ranging from the production of metabolites such as brown or blue pigment in eyes to survival mechanisms for entire species.

Dawkins showed that in the natural selection of Darwin's evolution theory, it is not the well-being of the group or species that is

central but the gene. Genes are the 'designing elements' of an organism and are the only substances that are passed on from generation to generation. The gene with the best survival apparatus survives. Seen from this angle, genes compete with other genes that fulfil the same function in a different manner (alleles). This is what Dawkins means by 'selfish' genes: those that build the best surviving apparatus will live long enough to pass on their properties to the next generation. Dawkins uses a loose interpretation of the word 'gene': instead of the narrow definition of a gene as a part of the DNA serving as the code for one single protein he takes it to mean 'all genetic information that leads to a specific property or behaviour, if need be through many intermediary steps'.

Although genes can be considered selfish, this does not necessarily mean that the organism (the survival apparatus) whose construction is based upon the cooperation of many genes is selfish as well. Therefore Dawkins' way of thinking also leaves space for altruism, as can be observed in various animal species including humans. An example is a monkey that warns the colony – with an alarm cry – that a predator is in the neighbourhood, thereby drawing attention to itself. It seems logical that this behaviour gives the colony the best chance of survival, including the individuals with the 'alarm cry gene'. But for the monkey this behaviour is only relevant if close relatives (the colony) have the same habit.

3. GNOSEOLOGY: RESEARCH METHODS IN AGRICULTURAL SCIENCES

3.1 Introduction

During the scientific revolution of the 17th century, two dominant approaches for gaining scientific knowledge were formulated: empiricism and rationalism.

According to logical empiricism, true knowledge must be based on sensory experience. On the basis of perceived regularities in research findings, general laws and theories can be formulated, based on inductionist generalisations. This kind of reasoning proceeds from the specific to the general. Perceived individual observations are combined to seek general conclusions, and mathematical processing allows generalisations to be made.

Under a rationalist approach, true knowledge is to be deduced from rational principles. This deductionist approach argues from the general to the specific. Research therefore starts with hypotheses, deduced from general theories, which can be tested through concrete experiments.

August Compte (1778-1857) laid the foundations for these scientific methods. He postulated that in the course of the history, science had moved away from theological methods, where supernatural forces were considered to explain the course of things, and also away from metaphysical methods, which seek to provide answers based on pre-scientific dogmas and abstract concepts such as reason and spirit. He designed a scientific method known as positivism. In positivism, religion and metaphysics are no longer considered relevant for science. Only the combination of logical thinking and empiric perception can lead to laws that can explain and predict phenomena. According to Compte, this methodology can be used both for natural sciences and for the humanities. The only difference is that, in the social sciences, the number of variables is much larger; therefore, the degree of predictability is lower than in the natural sciences. But, if scientists of different disciplines work together, think systematically and collect empirical data, progress can be made.

The empirical research cycle is one of the methodological frameworks used for positivist reasoning. It follows a sequence of steps that combines induction and deduction by formulating researchable hypotheses based on theories, systematic collection and processing of data. Methods used to understand social systems can include quantitative methods, and these are often combined with qualitative methods. Examples of quantitative methods are field or laboratory trials replicated several times in order to be able to derive statistically significant results to prove with a degree of certainty that the hypothesis tested was not false.

3.2 Plant nutrition and Law of the Minimum

Albrecht Daniel Thaer (1752-1828), a German physician, is considered one of the founders of modern agricultural science, which started to emerge at the end of the 18th century. His most important writing was the book Grundsätze der rationellen Landwirtschaft (Principles of scientific agriculture, 1809–1812).

Modern agricultural research is said to have started with Justus von Liebig (1803-1873), a German chemist and pioneer in the field of applied chemistry (Brock, 1997). He is considered the inventor and first user of synthetic fertiliser. As a professor at the University of Munich he carried out research into the elements plants need for their growth. His most important discovery was fertiliser based on nitrate. He formulated Liebig's Law of the Minimum about the nutrients a plant needs for optimal growth. The plant only grows faster when the element that is most lacking is added. As an aphorism: 'A plant's growth is limited by the one essential mineral that is in the relatively shortest supply.' Around the same time the Law of Diminishing Returns was established in economics. This states that in all productive processes, adding more of one factor of production, while holding all others constant, will at some point yield lower per-unit returns.

For example, the use of fertiliser improves crop production on farms and in gardens; but at some point, adding more and more fertiliser improves the yield less per unit of fertiliser, and excessive quantities can even reduce the yield. If a farmer increases the amount of seed or fertiliser only, the response in yield will

gradually become less per unit of seed or fertiliser added. Only if more seeds are combined with more fertiliser will both production factors become more efficient. This is one of the reasons modern production ecologists advocate intensive agriculture: it makes best use of each individual resource.

3.3 Crop models and crop ecology

In Wageningen plant scientists focus on the production systems model and its crop ecological approach uses the following formula:

P = G x E x M x S

Where **P** = Performance of a crop or a cropping system. This can be expressed as tons per hectare, where wheat, apples or potatoes are harvested, or kg of milk per cow per day, number of flowers per pot or per square metre, and so on. It can also refer to the amount of processed food, feed or fibre: kg of French fries per hectare.

G = Genotype of a crop breed that may be a species such as a grass, cereal, fruit tree, bovine or a fowl. More specifically, it may refer to a variety of the species, such as ryegrass, golden delicious, a Friesian-Holstein, or New Hampshire. In practice and in scientific experiments, the genotype is the basic material that cannot be altered within a limited timeframe. It may also include the age and vitality or health of the seed planted as this too influences performance: are the seeds viable and disease free?

E = Environment where the production system is located. The environment has two subclasses: soil and weather. Soil has properties such as granular composition, acidity, water-holding capacity, soil organic matter concentration, mineral content and many more. The weather has components such as minimum and maximum temperature, rainfall, solar radiation and more. For crops, the environment should provide a suitable temperature-time window for growth to take place. For potatoes, the maximum temperature should not go above 30 degrees Celsius and the environment should be free of frost. Rice and banana require environmental conditions that are found in the tropics and subtropics; pine trees thrive in the tundra among other environments.

M = Management of the crop. This consists of the activities growers carry out to optimise yields, such as ploughing and seed-bed preparation; weeding and disease control; irrigation to avoid drought; and the application of organic amendments such as manure and compost or chemical fertilisers. Management includes many classes of activity and instruments, such as farming machines, farming operations, active ingredients in chemicals preparations, decision support systems and registration and bookkeeping for labels and tax purposes. More and more growers are assisted by decision support systems that allow them to adjust time and dose of treatments such as biocides, fertilisers and water. They keep track of all operations and enter these in computer-based good-agricultural-practices (GAP) records as a way to optimise yields.

S = Society, and refers to the prerequisites members of a society have when it comes to food production. They may want food to look attractive, be safe (devoid of abrasive or toxic substances). In the west priority is attached to food being tasty and healthy, and there is a demand for food to be produced in an environment- and animal-friendly way. Finally, specific consumers may have specific desires, for example that food does not contain genetically modified ingredients or that it is produced according to organic agriculture principles.

The reductionist and quantitative way of looking at crop production, P = G x E x M x S, makes use of computer simulation models in which crops and cropping systems behaviour can be explored. C.T. de Wit and J.L. Monteith pioneered this theoretical modelling. A simple crop model uses 'temperature' for the aspects related to plant development and 'solar radiation' for the aspects that determine growth of biomass. Initially the newly emerged plants derive most of their energy from the mother seed or tuber, and initial leaf development is also temperature dependent, with fixed rates for leaf expansion for each temperature.

In potatoes, tubers form earlier at higher temperatures tubers, but when the maximum daily temperature is above 30 degrees Celsius tuber growth stops. A potato crop dies when the tuber growth is faster than the total daily growth of the crop because

Potato field in the Netherlands

then the leaves are emptied and die. The growth speed of the crop is determined by the daily amount of solar radiation intercepted by the green leaves. At emergence the amount is zero and when the soil is completely covered by the canopy, one hundred per cent of the solar radiation is intercepted. For each unit of solar radiation that is intercepted by the crop, the leaves make a fixed amount of dry matter (2.5 g/MJ) that is distributed to the leaves, stems, tubers and roots at varying rates (radiation use efficiency) in function of the (temperature dependent) development stage.

When temperatures are below or above certain values, the radiation use efficiency decreases according to fixed rates. This also holds when soil water is limited. The model can be made more or less mechanistic depending on which process is being studied in greater detail. Most of the crop parameter values are very conservative and they can be generalised to apply to many crops and conditions. The reductionist view is that a phenomenon exists as long it can be measured, for then it can be captured in a formula and its behaviour explored under different conditions. A similar line of reasoning was applied in physics, one of the results of which was that man was able to walk on the moon. Using the models described above and long-term past weather data, researchers were able to calculate the carrying capacity of the earth (how many people can the globe sustain?)

and to study questions such as the repercussions of global climate chains, the water cycle and global nutrient flows.

3.3.1 Breeding and genetics

The G for genotype in the P = G x E x M x S formula is most important factor when it comes to performance of our produced food. All food crops have most of their DNA in common; they all have genes for the formation of roots and leaves and for the formation of chlorophyll to capture sunlight and produce sugars. They do, however, differ in important traits that help them adapt to various conditions and produce different foodstuffs.

According to Darwin's theory of evolution, all life, whether humans, animals, plants, bacteria, fungi and so on, originates from a single organism that lived some 3.7 billion years. Darwin did not know of genes, nor did Gregor Mendel the father of modern genetics (Smith et al., 2006). The latter crossed peas with different properties such as the colour of the flowers and developed a theory of how those properties behave in the next generation. He assumed that gametes can be considered as fixed units and that the combination of two of these units determines which property will be expressed. It is possible that one 'unit' dominates over the other and will express itself. When the gametes are formed, in pollen for instance, each gamete arbitrarily receives one of these two properties and for another property it may be a different unit. Mendelian findings were 'rediscovered' in the early 1900s by Hugo de Vries. More than five decades later the structure of DNA was discovered by James Watson (1928) and Francis Crick (1916-2004) and this opened the way for modern biotechnology techniques, such as chromosome sequencing and the production of recombinant DNA

3.4 Genetic modification to develop new (potato) plant varieties

Given the author's research expertise, below follows an explanation of the key methods of genetic modification used to improve potato plants in the Wageningen approach.

Genetic modification is the direct, human-induced, change of an organism's genome using modern DNA technology and consists of the following steps:

- Isolation and amplification (cloning) of the gene that needs to be modified.
- Adaptation of the gene if so desired.
- Transfer of the gene to a suitable vector (often a bacterium).
- Transfer of the gene to the target organism.
- Selection of the modified organism.

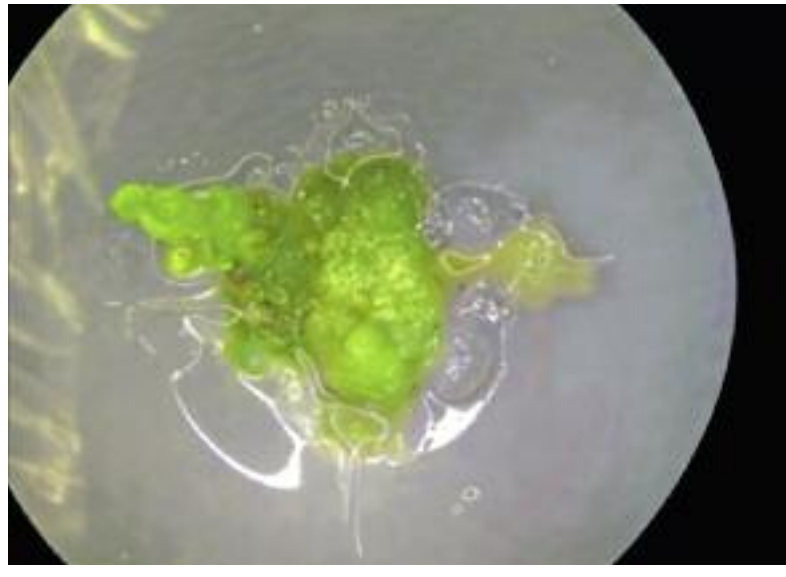
Genetic research is considered controversial, and is subject to scrutiny especially when genetic modification techniques use bacteria, such as E. coli for cloning and A. tumefaciens for transferring genes. Strict procedures have to be adhered to if admission to the market is to be granted, and extensive testing for human and environmental safety needs to be carried out. Wageningen UR sees it as its task to carry out research in all aspects of genetic improvement of crops, including those that go beyond conventional breeding: protoplast fusion, cisgenics, intragenics, transgenics. It wants to be transparent about this, thereby informing the public and stakeholders so that they are able to make their own decisions regarding perceptions of risks and benefits. The various techniques are described briefly below.

Protoplast fusion is a form of genetic modification that is exempted from additional legislation in the European Union and – so far – is considered to be not more risky than conventional breeding. It consists of a technique whereby two cells – or rather their protoplasts – of two plants of the same or of different species are fused to form a new hybrid plant. This can be a useful technique to use if a potato plant does not flower, or to create triticale, a hybrid of wheat (Triticum) and rye (Secale). In the same league is the use of mutation breeding, which makes use of mutation enhancing substances (chemicals) or radiation. This technique may be used to induce slight changes (e.g. in colour or shape) but does not add new properties that require the introduction of new genes. Mutation breeding, too, is considered a genetic modification that does not require the scrutiny for admission that GM crops require.

Genetic modification

Genetic modification uses cloned genes and a vector. A vector is a bacterium in which a modified gene has temporarily been introduced. Usually A. tumefaciens is used for this. Three forms of genetic modification can be distinguished: cisgenesis, intragenesis and transgenesis.

Cisgenesis: only genes from a species' own gene-pool are used for genetic modification. Such genes could also be introduced through crossing but would then be accompanied by many unwanted genes. Cisgenesis is genetic modification (=GM) of plants with cisgenes only. A cisgene is a natural gene for a (agricultural) trait, from the crop plant itself or from a sexually compatible donor plant that can be used in conventional breeding. The gene belongs to the conventional breeder's gene pool. A cisgenic plant contains no foreign genes. See http://www.cisgenesis.com/



Tissue culture derived from a potato cell containing a resistance gene against late blight (3 mm diameter)

Intragenesis: Specific genes of the same species – say Solanum tuberosum, potato – are isolated, altered, cloned and placed back with the help of a vector into the same potato. Such an intragenic plant does not contain foreign DNA, but altered DNA. Examples are that the promoter of a certain gene is used as the promoter of another gene to enhance or diminish its

expression. Another example of a technique used in potato is to 'knock out a gene', meaning that a gene cannot express itself anymore. Potato produces two types of starch: amylose and amylopectin. By isolating the gene that codes for amylose, reverting it and placing it back into the potato genome, the resulting regenerated plant's tubers contain only amylopectin.

Transgenesis: a transgenic organism contains a gene from another species with which conventional crossing is not possible. This may happen spontaneously in a natural process (e.g. when a bacterium modifies its host so that it produces a gall in which the bacterium thrives) but in science it requires genetic modification. An example is crops that have received DNA of Baccillus thuringiensis and then produce a substance that is toxic to insects such as the corn or cotton borer, making the use of an insecticide redundant, thereby positively influencing the ecological footprint of such crops.

3.4.1 Risk perception from society at large

Novel techniques often encounter resistance, for example from members of the public, as they may be perceived as involving risks. Atomic energy is a clear example, where many perceive the risks (accidents, release of radio-active material) associated with its production as greater than the benefits (cheap energy, mitigation of climate change due to CO2 neutral power production). Similarly, genetic modification clearly has benefits (no need to spray crops against insects thereby benefiting the environment (less effect on non-deleterious organisms) and workers (less exposure to toxic substances). Yet some – in this case a few NGOs, Greenpeace being one of them – perceive genetic modification as being associated with risks, and therefore oppose its development and use in the field. They do not oppose its contained use in laboratories, for example for bacteria to produce medicine. The main disadvantages they see are:

- Food produced via GM may prove to be allergenic or toxic to humans (in the long run)

- Genetically modified plants may grow rampantly and become noxious weeds, or their pollen may contaminate non-modified plants and cause deleterious effects

- Genetic modification is costly and can only be carried out by large multinational companies that threaten to protect their interests and make growers dependent on monopolies, and will finally hold the food industry and consumers hostage.

- Pests may adapt themselves and thus undo the benefits gained from the genetic modification.

These organisations are generally not open to the scientific proof that demonstrates the safety of these techniques. They tend to counter with arguments such as 'not all avenues have been researched', 'the long-term effects are not known because not enough time has passed since application' and 'the research is carried out by those who also benefit from the development'.

Meanwhile, globally, over 10 % of the whole area of 1.5 billion ha of arable land is already covered by GM crops. Well over 160 million hectares is now planted with maize, soya, canola and cotton. Little do the NGOs realise that their obstruction and fear induces legislators to require more and more tests and proof of companies looking for market access, and this makes the whole process very costly. For example, the company BASF when seeking access for Amflora (a genetically modified potato that only produces one of the two starch types: amylopectin and not amylase so it has more industrial value) had to invest 13 million euros before it complied with the EFSA (European Food Safety Authority) regulation. This is a far greater sum than the amount spent on R&D to create the new GM variety in the first place. So only the very large companies can afford access to this market. The rearguard, conservative – when it comes to genetic research – battle being fought by people and NGOs with these views hampers progress in science, development, sustainability, competitiveness and prosperity.

3.4.2 European legislation on genetic modification

An official European website[1] explains the requirements for GMO crops admission. GMOs must receive authorisation before they enter the market. This applies to GMOs used in food and feed, and to seeds for GM crops. In 2004, a new, fun-

1. www.gmo-compass.org

damentally revised legal system took effect in all EU member states. The essential foundations of the EU's policies are tight safety standards and freedom of choice for consumers and farmers.

Based on a comprehensive decision making process, the EU and the member states are of the opinion that using genetic engineering in agriculture and food production is permissible.

Nonetheless, each individual GMO must receive approval before it can be sold as seed or used in food and feed. Approval is granted only under certain conditions, listed below:

Safety: The product must be safe and cannot pose threats to human or animal health. It also must be safe for the environment. All products from GMOs must be considered as safe as their conventionally derived counterparts, as indicated by tests using the most advanced knowledge and technology available. If this is not the case, the GMO will not receive authorisation.

Freedom of choice: Even GMOs that receive authorisation are subject to special requirements. Consumers, farmers and businesses must be given the freedom to either use or to reject products made from GMOs. This means that it must remain possible in the long term to produce foods without the use of genetic engineering. The term used for this is coexistence. Genetically modified plants must be grown and handled in such a way that prevents uncontrolled mixing with conventional products. It is up to the individual EU member states to decide how to ensure coexistence. The European Commission has provided a set of guidelines to help this process.

Labelling: Labelling is the most important tool for ensuring the freedom of choice, a freedom that is required by EU law. Where GMOs are intentionally used in a food product, this must be clearly stated on the label. Every consumer is thereby entitled to make an 'informed decision'.

Traceability: Labelling is required even if GM content cannot be detected in the final product. This is why all producers, sup-

pliers and retailers must inform their buyers if GMOs were used in their products. To do this, stakeholders must set up systems for keeping and sharing information and documentation. The obligation to keep records and allow for traceability is set down in a separate EU regulation (1830/2003).

At present, the EU is thinking of distinguishing various methods of breeding and genetics, and perception of associated hazards such as risks to health and environment. There is a tendency to group conventional breeding and cisgenesis as having low risks perception and intragenesis and transgenesis as having higher risks. The latter will require more severe tests before market admission becomes a possibility.

4. AXIOLOGY: THE VALUES THAT INFLUENCE RESEARCH

4.1 The relationship between Man and Nature

The Netherlands is a very low-lying country with about one-third of its land lying a few metres below sea level. Ensuring that water from the sea and rivers does not flood the land traditionally required and still requires much cooperation. This started in the Middle Ages, when farmers made small hills where villagers were able to keep their feet dry when flood waters rose. Along the rivers dykes were built from clay and peat to contain the winter and spring floods. Efforts grew and during the 'golden century', the period in the 17th century when the Netherlands reached its peak as a seafaring nation and accumulated vast riches from trade, merchants bought lakes, built dykes around them and evacuated the water using pumps powered by windmills, thus creating polders. These are areas of reclaimed land, which could then be used for agriculture, but requiring sophisticated water management to prevent flooding. To control and manage the various water levels within and between polders, water authorities were established with their own representations, creating an early form of water governance. Cooperation was and is a matter of life or death: survive or drown. Negotiation until consensus is reached, often requiring lengthy meetings, is part of the culture of the Netherlands. This is also reflected in how agricultural research is funded: all needs have to be satisfied to some extent. Not just greed, not just environmental sustainability or the requirements of the needy, but a little bit, or rather – in this affluent society – a lot of everything.

Probably the value most shared by the Netherlands agricultural science community is that the results of research should contribute to a sustainable food production system. Sustainability expressed as People, Planet and Profit. Agricultural research should benefit people, ensuring they have safe, healthy and enough food (and fibres for clothing and construction). The earth should be exploited in such a way that it will be able to sustain us for many generations to come, and food production systems in a market place should

also be competitive in a way that enables them to continue to function for the benefit of those investing in them.

Wageningen University is a product of Dutch society and is largely dependent on funding, received through students and research grants from the Netherlands and other Western countries. Therefore the values of the Netherlands play a role in its identity and being a public university to a large extent determines the room to manoeuvre in the choices it makes concerning research and education. In the Netherlands, and Western countries in general, there is no homogeneous value system. Diverse philosophical, political, religious and social orientations exist. Some of these may be complementary, others contradictory or incompatible. And in the course of history, the relative importance of value orientations may shift. What are shared, however, are democratic values, a notion of charity, importance attached to human rights and belief in progress through technology and economic growth.

A recent study carried out by the National Institute for Public Health and the Environment (RIVM) revealed that in Dutch society the differences in basic values can be classified along two axes. Individuals, groups or collectivities may lay more or less emphasis on one of the following poles:

1. Emphasis on individual freedom versus emphasis on communal interests.

2. Focus on material well-being versus spiritual and moral values.

These differences in focus will lead to different choices related to agriculture, which creates dilemmas regarding food security and food sovereignty, maximising profit for entrepreneurs versus climate change, large-scale commercial farming versus conservation of biodiversity, poverty reduction versus creating economic growth, enhancing food production in the Netherlands versus stimulating food security and sustainability worldwide. The typically Dutch way of addressing such controversies is to hold broad-based discussions until consensus is reached about which direction to take.

In democratic societies a key mechanism for coming to agreement is voting, where the majority wins. The Netherlands uses a special way to bring together the different value orientations. The word for this in Dutch, 'to polder', is derived from a typically Dutch activity (already described above), namely that of the civil works undertaken to reclaim land from the sea. Carrying out this work requires conviction in the act of cooperation and the dedicated involvement of every stakeholder. The Netherlands solution to realising this is to negotiate with all stakeholders and seek a solution in which each orientation recognises itself and finds the motivation to take part. Wageningen UR follows the same pattern, and this way it tries to combine different interest groups and value orientations into an integral and coherent vision, in which there is room for all stakeholders to play their role, but where each take into account the interests of others. It should be noted, however, that Wageningen UR, although it may express a vision, depends too much on governmental funding to diverge much from governmental policies. Current government policy is that not policymakers and civil servants should determine the research priorities but that this should be done by consortia of companies brought together in ten 'top sectors' of which Agro and Food, and Horticulture and Propagation Material are two prominent ones.

4.1.2 Funding

Agricultural and food research in the Netherlands is carried out by private companies, research institutions such as universities (Wageningen being the most important one), and research institutes (the contract research part of Wageningen UR being the most important one). The funding distribution between private (large food, production and breeding companies) and public is estimated to be 50-50, but this is not certain. Much research at WUR is also carried out in PPPs: public-private partnerships. Here companies and government aim at making the industry more competitive.

Public funding

Public funding means that the research is funded from taxpayers' – i.e. public – funds. Unlike in most countries, agricultural research and education does not depend on funding from

the ministry of science and education, but from the ministry of agriculture. The Dutch Ministry of Economics, Agriculture and Innovation – the agricultural sector being such an important part of the economy – is considered by some to be a state within a state: it has its own tax collection system (mandatory levies of the commodity boards), its own police: the general inspection service that controls farmers' compliance with regulations such as the use of biocides, hormones, antibiotics, slaughterhouse hygiene and so on. The ministry also has its own education system, from secondary, higher agricultural education all the way up to university level in the form of Wageningen University, which until recently was an agricultural university but now has a broader mandate as a university of life sciences. The ministry also has its own research organisation: DLO or 'agricultural research service' that is part of Wageningen University and Research Centre. Research varies from policy support research (e.g. what grazing regime results in the least methane emission from dairy livestock) to support for the private sector (e.g. how to rid potato of blight and make the sector more competitive). Currently there is a strong tendency towards support for the private sector (as a result of a centre to liberal government) but this may easily shift again to more policy support if an election results in a more social-democratic government that is more likely to interferes in markets and favour increased government spending. At present the university's funding is not subject to conditions, but this may change. Besides funding from the Ministry of Agriculture, some research is also funded by the Ministry of Science and Education, but this usually is less applied and more fundamental.

Three types of research are funded by the Ministry of Agriculture, all of which are aimed at a competitive, productive, beneficial and sustainable agricultural sector:

- Policy support research, e.g. effect of surplus manure on ground water quality or the effect of climate change on productivity in the Netherlands and also in developing countries.

- Knowledge base research, of a more fundamental nature, so

that pure research progresses, allowing future policy issues to be addressed.

- Statutory tasks such as gene bank maintenance and compliance with food safety regulations and norms. Research on risks associated with genetic modification also falls within this category.

The condition for public funding is that results are published. If rights to intellectual property can be asserted (patents), this is permitted and future proceeds will go to the owner, in this case the institute that is the patent owner. Patents are made public so the knowledge is still in the public domain, but the proceeds are not.

The European Union through its 'Five Year Framework Programmes' is also an important public spender. Currently research falls under the 7th Framework Programme (FP7) and annually hundreds of millions of euros are spent on competitive tenders. The objective is to create a competitive and sustainable agricultural and food sector in the EU. Collaboration of research groups from different parts of the EU is a prerequisite as well as – in many instances – the participation of small and medium enterprises.

Private funding

Universities and institutes are encouraged to elicit funding from private parties. Such parties may be private companies, stock market listed or not, NGOs disbursing funds from donations and membership fees and commodity boards that collect taxes/levies per kg or per hectare. The latter usually fund pre-competitive research, and the results are in principle made available to all levy payers. An example is the research done on the control of a bacterial disease – Erwinia – in potato. The control measures ensuing from the research are made available to all, even to foreign competitors but usually the problem addressed is typically a national one. NGOs may commission research to counter an opinion based on a particular finding or publication: if research shows the highest milk yield is achieved when cows stay inside all year round, an animal action front may want to test the wellbeing and health of such animals compared with

that of cattle allowed to graze in meadows in summer. Especially when the outcome is favourable – aligned with the ideals of the NGO – the results will be published and promoted in the media. Private companies where shareholder value is the priority may fund research – outsourcing – on a problem or product for which they do not have sufficient in-house experience, but are very capable of exploiting the outcome. A company may fund the cloning and transformation of a resistance gene to gather information for its own purposes. Such results are usually confidential and not published anywhere. The company that pays is the owner of the knowledge. Before a research project begins, an assesment is made of existing knowledge and the knowledge that will be generated. A decision is taken on whether the research findings will be shared or used only by the funder. A secrecy agreement usually completes the deal, which specifies for how many years the institution is not allowed to publish the results. Five years is often a term that is acceptable to both parties.

The costs of funding research increase with the level of confidentiality. Wageningen UR's hourly research tariffs are about two times higher for private companies than for ministerial research and other parties pay fees somewhere in between.

Public private partnerships (PPP)

PPPs are research projects that receive partly public and partly private funding. The advantage of this for the ministry is that it is certain that the research that is being carried out is relevant to the agriculture and food industry, and the advantage for the private partner is that risky research (of which the outcome is uncertain) is partially supported by the government. Within the European Union 'state aid' is forbidden: a country cannot subsidise the R&D of a private company, as this would endanger the competitiveness of the industry in another nation. Research project calls – depending on certain conditions – often have to be announced EU-wide, also to give all prospective research groups equal chances.

Lobbying

There are many lobby mechanisms through which interested parties try to get public funding so they can carry out research

that furthers their interests. Especially in Brussels, there are many full-time lobbyists. They try to influence decision-making processes and even the law-making process through contacts with parliamentarians and commissioners. The same happens at national level too. Also, NGOs and private individuals may exercise influence by bringing pressure to bear and or through 'elegant' agenda setting. The national farmers' organisation is quite strong in the Netherlands and usually puts pressure on parliament when the sector needs help, for example after a disaster such as flooding following excessive rain or the outbreak of an infectious disease in animals.

4.2 Mission and vision of Wageningen UR

4.2.1 Introduction

Officially, the mission of Wageningen University and Research Centre is 'To explore the potential of nature to improve the quality of life'. Within Wageningen UR, nine research institutes – both specialised and applied – work together to help answer the most important questions in the domain of healthy food and living environment. The integral approach to problems and the cooperation between the exact sciences and the technological and social disciplines are at the heart of the 'Wageningen Approach'. Wageningen UR has not formulated a categorical vision on how to achieve its mission, phrasing it as follows: a diversity of approaches exist and dialogues between different disciplines and research institutes show the complexity of the issues at stake.

In 2012 the seven billionth world citizen was born and during the next thirty years another two billion will be added. The human genes are quite successful compared to those of species that are becoming extinct, such as smallpox and rhinos. However, two billion more people does not mean 2/7th more food production, as people – especially in newly industrialising countries – are eating more and more meat, requiring the production of more and more feed, based on the 'protein-rich waste material' of crops such as maize and soya after extraction of starch and oil for human consumption. So over the next generation food production will have to double. We need to rationalise agriculture, as this is the only feasible way to max-

imise production per unit of resource such as land, water, energy chemical inputs and manpower. Currently the world has about 1.4 billion hectares of arable land. Doubling this area will not be possible, as much land is marginal, being too dry, wet, salty or acid. Clearing forests is a method that meets much opposition so intensification (higher yields per unit of land) is the only option. And this needs to be achieved without compromising sustainability; without increasing our ecological footprint.

The vision of Wageningen can partly be illustrated by considering its contribution to some of the Millennium Development Goals, its perspective on sustainability and its approach to co-innovation. Take the goal of ridding the world of extreme poverty and hunger: it is in its mission to assist in the increase of food and create added value in the food supply chain. Wageningen has contributed strongly to agricultural research and dissemination of results through cooperation with numerous universities and research institutes all over the globe. When it comes to the pursuit of universal basic education, while Wageningen does not work directly at primary school level, it is the Dutch university with the highest proportion of foreign students, and the majority of them come from developing countries. It offers vocational short courses on a broad range of subjects including breeding and crop protection; some are even commodity oriented, such as the annual potato course that has been held for some forty years now. Control of diseases, such as malaria also receives priority: the department of entomology carries out research (partly funded by the Melinda and Bill Gates Foundation) on control of the mosquito that spreads the disease. On the subject of protection of a sustainable environment Wageningen has a strong record in areas such as improving the use of resources, reduction of erosion, and reducing emission of nutrients, biocides and carbon dioxide.

4.2.2 Sustainability

Wageningen researchers actively look for funding and derive satisfaction from research on sustainability. To tackle sustainability, and not just in qualitative generic terms of people, planet and profit, main principles and a set of underlying criteria

and indicators for sustainable potato production are now being extended to apply to any commodity in any setting. To address sustainability it is broken down into four areas: principles, criteria, indicators and norms. Principles are issues that we all agree benefit sustainability and mankind. A criterion assumes an action (or indicates an absence thereof) to achieve the principle. An indicator is a parameter that can be measured and a norm is its mandatory minimum or maximum value.

An example is the principle of biodiversity conservation: for a representative sample of biodiversity in an area to be conserved the criteria might include 1: the area of cleared lands required for crop production should be minimised (Indicators of this are a) crop yield per season per field and b) crop production on all cleared fields of a farm per year). Or criterion 2: the proportion of farm land cleared for crop production should be minimised (where the indicator would be the proportion of the farm property cleared for crop cultivation). Another criterion might be the use of biocides and minerals that may threaten biodiversity, where indicators would be the amount used and the environmental impact of the individual biocides and minerals such as nitrate and phosphate.

Another example is the principle concerning water: water reserves should not be threatened by crop production. The criteria are the quantity and quality of fresh water reserves that should be preserved. Indicators include the total amount of water available for a crop from rain and irrigation, the amount of water used to irrigate a crop and the amount of water lost through evapotranspiration by the crop and the soil.

An important principle aimed at mitigation of climate change concerns energy: the contribution of potato production to carbon dioxide emissions should be minimal, so as to reduce its impact on climate change. Two criteria apply: the energy contained in crop inputs should be minimised, and secondly the energy needed for crop management operations should also be minimised. Indicators are the amount of energy in biocides and in fertilisers (also soil emission of methane and laughing gas) and the amount of energy required for irrigation, machinery and transport. The food industry is currently developing tools (e.g. the Cool Farm Tool) that allow a

quick scan of CO2 costs of inputs and farm operations per unit of produce, say a ton of processing potatoes destined for the French fries industry.

4.2.3 Co-innovation

The Wageningen approach consists of more than a mere joining of scientific forces from different areas of expertise. Its strength is to combine in-depth scientific expertise and professional skills with a broad understanding of the wider context of any issue under study. In addition to allowing Wageningen scientists to integrate their work with other scientific disciplines, this also places research in a societal context. Technology alone cannot gain societal acceptance for research results or solutions to problems: socio-cultural and socio-economic aspects must be and are taken into consideration. In other words, we look at the big picture and continuously seek out potential contributions from – sometimes unexpected – other scientific domains when embarking on a search for answers. We call this concept co-innovation – striving for interaction between science and society. Part of this interaction involves defining the scope of the issues that need to be resolved. And it is this interaction that formulates research agendas. The co-innovation concept facilitates joint participation in public-private research projects. In other words, innovation processes are a joint activity of all stakeholders. In business, entrepreneurs take the lead in the process and science contributes to the process by analysing and designing. Examples include the development of new varieties, new food processing technologies, or new bioprocess technologies to clean wastewater. The role of science in policy-making processes is even more complex. The different phases in a policy cycle (signalling, design, decision, implementation and evaluation) are long-term joint learning processes. This requires on-going cooperation and interaction between stakeholders and scientists. Many generations of Wageningen researchers, teachers, students and alumni have made and continue to make significant contributions to co-innovative processes, for example in the development of the food business or resolving environmental issues.

5. THE CASE OF DuRPh: RESULTING KNOWLEDGE

Experimental field for comparing the responses of different varieties to late blight infection

5.1 Introduction

The reductionist positivist approach to generating knowledge – especially using plant genes – has resulted in many examples, such as round-up ready soya for which no tillage is required. Bt-corn and cotton which have made chemical sprays redundant. There are also examples where there are no scientific or technical obstacles, but where acceptance – so far – is an issue. These include 'golden rice' (enhanced with beta carotene) which has been blocked by activists such as Greenpeace. Bt-potato that is resistant to Colorado beetle and potato tuber moth. Industry itself deemed export to markets such as Japan too risky because of the opposition.

In this section we describe an approach that does not stem from industry but from a government policy. It is not aimed at furthering the interest of multinationals, but rather that of small and medium enterprises such as potato breeding and seed potato cooperatives and companies in the Netherlands.

In January 2005 an interdepartmental committee consisting of senior policy makers of a few ministries, among them that of

agriculture and that of environment, came to Wageningen UR with a vision and a mission. The committee 'wondered' whether Wageningen UR would be able to produce a genetically modified crop. The government had noticed that no company in the Netherlands was producing, and not even developing such crops, whereas elsewhere in the world already some 100 million hectares of such crops were being grown, benefiting the developers of such crops as well as shareholders (e.g. Monsanto), growers and the environment. An example is round-up ready soya bean: a bean that has been made resistant to the herbicide glyphosate. The resulting technology was that with no tillage (beneficial for the environment as it reduces the energy need of the crop and erosion) seeds can be sown in a weedy field and after emergence the herbicide is applied, killing all plants except the soya plants. After two weeks the weeds have decomposed and serve as mulch, reducing water evaporation and emergence of new weeds. The technology helped revive a country such as Argentina, where the economy was experiencing a severe slump after a series of economic crises.

A country that benefits so much from knowledge about genetics (in particular breeders working with flowers, vegetables and propagation material) might lose its competitive edge if no new impulse were given to genetic modification. It was decided to work on an important crop (potato) and on an important issue: late blight, a disease caused by the oomycete Phytophthora infestans.

The gene to gene battle between potato and late blight centres around recognition and hypersensitivity: if a spore falls on a potato leaf it needs some eight hours of moisture to germinate. If the potato is resistant to blight it will recognise a protein secreted by it (called an effector) and as a consequence it will kill a few hundred of its cells (leaving a small brown lesion on the leaf) and killing the organism that causes the disease (Phytophthora infestans) with it. If, in the enormous population of late blight, a pathotype appears through introduction from elsewhere or through a spontaneous mutation that forms another protein (effector) that is not recognised, then the hypersensitivity reaction does not show and the whole leaf, and the entire crop, is destroyed within weeks.

Knowing there is resistance against genetic modification, a project, aptly named DuRPh (an acronym that makes a wordplay on the Dutch word for 'courage') was envisioned incorporating a number of principles. The DuRPh principles are summarised as follows:

- The research only uses genes of crossable potato species (cisgenic approach).

- The project makes use of genetic modification techniques in the laboratory, such as cloning for the bacterium Escherichia coli and transformation for the bacterium Agrobacterium tumefaciens.

- It does not use a section marker such as an antibiotic or herbicide resistance coupled to the R-genes that are transformed; the technique is marker free; the marker is resistance to late blight caused by Phytophthora infestans.

- Use is made of existing varieties that have proved their value in the market. Many varieties are dozens and some over one hundred years old. So such varieties are not altered, except for their late blight resistance.

- Varieties are not supplied with a single R-gene, as in the past late blight always overcame such single gene resistance, but with a stack (pyramid, cassette) of three to four R-genes to make sure that the resistance is durable.

- The population of Phytophthora is monitored every year by planting plots of the wild species from which the R-genes were cloned and transformed at three sites in the country. When one of the wild species is affected the DuRPh team knows that one of the R-genes is no longer effective.

- This way 'dynamic varieties' are created by changing the composition of the R-genes in the cassette in time and place: one country may require a different set depending on the local composition of the late blight population.

- The techniques of isolation and transformation are patent-

ed and so are the cloned genes after their sequence is established and it is shown that they are not homologous to already patented genes. Note the genes in the wild species as such are not patentable: they are free for all breeders to use in breeding programmes.

- It is not Wageningen UR that will produce new varieties; this will be done by private companies or consortia. No one company can claim the R-genes exclusively; they will be made available to all interested parties that all face similar conditions.

- For humanitarian purpose a HUL (humanitarian use licence) may be granted for developing countries where food security is an issue.

The government provided the project with a 10-million-euro grant for a period of ten years, disbursing one million per year. The funds came from natural gas proceeds, of which by law a certain proportion then had to be invested with an expected rate of return.

The various approaches were divided into sub-projects and activities consisting of:

- Cloning newly discovered resistance genes (R-genes).

- Transferring them to existing varieties.

- Selecting regenerated plants that exhibit blight resistance and have proper agronomic characteristics.

- Applying measures to assure the durability (longevity) of the resistance.

- Communication to all interested parties.

5.2 Potato and blight

Blight caused by Phytophthora infestans

More than 400 years ago the Spaniards brought the potato from

America to Europe. The potato has since then superseded cereals as a main food in Northern regions. The oomycete Phytophthora infestans, the pathogen that causes late blight, did not emerge straight away. There are various possible reasons. The disease may not yet have been present in Peru, the area from which potatoes originated; or infected potatoes may have rotted completely during the voyage so that they never reached the fields. But potatoes may also have been introduced into Europe via seed; there is no certainty about this.

Via Europe the cultivated potato also reached North America. Many wild potato species, such as Solanum demissum, S. bulbocastanum and S. edinense, were at that time already found in Mexico. These species had already been exposed to Phytophthora for thousands of years. Such situations create a sort of arms race, during which processes of evolution and selection form plants with a defence mechanism against the pathogen by developing resistance genes. But this – in turn – is followed by selection pressure causing the development of pathotypes that can break resistance. This then puts the ball back into the plants' field. All of this results in the side-by-side survival of plants and pathogens for many thousands of years. This meant that when the European cultivated potatoes arrived in Mexico, they automatically came into contact with Phytophthora.

In the mid 19th century potatoes from North America came to Europe. And this time the sailors and merchants did manage to bring the pathogen along with potatoes. The disease spread very rapidly throughout Europe and then to the rest of the world. Total harvests were lost as the leaves and tubers rotted rapidly. In Ireland this even led to the great potato famine, followed by an enormous wave of emigration, as a result of which the population of Ireland decreased by about half.

Nowadays, the disease continues to cause yield losses and other costs throughout the world. For the Netherlands, the total annual costs associated with the disease are estimated at over 100 million euros. A best possible estimate of the worldwide damage puts the figure at 10 billion euros per year (Haverkort et al., 2009). Developing countries are most severely hit by

these costs. In Western countries the disease accounts for more than ten per cent of the energy use in potato cultivation. In the Netherlands more than half of all chemical crop protection products are used to fight Phytophthora.

In the Netherlands an area of 165,000 ha, with a yield of 45 t/ha, yields 7.9 million tonnes of potatoes, which represents an average value of about €790 million. Fungicide application involves the costs of the chemicals and the costs of applying them (machines, labour and energy). The number of sprays varies between 10 and 16 times per season. Seed potatoes receive fewer sprays as they are harvested prematurely, but the chemicals used for these are more costly per kg. Growers tend to alternate systemic fungicides with contact fungicides to avoid build up of resistance of the disease against the chemicals.

The cost of the 1,424 tonnes of chemicals applied to potato crops in the Netherlands are calculated at € 61.1 million per year. The costs of applying these chemicals, on average 15 times per season (for machinery, labour and fuel), are also calculated (KWIN, de Wolf and van der Klooster, 2006) at € 330 per hectare (€ 54.4 million for the total area) making the total costs of control (chemical + application) € 115.5 million.

Chemical control of late blight involves up to 15 sprays per year, but becomes potentially obsolete with cisgenic approach

In developing countries farmers are often unable to afford crop protection products. This means that they face enormous yield losses whereas they are utilising the full amount of labour, land and water. The application of any chemicals used there is often done injudiciously.

Spraying phytophtora-infested potatoes in the Philippines.

5.3 Cloning and transfer of genes within potato varieties

In this section we describe the methods being used in the DuRPh research project to arrive at potato resistance against Phytophthora.

Testing genetic properties in (wild) donor species

To discover whether a wild potato species possesses a still unknown resistance gene (R gene) we cross resistant and susceptible plants of closely related species. The progeny is then tested for their susceptibility or resistance for a disease, in our case Phytophthora. The ratio between susceptible and resistant progeny tells us whether the resistance is indeed caused by one gene. A splitting ratio of 1:1 between resistance and susceptibility allows us to conclude that one dominant R gene is responsible for the resistance. These results enable us to start searching for the resistance gene. Resistance or susceptibility are established by means of leaf tests in the laboratory and whole plant tests in the field. In these tests leaves or plants are infected with spores of a well-characterised Phytophthora isolate. In addition to these tests we currently also use so-called effector tests.

Establishing the location and relocation of the genome

The location of the 'genome' in the new R gene needs to be established after characterisation of a progeny population as described above. The genome is the collection of all genes of a potato plant, divided over the 12 chromosomes. So-called molecular markers, of which the location in the genome has already been determined, are used to establish this position. This first leads to a rough estimate of the place of the R gene (genetic map), followed by 'zooming in' for a more precise determination of the location on the genetic map. The full DNA sequence of the cultivated potato, which became available in 2010, is currently being used for this purpose.

After accurate establishment of a genetic position, the DNA of the wild potato is cut into relatively small pieces. Because it is known which identified pieces of DNA are located near the gene, we can start looking for the fragments on which the gene should be located. To find the right fragment, all DNA pieces are first incorporated into so-called Bacterial Artificial Chromosomes. Such DNA fragments are reproduced in a bacterium (cloned).

Co-reproduction

One piece of plant DNA is then co-reproduced in each bacterium colony. We then start searching for the bacterium colonies that contain DNA fragments very close to the R gene. The exact DNA sequence of these two DNA fragments of the wild potato is then determined. Bio-informatics techniques are then used to investigate if and where the genes are located that may be responsible for the resistance. About 20 genes are predicted in the schematic example. At this stage we do not yet know which of these genes is the R gene. Some of the twenty genes are discarded on the basis of the DNA sequence. The remaining 'candidate R genes' are then investigated to see whether they do indeed code for resistance. In the past, the genes then had to be inserted into the potato via genetic modification after which the plants could be tested for resistance. This process nowadays can be speeded up because a full DNA map of Phytophthora infestans is available as well. We have identified a series of Phytophthora genes of which we expect that they are coding for components that are recognised by R genes (effectors).

In specifically conditioned greenhouse compartments we transform tobacco leaves with genes of wild potatoes which are expected to be the R genes. We simultaneously also transform the leaves with possible Avr genes of Phytophthora. The cells of the leaves then start 'reading' the genes. When a combination of an Avr gene with a corresponding R gene has been used, the leaf reacts by inducing cell death. This reaction also takes place in the wild potato and stops further growth of Phytophthora. This is called a hypersensitivity reaction.

We use an enzyme to cut the DNA out of a plant from which we wish to clone an R gene into relatively small pieces. The

potato DNA fragments are cloned in the bacterium Escherichia coli. We then let each bacterium develop into a colony, which contains one small DNA fragment of the wild potato. The E. coli colonies that have successfully incorporated a potato DNA fragment are easily recognised because they are white.

Transformation

The resistance genes (R genes) of wild potatoes are transferred to Agrobacterium tumefaciens bacteria aided by plasmids, circular pieces of DNA frequently found in bacteria. Agrobacterium can then insert the R genes in the DNA of the cultivated potato.

Next, stem fragments of cultivated potato are placed for some hours in a suspension of Agrobacterium with the R genes. The Agrobacterium has the opportunity to enter cells of the stem fragment and to insert the DNA in these fragments. After two to three days the DNA of the wild potatoes has been transferred to the DNA of the cultivated potato.

Some of the cells of the stem fragments now have been genetically modified. The stem fragments are subsequently placed on a nutrient medium so that new plantlets can grow from the stem fragments. About three per cent of the new plantlets originate from a cell in which the DNA of the wild potato has been inserted and of which all cells contain the extra DNA of the wild potatoes. All new plantlets are therefore also studied in the laboratory to select the plantlets that do indeed contain the DNA of the wild potatoes. These plantlets are called the 'transformants'.

The transformants can then be tested for resistance against Phytophthora. And the DNA of these transformants is studied in more detail. This way the plants are selected in which Agrobacterium has only inserted the DNA of the wild potatoes.

The amount of resistance genes is not inexhaustible. DuRPh researchers therefore handle the resistances very carefully. They develop strategies for extending the useful life of resistances as

Potato variety Premiere: foreground, provided with a resistance gene, background, unmodified Premiere affected by phytophtora

long as possible. First, the scientists develop methods and techniques for actively monitoring the genetic composition of Phytophthora in the field. They use these techniques to detect mutations in the Phytophthora genes that recognise the resistance genes of the wild potatoes, so-called avirulence genes of Phytophthora.

5.4 Perspectives

Expectations

If the DuRPh approach can indeed prove to lead to the development and use of cultivars with a durable resistance and Europe were to decide to allow cisgenesis a special position within the regulations governing genetically modified crops, the breeding companies together with Wageningen UR would be able to 'upgrade' their own existing cultivars into cultivars with a durable resistance for a fraction of the DuRPh research costs (10 million euros spread over ten years).

DuRPh uses cisgenic genetic modification in its breeding research, a technique not yet commonly understood by the Dutch public. This is a reason for scientists to communicate actively with the general public, through presentations, newspaper articles and the internet, and to participate in discussions and debates. This enables anyone who is interested to form her or his own opinion about the use of cisgenic genetic modification for acquiring durable resistance against Phytophthora. The DuRPh team also contributed to the development of a teaching module for pupils at high school preparing for university entry. The reader is aptly entitled 'Battle of the genes'. In the introduction the teacher explains the need for increased food production and the amount of chemical biocides involved to combat late blight in potato production in the Netherlands. Then a team of three pupils, representing various stakeholders in society, is challenged to arrive at the best genetic solution to control late blight: will they fund the DuRPh project as proposed by Wageningen? They discuss the global importance of the crop and its potential contribution to food security, especially if free of late blight. Then the various means of breeding (conventional, marker assisted, cis- and transgenic) are discussed and options put forward. After this the defence mecha-

nisms of plants are explained. The life cycle of late blight is shown and the hypersensitivity reaction of the host (potato plant) is explained. Pupils are encouraged to discuss questions such as 'Is it possible to fully eradicate a pathogen like Phytophthora infestans?' Finally, the DuRPh project is explained and results to date shown.

Exploitation of DuRPh results

Breeders will apply for plant breeders' rights for the useful potato lines they develop with DuRPh technology and isolated resistance genes. Part of the income derived from these plant breeders' rights will flow back into research. This will probably result in a continuous investment in the development of knowledge and plant material. For DuRPh it is very important that knowledge and material are spread as widely as possible around the world. Developing countries that do not import Dutch seed potatoes will therefore be permitted to use the knowledge 'for free'. To obtain useful resistance genes, resistant plants of certain wild species are crossed with a susceptible plant of the same species. The resistance will then 'split': part of the progeny will be susceptible and part will be resistant. Studying the DNA of these plants enables the researchers to find the gene to be isolated from the plant. This is the aspect of the DuRPh research that pertains to intellectual property.

6. VALIDATING RESULTS AND SPREADING KNOWLEDGE IN OUR KNOWLEDGE COMMUNITY

6.1 The Dutch education system

Wageningen University and Research Centre is part of the public education system in the Netherlands. Compulsory education starts at the age of four. From the age of 16 education is partially compulsory, meaning a pupil must attend some form of education for at least two days a week. Education is no longer compulsory for people aged 18 and over, or after they have completed a degree. Public and special (whether based on religious or other affiliations) schools are government financed. All schools that meet the criteria stipulated receive equal financial support from the government. Although they are officially free of charge, these schools may ask for a parental contribution. Public schools are controlled by local government authorities. Special schools are controlled by a school board, and are typically based on a particular religion; those that are not based on religious affiliation are known as general-special schools. These differences are present in all levels of education. As a result, there are Catholic, Protestant, Jewish and Muslim elementary schools, high schools and universities. All school types (public, special and private) fall under the jurisdiction of a government body called the Education Inspectorate, which can require a school to change its educational policy and quality at the risk of closure. In elementary and high schools, pupils are assessed annually by a team of teachers who determine whether they have advanced enough to move on to the next grade. After attending elementary education, Dutch children (by that time usually 12 years old) go directly to high school. A high school can offer one or more levels of education, at one or multiple locations. A focus on (financial) efficiency has led to more centralisation, with large schools that offer education for all or most educational levels.

Higher education

Since September 2002, the higher education system in the Netherlands has been organised around a three-cycle system consisting of Bachelor's, Master's and PhD degrees according to the Bologna process. At the same time, the European Credit Transfer and Accumulation System (ECTS) was adopted as a way of

quantifying a student's workload (both contact hours, and hours spent studying and preparing assignments). Under Dutch law, one credit represents 28 hours of work and 60 credits represents one year of full-time study. Both systems have been adopted to improve international recognition and compliance. To enrol in a BSc programme, a student is required to hold a high-school diploma preparing the student for university education or to have completed the first year (60 credits) of a professional college programme and to have therefore gained a certificate. Admission to certain programmes is restricted, primarily in the medical sciences, and places are allocated using a weighted lottery. For admission to all Master's Programmes, a Bachelor's degree in one or more specified disciplines is required, in some cases in combination with other requirements.

Accreditation and quality assurance

A guaranteed standard of higher education is maintained through a national system of legal regulation and quality assurance.

The Ministry of Education, Culture and Science is responsible for legislation pertaining to education. A system of accreditation was introduced in 2002. Since then, the New Accreditation Organisation of the Netherlands and Flanders (NVAO) has been responsible for accreditation. According to the section of the Dutch Higher Education Act that deals with the accreditation of higher education, degree programmes offered by research universities and universities of professional education will be evaluated according to established criteria, and programmes that meet those criteria will be accredited, that is, recognised for a period of six years. Only accredited programmes are eligible for government funding, and students receive financial aid only when enrolled in an accredited programme. Only accredited programmes may issue legally recognised degrees. Accredited programmes are listed in the publicly accessible Central Register of Higher Education Study Programmes (CROHO). Institutions are autonomous in their decision to offer non-accredited programmes, subject to internal quality assessment. These programmes do not receive government funding.

6.2 Evaluating knowledge

Students enrolled at Wageningen University are taught mainly

scientific subjects and the level of their knowledge is tested in various ways. Students must attend classes and practical exercises. For some subjects they are required to sit for exams, for others they must submit written pieces of work based on lab, field or literature research. The first academic degree that can be obtained is the BSc, which usually takes three years of attending classes in various disciplines depending on the orientation chosen. There are two types of BSc degrees in the Netherlands: those awarded by a university of higher professional education college (applied) and those awarded by a university (scientific). On graduation many students decide to look for a job, but most continue to study for an MSc, which takes another two to three years. Here the emphasis shifts from the classroom to carrying out research. The majority of master's graduates look for a job, expecting to find a better-paid job than they would find with only a BSc. Degrees may be granted with or without honours depending on the grade level attained.

Those really interested in science may opt to continue for a PhD in the agricultural sciences. At Wageningen this takes about four years, and involves much research in the lab, greenhouse, field or survey work, becoming familiar with state-of-the-art knowledge and contributing to this with some three to five articles in scientific journals. Many choose to base their PhD thesis on these articles (actual publication, however, is not mandatory), adding a general introduction and a section including a general discussion. A PhD thesis is submitted to an exam committee consisting of four or five scientists from other departments and universities, who have to approve it as being 'defensible' by the PhD candidate. A few months later the same members of the committee question the candidate at a public defence where peers (and friends and family) are present. As the committee has already approved the thesis, the candidate cannot fail this test, but the performance at the ceremony and the contents of the thesis decide whether the candidate receives the grade with or without honours.

6.3 Publications and peer reviews

Disseminating knowledge – and in particular newly generated knowledge – in the mainstream academic world occurs in various ways in addition to teaching. 'Publish or perish' is an often heard credo which describes the conditions to which the profes-

sional progress of scientists is subject. To maintain their position and to justify the next step in their career they have to publish their research findings. The principal means in the world of science is to publish research findings in a scientific peer-reviewed journal. The procedures can be summarised as follows:

- A researcher, together with his or her supervisor and/or co-workers, decides to publish recent findings, usually original new findings, but occasionally summarising part of a discipline and arriving at new conclusions and insights (the latter is called a review).

- They decide who is the first author, which is usually the person who has done most of the writing and usually also most of the work (although this is often a research assistant, who is usually only acknowledged), and then who is the second author and so on. The leader of the department may be added at the end of the list as a courtesy. If the order is not obvious, the authors are placed in alphabetical order.

- The manuscript consists of a concise title reflecting the contents, a summary or abstract that highlights results and conclusions, some key words to identify the contents easily for search engines, an introduction showing the state of the art and the objectives of the research. Next the material and methods are presented in such a way that independent research can be performed to imitate the research being reported, so that it can be reconfirmed, falsified or built upon. The results section reports the findings, accompanied by statistical analysis and relevant tables and graphs. Then a discussion follows in which the results are interpreted, conclusions are drawn and suggestions for further research are put forward. In an acknowledgment, thanks are given for assistance and to funding sources. A final section contains a list of all literature that was referred to.

- The manuscript is sent to a journal with as high a citation index score as possible, but one should not aim too high as this increases the chance of being rejected. A journal's citation index score is based on the number of times an article in a journal is referred to in other articles later on.

The higher the citation index, the better the journal.

- Once uploaded to the journal's editorial system the editor-in-chief (if the subject of the manuscript is deemed suitable for the journal) will allocate it to the editor on the editorial board who is most familiar with the subject. The editor then assigns the article to two scientists he/she thinks best able to judge the authenticity, the novelty and soundness of the methodology and results and conclusions, and whether there is redundancy or omission. They report back within a few weeks to the editor who makes a decision: accepted, accepted with minor revision, accepted with major revision or rejected. The editor then submits the decision to the editor-in-chief who endorses it and the manuscript goes back to the authors or to the journal to process it for publication.

- Just before going to print the corresponding author (usually the first author) receives the proofs for a final reading and then the article is published, usually electronically and sometimes still in a print version a few weeks later.

Scientists are expected to publish a few papers per year on average. If they have a heavy teaching load or are carrying out large amounts of contract research they will not be expected to publish so much as they have less time to dedicate to publishable research.

6.4 Reviewing funding

Research may be funded from public funds (government) or private funds (industry) or from a mix in the form of public private partnerships. Part of the research, especially the contract research component of Wageningen University and Research Centre, may be carried out after a confidentiality agreement has been signed. In such case the party that funds the research (private business or an NGO) is then the sole owner of the newly generated knowledge.

Research at the university is mainly carried out by (assistant) professors that receive lump-sum funding based on the number of students enrolled. Many PhD positions are funded by competitive grants awarded by the university itself, the Royal Netherlands Academy of Sciences, or from industry or NGOs.

Calls are responded to by writing a proposal in the desired format. These are evaluated along the same lines as peer reviews for scientific articles and then ranked according to a number of criteria. The highest-ranking proposals are accepted until the funds for a specific call have been depleted. For a PhD project, the work plans have to be approved by a Research School – a cross-departmental multidisciplinary group of scientists that safeguards the quality of research and ensures its excellence. Once approved, it usually is between the PhD student and the supervisor to conduct all that the work that is necessary to conclude the doctoral study successfully.

Most of the research that is funded by the ministry of agriculture is decided upon by policy makers, often after consulting private parties. The proposed research is described in some detail and the board of the institute may allocate subjects (and funds) to institutes that qualify. Wageningen UR has five such institutes (in which University departments are also housed): Plant Sciences, Animal Sciences, Environmental Sciences, Social Sciences, and Agrotechnology & Food Sciences. Once the research is being carried out, it is supervised by a steering committee of a few civil servants/policymakers, occasionally augmented by scientists from other departments or from industry.

The awarding of competitive grants by the ministry of agriculture or other ministries follows roughly the same path as that for the University-awarded grants. After being awarded, however, the client usually installs a steering committee to make sure that the deliverables that were promised are produced.

6.5 Wageningen and inter-science dialogue

Genetic research on plants at Wageningen is performed according to strict scientific mechanistic principles. Key words apply: gene, matter, rational, technology, secular, accreditation and patent. This, however, does not mean that highly specific research is not part of a holistic approach. The DuRPh project is a good example of a reductionist approach set in a much wider frame. To date, plant breeders have only introduced one single resistance gene into a new variety, while the disease that has many hundreds of genes to overcome this resistance. After growing an initially resistant variety for several years (temporal

aspect) on several hectares (temporal aspect) the resistance was broken down and the quest for a new gene started. Now we realise that this vicious circle can only be broken by adopting a truly interdisciplinary approach:

- Biotechnology to clone and transfer genes.
- Phytopathology to locate resistance genes and determine their mode of action.
- Epidemiology to ascertain the durability of acquired resistance by deploying the sets of genes wisely in time and space.
- Legal administration of the patented genes, breeders rights for the new varieties and humanitarian use licences.
- Financial procedures agreed on with an exploitation consortium concerning property rights and distribution of proceeds.
- Agronomy to organise the production of seeds of the newly produced resistant varieties and replace them with the same variety but with another set of resistance genes.
- Communication science and technology to show the world why we do it, how we do it, what the results are, what the benefits are and what to do to avoid risks.

In this respect the Wageningen approach is not unlike the other sciences discussed in this book. It shares a number of aspects with some or all of the other cases:

- The shared value of respect for nature and people is central. The DuRPh project is aimed at producing food while causing less harm to nature (for example by using fewer biocides), while respecting people's feelings and opinions regarding certain biotechnological approaches.
- Food production by plants and farmers, and human concerns such as feeding or curing people play a key role. If potato can be rid of its most important disease it will greatly contribute to world food security.

- Experimenting is implicitly or explicitly part of the learning experience.

- Principles, criteria and indicators are an integral part of defining desired directions and results, and outlining how to get there.

- Respect for the earth and its resources motivates experimenting and learning. A food crop – potato – grown more rationally will make much better use of the limited resources and carrying capacity of the earth.

- Connection between the subject of research and addressing 'imponderables' in a learning process. The cases in the book mention the spiritual world, ancestor involvement, the unmanifest or Mother Earth. In the case of DuRPh, the imponderables revolve around the fear of engineering genes, maintaining the integrity of plants and the reasons why cisgenesis was chosen as the approach to tackle the problem, where transgenic methods might be more efficient.

- In all cases it is clear that there is a multiple agenda involved when research is embedded in a complex system. The DuRPh project also addresses many scientific and societal issues.

- Temporal and spatial issues are as evident in DuRPh as the rotation of crops in time and space in the Andes.

The list can probably be extended, but it shows that many, if not most, aspects of the five cases refer to similar key words: connectivity, respect, social responsibility, systems approach. Wageningen could learn from the other sciences where similar issues are present. We could think of societal processes related to ancestors, for example by asking ourselves 'How did they do it?', 'What would they have thought of how we are doing things now?', and by posing questions concerning ethics: 'Should everything that is possible be permitted?' Mainstream science also has to consider how to deal with aspects that cannot be measured but which are important in society, such as faith, beliefs (e.g. in organic agriculture) and fears (e.g. of biotechnol-

ogy). Ownership is a subject that is much discussed in the Netherlands – for example how can we make all members of society owners of a problem and of a solution? And which communication patterns and skills are effective for reaching particular goals? Other sciences communicate their learning through community debate, festivals, associations and joint-learning forums. Wageningen researchers have their own festivals, which take the form of scientific conferences, but interaction that involves knowledge transfer to users (extension) or end users (consumers) is very limited, and often stands in the way of acceptance of research results.

A greater amount of interaction between Wageningen scientists and representatives of other sciences, and learning from this, is also needed because of a new phenomenon: people or society are losing their respect for science and scientists and, increasingly, no longer believe them. Opponents argue that there still are risks attached to applying an innovation because not everything has been researched (we are back to Popper!). Another argument put forward is that scientists whose research is paid for by industry produce the outcomes that favour industry. A recent case of a famous Dutch scientist who had faked research results for many years and has now been exposed as a fraud has not helped revive people's trust in science. We could perhaps learn something from the more robust interaction with users that has been shown to take place in the other cases in this book. Wageningen might profit from examining the mechanisms in place elsewhere to create wider public support for innovations.

Could the other cases in this book learn from the reductionist positivist Wageningen approach? The successful contribution of Wageningen to the green revolution (high-yielding varieties, pest and disease control through genetics and chemistry) and as such enabling the world to feed an ever-increasing population was made possible by the 'pyramid of knowledge'. So maybe the following could be taken into consideration by the other sciences of this book:

Go in pursuit of more knowledge and develop a system to accumulate it; build a pyramid.

- Try to make observations and assumptions quantitative (measurements) or at least qualitative (yes, no, good, better, bad).

- Try to make a desired outcome the result of a more mechanistic approach based on a systems analysis.

- Try to achieve a positive global impact with this methodology and disciplinary approach by deriving generic mechanisms.

These and a few more should probably be accepted or rejected, but only after considerable study and peer review. Where phenomena – in other sciences – cannot be observed and measured in the ways described in this chapter, they are not likely to be accepted and thought of as having relevance for the advancement of science.

A potato flower

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Technical education is imparted in the students' own rural environment and involves local experts

Chapter 5

Knowledge dialogues for sustainable endogenous development

Reforming higher education and research in Bolivia

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AGRUCO staff supporting documentation and local assessment of Andean farming practices

1. BACKGROUND

1.1 AGRUCO

In 1985, the University Mayor San Simon (UMSS) of Cochabamba in Bolivia created the centre for Agroecology, AGRUCO, as part of an agreement with the Swiss Agency for Development and Cooperation, SDC. The centre carried out research and education based on an agro-ecological approach, many aspects of which were against the mainstream vision of the time.

During the last two decades of the 20th century, the discourse and praxis of science and development focused on improving economies and centred mainly on the material aspects of life. This approach suggests that if material improvements take place, social reality and well-being will automatically improve. However, this inadequantly addresses social development and neglects concerns related to spirituality. At that time, those who did take into account the socio-cultural or spiritual dimension of native indigenous peoples were regarded as being against progress or traditional fundamentalists. The Green Revolution was regarded as the option for development and was seen as the scientific answer to food shortages. It was based on an agro-industrial approach: use of external inputs (packages of hybrid

seeds, fertilisers, agro-pesticides, mechanisation and irrigation), market orientation and capital investments. It tied the peasant productive systems to the commercial food markets, often at the expense of their subsistence livelihood, crop diversity and food sovereignty. In fact, those in academic circles in Latin America – and especially Bolivia – thought that the only way out of underdevelopment was through the total modernisation of society, politics and economy, the so-called neo-liberalist approach. Anybody who thought otherwise was considered an enemy of national development. Thus, 25 years ago, it was extremely difficult, risky and arduous for AGRUCO to promote agro-ecology and re-valuation of local and indigenous knowledge systems. (Re-valuation is a translation of 're-valuacion' and is used here to mean giving new value to indigenous knowledge. Its usage here is distinct from 'reevaluation'.)

As people started to question the tenets of neo-liberalism in those same decades an important milestone was the United Nations Conference on the Environment and Development, which took place in Rio de Janeiro in 1992. This was one of the key occasions where the idea of 'sustainable development' was proposed, and the event stimulated further analysis and debate on how economic development should take place.

At present, we are witnessing the re-valuation of ancestral knowledge systems in India, Africa, Andean countries, Mayan countries, USA, Canada and New Zealand. Critical debates focus on the educational role of universities in the south that, instead of building or creating their own knowledge, simply reproduce and replicate exogenous knowledge. These debates have resulted in insights and initiatives in several countries towards endogenous development, endogenous education and endogenous research.

In 1996 AGRUCO joined the COMPAS, a programme for comparing and supporting endogenous development that was implemented in 14 different countries across the globe. Since 2008 it has been part of the international CAPTURED programme. CAPTURED focuses on human resource training in universities, the development of training materials and research that can support endogenous development, in pursuit of the

social, material and spiritual knowledge inherited from our ancestors.

Currently we can say that these experiences have allowed us to take important steps as a university centre to support sustainable and endogenous development and inter-scientific dialogues. We believe that the lessons we have learned can contribute to tackling problems related to food production, food sovereignty, climate change, financial issues and the crisis faced by mainstream knowledge and science.

1.2 Political reality of Bolivia today

We are proud to say that Bolivia has undergone substantial policy changes in the past decade and has fundamentally changed the position of its indigenous peoples and their knowledge.The Political Constitution of the State, accepted in 2008, acknowledges our indigenous nations and their ancestral knowledge, and prioritises their inclusion in educational programmes. It refers to the rights of native indigenous peasant peoples:

- To have their own cultural identity, religious beliefs, spiritualties, practices and traditions and their own cosmovision.

- To have their knowledges and traditional wisdom, traditional medicine, language, rituals, symbols and dress valued, respected and promoted.

- To have an intra-cultural, inter-cultural and multilingual education throughout the educational system.

The Educational Bill 70 describes the foundations of Bolivian education:

- It is decolonising, liberating, revolutionary, anti-imperialistic, de-patriarchalising and aimed at transforming economic and social structures; it aims at furthering the cultural reaffirmation of the native indigenous peasant nations and peoples, the inter-cultural and Afro-Bolivian communities in the construction of the Pluri-national State and 'living well' (in Spanish: 'vivir bien').

- It is lay, pluralist and spiritual; it acknowledges and ensures the freedom of conscience and faith and the teaching of religion as well as the spirituality of native indigenous peasant nations and peoples. It nurtures respect and mutual coexistence among peoples with different religious persuasions, without dogmatic imposition and fosters inter-religious dialogue.

- It offers intra-cultural, inter-cultural and multilingual training throughout the educational system. It promotes exchange and coexistence in a state of equal opportunities for everyone through mutual respect among cultures, by enhancing wisdom, knowledge and languages of the native indigenous peasant peoples, inter-cultural communities and Afro-Bolivian communities.

- It is productive and territorial, oriented towards intellectual and material production, creative work, the harmonious relationship between livelihoods and communities on Mother Earth, enhancing the territorial management of native indigenous peasant nations and peoples, inter-cultural communities and Afro-Bolivian peoples.

2. AGRUCO'S INSTITUTIONAL DEVELOPMENT

2.1 AGRUCO's learning process

AGRUCO's work on agro-ecology and advocacy on environmental and cultural concerns has been well received in native indigenous peasant communities. The work carried out during our first 10 years of existence as a university institute involved providing field orientation to our students and sharing daily life and livelihood strategies with the Aymara and Quechua peoples.

We established social interaction with communities by doing Re-valuative Participatory Research (RPR). We found that we needed to build upon local people's knowledge and wisdom to improve their quality of life. We developed a multidimensional perspective instead of a purely economic or technocratic one. This vision constituted a joint learning process with native indigenous peasants, in which the economic, social, political and spiritual aspects are fundamental.

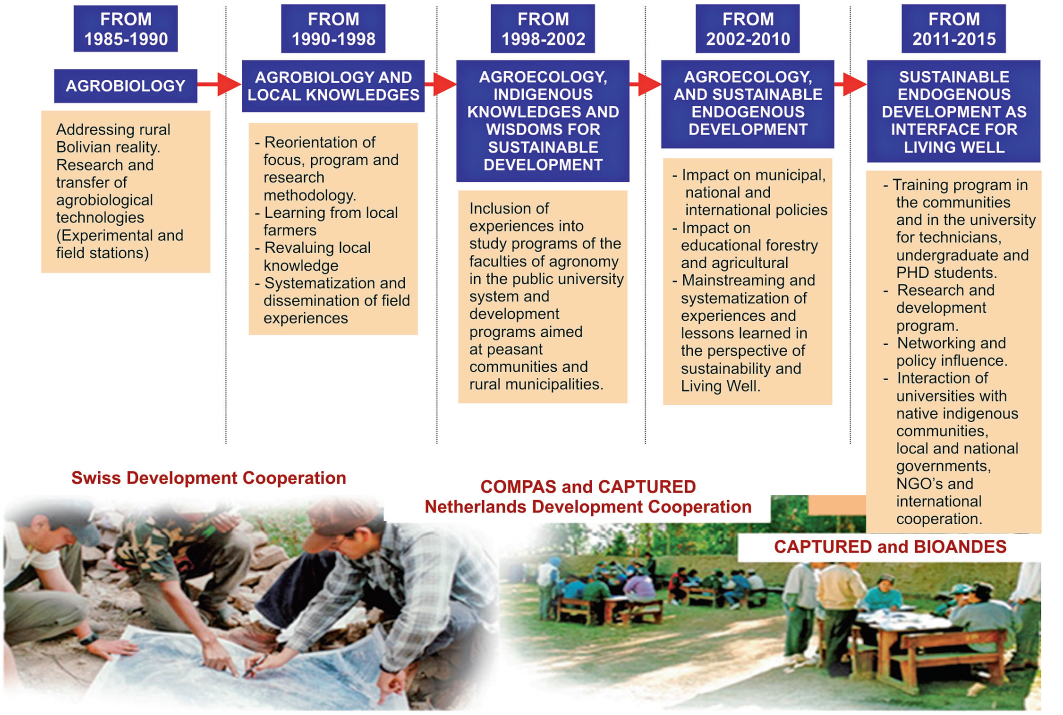
Subjects such as agro-ecology, food sovereignty and food security, indigenous genetic resources, community justice, and especially the conceptualisation and re-valuation of local knowledges, have oriented the university training of future professional agronomists, animal husbandry specialists and veterinarians, foresters, biologists, sociologists, economists and others who have studied in our institution.

All this has been made possible though our cooperation with the Centre for Development and Environment of the University of Bern, COMPAS and CAPTURED, but most importantly with the Constituent Assembly and, specifically, in the committees for education, justice, agriculture and environment.

Here we were able to make contributions towards the new political constitution of the Pluri-national State of Bolivia, which we consider to be one of the most inclusive and democratic constitutions in the world.

AGRUCO's institutional development process can be understood in four stages:

FIG. 5.1 – AGRUCO'S LEARNING AND INSTITUTIONAL DEVELOPMENT PROCESS



Source: AGRUCO Master Plan Phase IX 2011.

As indicated in Fig. 5.1, the first stage (1985-1990) focused on the promotion of European-based organic agriculture, where emphasis was placed on promoting non-polluting and healthy agriculture that preserved the environment and the productive bases. This process taught us that indigenous communities already have a great wealth of knowledge and technologies on these themes and that rather than replacing these with concepts from Europe, it would be better to re-value and strengthen indigenous knowledge.

The attempt to relate organic agriculture with local knowledges was the main focus during the second stage (1990-1998) and this allowed us to look for complementarities and identify differences.

We learned about the practices in the daily life of native indigenous peasant peoples based on an integrated and holistic cosmovision.

This led us to adopt agro-ecology based on indigenous knowledge and practices in the third stage (1998-2002). We learned about Andean indigenous peasants' concepts of nature and their relationship with the spiritual, social and political dimensions of society. For professionals trained within a disciplinary approach, this meant expanding knowledge beyond the realm of technical agronomy and complementing it with social and human sciences. We developed a continuous dialogue within the team and with native indigenous communities and looked for options relating to agricultural production, food security and sovereignty, social and cultural development.

Working with the communities demonstrated the values of the knowledge and wisdom of native indigenous peoples. Their knowledge was not written up in books or studied in post-graduate courses. The importance of the knowledge of native indigenous peoples lies in its relevance for their own communities and we learned that research efforts should aim to re-value and strengthen it. We conceived a methodology that we called Revaluative Participatory Research (RPR), which is aimed at enhancing cultural identity, knowledge and wisdom of native indigenous peoples. RPR supports rural peoples in their ongoing indigenous learning and research activities. It enhances their ways and means of knowing their reality and complements their capacities with conventional research methods. Re-valuative Participatory Research assumes that the reality of rural people is complex and has different levels. One cannot conceive the productive technical aspects without considering the economic or sociocultural dimensions (San Martin, 1997). These insights presented a great challenge to reshaping policy and development.

Sustainable development and its combination with the knowledges and praxis of Andean communities became the basis for what we term the fourth stage (2002-2010), during which the concept of Sustainable Endogenous Development (SED) was developed. This concept was shared by the members of the international COMPAS programme in Asia, Africa, Europe and

Latin America and was taken as the starting point of a quest for new development paradigms.

Understanding the social and spiritual aspects of the daily life of native communities requires a holistic vision. Qualitative methods are articulated with quantitative dimensions and include both local and external scientific visions. This opens the way for what we call 'transdisciplinarity'.

AGRUCO developed a conceptual framework for sustainable endogenous development as a way to achieve living well during the fifth phase (2011 onwards). This involves supporting social movements, communities and municipalities to enhance their own perception of 'development', their own values (such as equity, justice, reciprocity, complementarity) and their own capacities. It will contribute to reducing the huge gap between 'mainstream' society that is used to exploiting its environment and nature and the society of native communities. In this approach indigenous people have the chance to reclaim all the wisdom they collected over centuries and work towards a society where their own notions of living well can be pursued.

Consolidating the conceptual framework and the methodological approach involved a continuous process of reflection and systematisation. The internal training programme for AGRUCO's research and teaching staff (who participated in diverse postgraduate programmes) was of utmost importance, as was their profound relationship with and commitment to native indigenous peasant nations. Further, we benefitted from the participation of many committed scientists from Latin America, Ghana and India, who were part of CAPTURED. Today, COMPAS Latin America has become a platform and network of institutions (NGOs, native indigenous peasant associations and organisations, and public universities) committed to the quest for new paradigms for science and development, building on the livelihood strategies of the communities and peoples, executing small SED projects, and conducting a dialogue on knowledges in Guatemala, Colombia, Ecuador, Peru, Chile and Bolivia.

As a university centre, we have established, without being aware of it, learning communities where dialogue between local

knowledges, the wisdom of our ancestors and mainstream scientific knowledges have contributed to the generation of new knowledge that improves the quality of life of native indigenous peasant nations according to their own values. This dialogue enables the creation of new training programmes. Examples are the Programme for Decolonising Inter-cultural Training (PDIT) and Livelihood Strategies in Bolivian and Latin American communities.

The dialogue between and construction of new scientific paradigms and views of life has had a profound effect not only in Bolivia but also in other Latin American countries, such as Ecuador that have reformulated their political constitutions. This is, undoubtedly, an effect of the leadership of the indigenous president in Bolivia, Evo Morales Ayma.

2.2 Evolving approaches for development and education

AGRUCO was able to go from an initial stage that was centred on organic agriculture towards agro-ecology and the re-valuation of knowledge and wisdom of Andean indigenous peoples, to now working with Sustainable Endogenous Development (SED) aimed at living well.

From our experience, dialogue has been the fundamental element in learning processes that stem from the full acknowledgement of the values, knowledges, technologies, beliefs and strategies which are an integral part of the daily life of native people. This dialogue allows new training programmes to be created; these are articulated through Re-valuative Participatory Research and applied in Sustainable Endogenous Development programmes as an interface for living well. Below we present some of the conceptual and methodological concepts that we learned from and with indigenous people and some of our educational programmes.

- **Documenting indigenous practices and intra-cultural dialogue**

  Documentation helps to re-value local knowledges and technologies in the Quechua and Aymara communities located in the South-Western provinces of the Department of

Cochabamba. Re-valuation becomes possible if endogenous knowledge is expressed and assessed in intra-community dialogues. In cooperation with Pratec, an NGO in Peru, AGRUCO has documented more than 1000 indigenous practices used in different Andean countries. These include activities related to agricultural and animal production, farm tools, health, cooking, rituals and festivals. Each document was presented on a card (cartilla), and contains a graphic presentation, mostly designed by indigenous people themselves, with an explanatory text on one specific technology. They are phrased in the terms of the persons who use the practices, and where necessary AGRUCO technicians helped with writing them down in Spanish and eliciting clear explanation in words and illustrations. The objectives of this process are to support intra-cultural exchange, stimulate endogenous development, inform development workers

Indigenous women teaching AGRUCO technicians about local potato varieties

and to innovate and adapt these technologies. The technologies are then assessed by the knowledge communities themselves and, through intra-cultural exchanges and dialogues, modified and improved so that they can be applied to other ecological zones or cultural contexts. The process is thus an important element of social interaction and participatory technology development. All cartillas are now available on a CD-ROM for sharing within the Andean and wider Latin American or Spanish-speaking communities.

- **Inter-cultural dialogue**

  This refers to complex cultural relations and exchanges that take place among peoples in relation to knowledges and practices that are culturally different. This form of interaction can take place between communities in comparable ecozones and with different cultural characteristics. Social, economic, political and power asymmetries may also play a role here. Dialogue between modern Western science and endogenous sciences was stimulated by AGRUCO and expanded towards other native indigenous peasant nations in Bolivia and elsewhere in Latin America, such as the Amazon nations, the Mapuche, Maya, Nahual, mestizo peasants, and the partners of the COMPAS and CAPTURED network (in Asia, Africa, Europe and Latin America).

  In Bolivia the support provided by the main community-based organisations and national political groupings or indigenous organisations has been fundamental to consolidating educational projects. At the Latin American level, cooperation between native indigenous organisations and NGOs such as Oxlajup Ajpop (Guatemala), Kumefelem (Chile), Pasos del Jaguar (El Salvador), CEPROSI (Peru) and Surcos Comunitarios (Colombia) has led to the collection of interesting experiences in the field of intra- and inter-cultural education.

  Complementing these experiences AGRUCO, with the support of CEPROSI, has managed to establish inter-cultural dialogues with the University of San Antonio Abad in Cusco, Peru, which runs a diploma course in sustainable endogenous development, climate change and transdisciplinarity.

- **Transdisciplinarity**

  This is understood as an integrative process within research and academic training. It builds on and includes disciplinary sciences, but also goes beyond formal disciplinary knowledge and thus provides space for rural people's knowledge. A transdisciplinary approach is adopted with the aim of furthering

innovations and sustainable endogenous development. It allows for the inclusion of different actors in the research-development process; not just academics or scientific communities from different disciplines, but also local researchers, such as native indigenous peoples, peasants, social movements, artists, etc. Transdisciplinarity allows for contributions towards development and new scientific paradigms. It can be conceived of as a self-training and action-research process oriented towards the true complexity of each context, and transcending the limits of disciplinary knowledge. One of the goals of transdisciplinarity is to transcend disciplines and their mechanical interaction. Another is to transcend multidisciplinarity and inter-disciplinarity understood as the sum of disciplines, each with its specific theories, methods and methodologies. It allows at a deep level for the inclusion of other forms of knowledge and other cultures – in what we call inter-cultural and inter-scientific dialogue (Delgado and Rist, 2011). AGRUCO's experience with transdisciplinarity has always been carried out through collective training processes, such as the technical level courses where teachers (academic actors) establish a frank dialogue with students (holders of the local ancestral knowledge systems). Though the teachers are in charge of steering the cognitive exercises, this is simply a formality, because in practice the process constitutes a community learning activity since 'everybody learns and everybody teaches' within an academic and rural context.

- Intra- and inter-science dialogue

  Processes which seek exchange of theoretical knowledge, applied and fundamental research methods, from different sciences, within a framework of acknowledgement and horizontality. Cross-science dialogue can take place between two or more sciences which share the same ontological, gnoseological and epistemological principles (i.e. intra-science dialogue) or between knowledge systems with different ontological, gnoseological and epistemological principles (inter-science dialogues). In both cases the exchanges are founded on a re-valuing process, in which both systems are acknowledged as potentially possessing the same importance, validity and pertinence (Delgado, 2006).

In Latin America, these dialogues, revisions and construction of new scientific paradigms and worldviews have had a profound impact and have contributed to an articulation of the endogenous notion of living well.

- **Permanent Decolonising Inter-cultural Training (PDIT)**

AGRUCO's experiences have provided the general framework for the Permanent Decolonising Inter-cultural Training programme. It offers training at seven different levels: vocational, middle and higher technical levels, undergraduate programmes, diploma courses, specialisation courses, Master's programmes and PhD. PDIT pursues not only the objectives of the market economy but also those of the plural economy proposed by the New Political Constitution of the State: the community economy, state economy and 'co-operative' economy. The aim is to further the personal development of students by maintaining their social commitment towards the community and the State, and to have them actively participate in a society that is ever more complex and requires greater skills.

PDIT supports the material, social and spiritual development of our native, indigenous and peasant nations and the acquisition of knowledge and wisdom required for life. It thus enables the individual to become more aware of his or her relationship with their community. It provides a space for social learning, discussion and construction of programmes and projects for sustainable endogenous development that can foster the intervention of diverse scientific disciplines according to territorial contexts. Doing this implies that the transdisciplinarity approach becomes mainstreamed in university training. Assuming that native, indigenous knowledge also has a scientific basis, transdisciplinarity also addresses training within the science frameworks of native indigenous peasant peoples. PDIT in practice transcends the separation between training, research and action by articulating these within the social learning process for sustainable endogenous development for living well and better territorial management.

Students participating in the PDIT programme in the municipality of Yamparaes

PDIT works with six inter- and transdisciplinary themes:

1. **Re-valuation, dialogue of knowledges and new paradigms for science and development:** This involves contemplation of topics related to theories of culture and society, the nature of different knowledge systems and their relation with mainstream knowledge, alternative paradigms for development and the application of inter- and trans-disciplinary research techniques.

2. **State and public policies:** This area includes topics pertaining to the nature of the State, the policies expressed in its laws, and decolonising public management aimed towards living well.

3. **Agroecology, food sovereignty and security:** This theme is relevant to all training levels as it redefines agriculture, food, security and sovereignty from an indigenous and agro-ecological perspective.

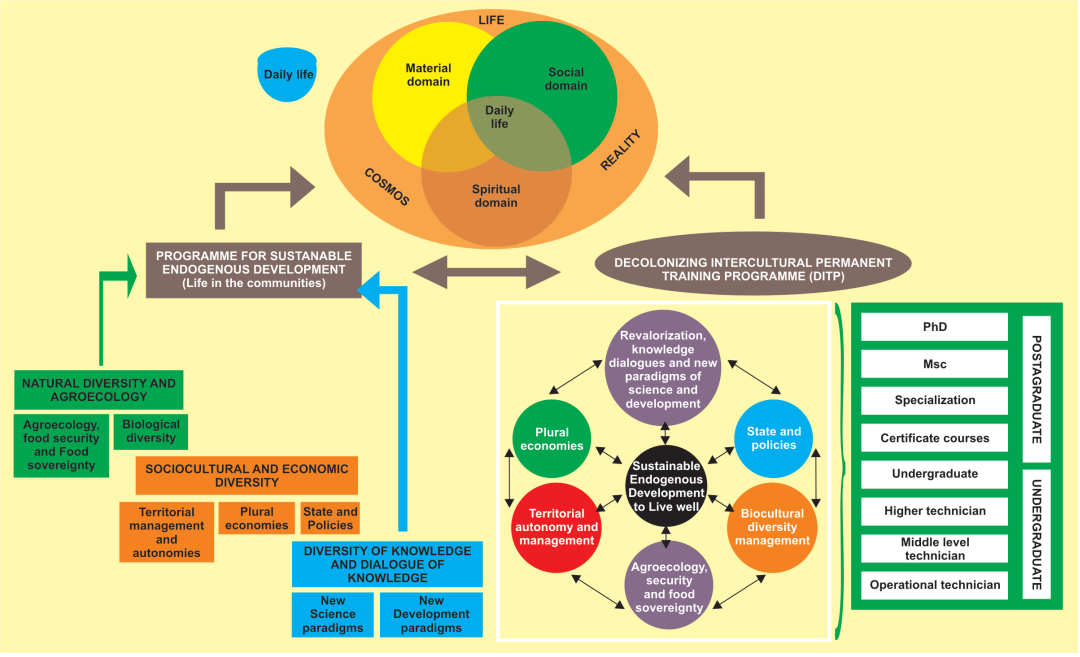
4. **Territorial management and autonomy:** This area deals with new territorial dynamics, territorial autonomy, and especially the relationship between territory and social constructions, such as cultural identity.

5. **Bio-cultural diversity management:** The environmental crisis, expressed in climate change, pollution and degradation of ecosystems, the loss of biological and cultural diversity, is one of the most important concerns of current governments and societies. Thus, this area addresses strategies to mitigate the effects of this multiple crisis.

6. **Plural economies:** The economic crisis we are currently facing is a consequence of the global neo-liberal market crisis, which has become institutionalised. Acknowledgement of the plural nature of an economy proposes economic alternatives that would allow us to overcome this crisis.

PDIT and the programme for sustainable endogenous development have coherent action lines. Fig. 5.2 depicts the thematic areas of both programmes.

FIG. 5.2 – RELATION BETWEEN PDIT AND THE PROGRAMME FOR SUSTAINABLE ENDOGENOUS DEVELOPMENT



Source: AGRUCO Master Plan Phase IX 2011.

Don Ignacio Vargas Jampiri: Traditional healer in the community of Chorojo

3. ANDEAN WAYS OF KNOWING

Below we present our understanding of Andean ways of knowing: worldviews, values and notions of living well, specific knowledge and ways of learning, and validating knowledge in the communities.

We do not directly represent an indigenous view of a particular knowledge community. What we present below is our understanding of the way of knowing of the Aymara and Quechua people in Bolivia. It is the product of what we – Bolivian researchers, some with and some without direct indigenous roots – have learned through intra- and inter-cultural dialogue with different indigenous groups in Bolivia. The way of systematising indigenous ways of knowing is partly based on our own analytical framework as it emerged in the context of CAPTURED. It is the result of a process in which outsiders to the communities, with an attitude of empathy and mostly with similar ethnic and cultural roots, are learning together with indigenous scientists. We integrate some direct contributions of indigenous scientists, notably of Fernando Huanacuni, who currently works for the central government in La Paz, and Andrés Pérez and Cecilio Torres from the rural community Capellani sub central de 8 de Agosto.

We see this document as a starting point to be improved upon by indigenous scientists and experts and by the undergraduate and postgraduate students carrying out fieldwork and research for CAPTURED.

3.1. Ontology: Andean cosmovision[1]

Andean nations have a very specific perception of the cosmos. In their cosmovision the central notion is Pacha, which houses the constantly inter-relating domains of social, material and spiritual.

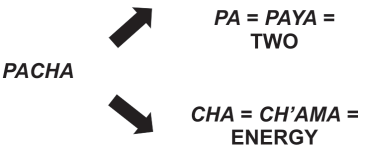
Pacha: Pacha can be understood in terms of two forces: the cosmic force (Pachakama), which comes from outside or from above the planet, and the earthly force (Pachamama) that comes

1. 1 Huanacuni, Mamani, Fernando. Vivir Bien/Buen Vivir; filosofía, políticas, estrategias, y experiencias regionales. La Paz: III – CAP / 2010

from within. These two complementary forces converge in the process of life and generate everything that exists. Pacha embraces time, space, history and life and the balance and dynamic evolution of these expressed as an interplay of forces from outside and within.

In the Aymara and Quechua languages Pacha means the coming together of both the visible and invisible forces; pa means two and cha means force or energy.

FIG. 5.3 – TWO ENERGIES: FROM THE COSMOS AND FROM THE EARTH



Pacha thus goes beyond time and space in their physical sense. It is a way to express the multiverse. It explains the origin, the complementarity, tensions, dynamics and the process and the horizon of past, present and future evolution. The notion of a pair suggests complementarity in all that exists and refers to a state of being naturally in balance. It assumes a joint commitment and responsibility and a corresponding awareness that aims at completeness. The commitment and responsibility is to sustain the process. Awareness gives insight into the processes that aim towards natural completeness. When we let nature flow, we complement ourselves with life, with parity.

Pacha has several spaces

Akapacha: Refers to the visible world; the world of humans, animals, plants and minerals and the inter-relations they build. In the human world akapacha corresponds to the physical body and physical perception and conscience.

Manqhapacha : Refers to the world from within Pachamama and

expresses the forces of Mother Earth. In the Andean worldview the interior of the earth is alive. In relation to human beings, manqhapacha is the inner world, the space of human perception and the subconscious.

Alaxpacha: Refers to the tangible and visible reality of the stars, sun, moon and lightings. In the human world, alaxpacha corresponds with the invisible and etheric body of the emotions and thoughts.

Kawkipacha: Refers to the indefinite and unknown world, the world beyond the visible. There is a world beyond the visible universe. For humans this corresponds with the world beyond human horizons.

Wiñaypacha: Referes to the eternal time space where the ancestral and new spirits connect with the world of the living beings, and transfer energy, wisdom and experiences.

Focusing on the forces of Pachamama in the daily life of humans has led us to understand daily life as the constantly changing confluence of the dynamics circulating within and emanating from the domains of social, material and spiritual life.

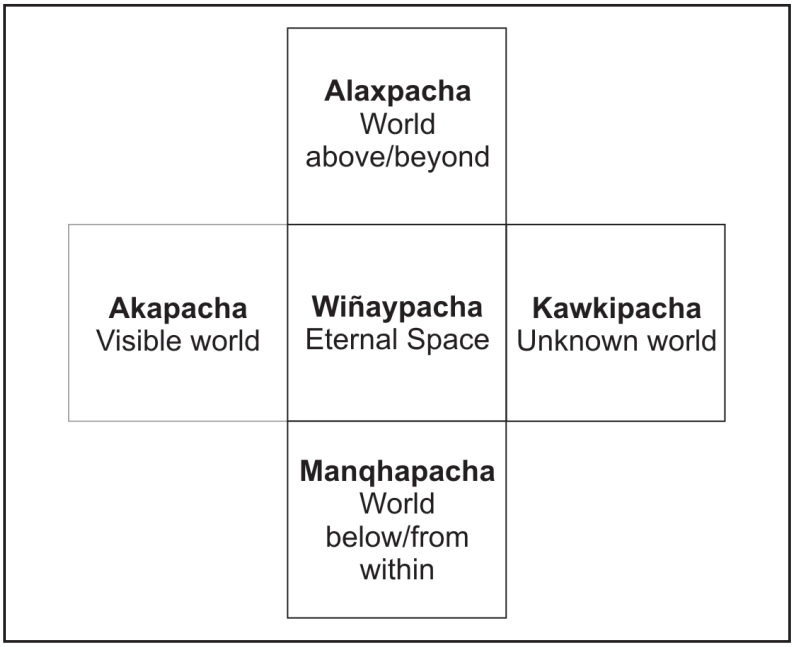
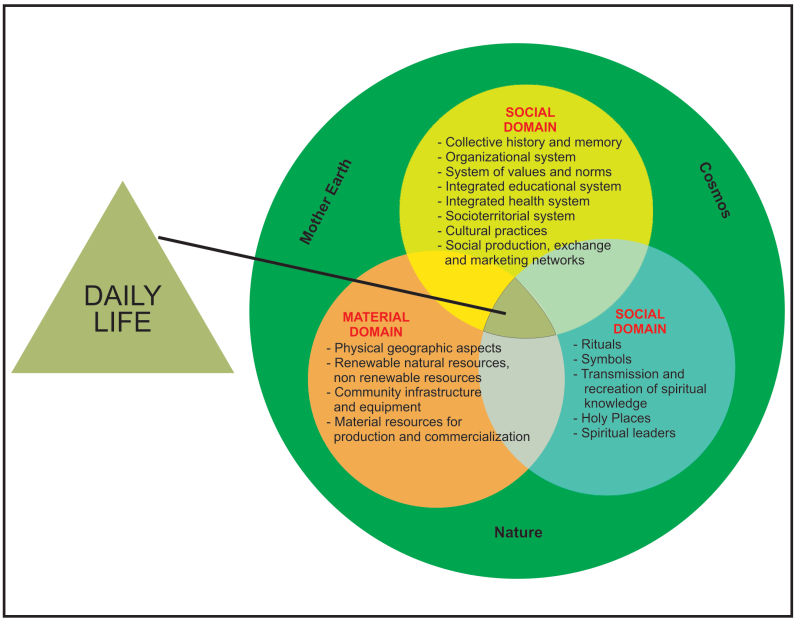


FIG. 5.4 – THREE DOMAINS OF LIFE



Source: AGRUCO Master Plan Phase IX 2011.

Compared to a Western worldview as it is presented in the natural and social sciences, the essence of the Andean lived-reality lies in the fact that it not only assumes a relationship between social and material life, but that it considers the dynamics of spiritual life as an integral part of daily life and one that exists in its own right as do the other two domains.

The model presented here also has an historical dimension, as it refers to life as a continuum and time as a cycle. There is an Aymara phrase that reflects the perception of time: ñayraruwa-puriñani, meaning 'We will arrive at the place where we were before', which implies returning to the past. However, as time and space change during the process of returning to the origin, the type of consciousness resulting from this process is different from the shape and content it had before starting its journey in time and space.

It is this confluence of the dynamics of the three domains of life that explains why the indigenous notion of 'development' is

better expressed as the concrete achievement of living well, realised in different degrees from one community to another. According to this view, the challenge is to maintain the dynamics of the three worlds in balance and care for the material (biophysical) world, as a pre-condition for achieving harmony in the social world, which also requires a constant effort to relate with the spiritual forces that are inherently linked with the social and material domains of life.

Cosmic complementarity of pairs

Pacha also explains the union and convergence of the forces chacha-warmi (male and female), as a result of which everything that exists is a pair: animals, plants, energies, stars, earthly forces, ancestors, stones, mountains, territories, sacred places, rituals, etc. In the great Andean stories the people and impurities that emerged in the global time-space are products of initially antagonistic but eventually complementary forces of good and evil.

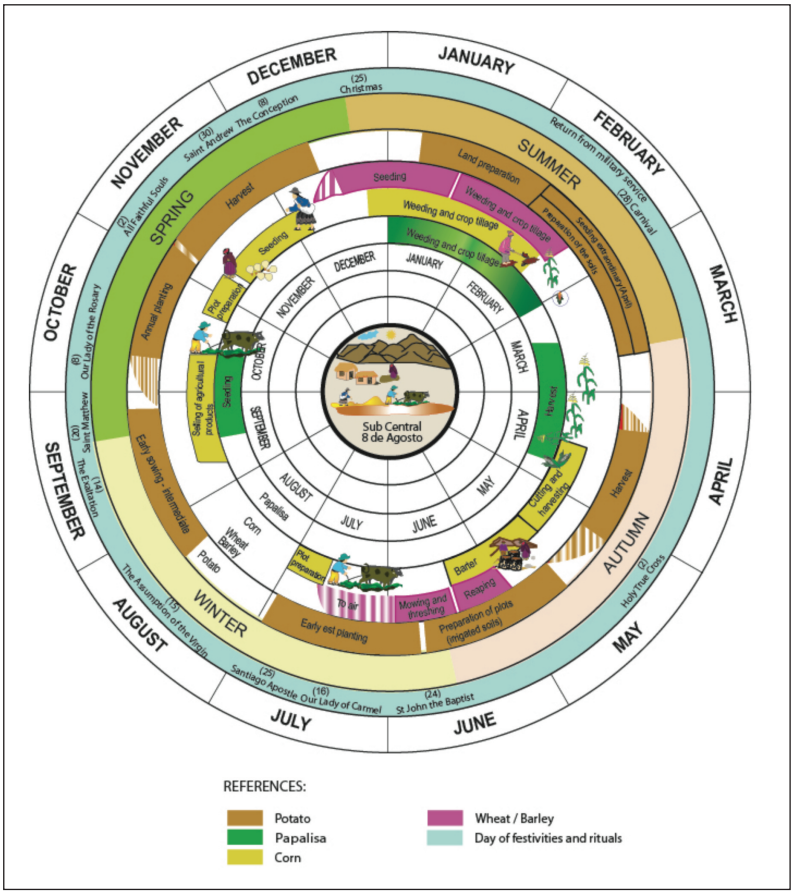
A situation where pairs are in balance is synonymous with life, health, harmony, beauty and perfection, while entities or situations that lack pairs are related to death, disease, imbalance and imperfection. In the Andean world there is no worse disgrace than to be 'impaired', and thus out of balance or harmony in the community, disjointed from unity and integrity, and not connected to suma qamaña (living well and living in balance).

Pairs are not always in harmony; sometimes they are out of balance, engaged in rivalry or conflict, as part of the cycle that precedes all that exists and coexists in the universe. But in the tinku (the forceful encounter of two opposing, but eventually complementary forces) balance is created and the dynamic reproductive processes of life, of Mother Earth, the community, the ancestral and spiritual world are restored. The search for permanent cosmic, social, spiritual, economic, ecological and political balance is the precondition for reaching suma qamaña and requires permanent personal and communitarian action.

Based on this notion, Andean people emphasise the principles of reciprocity and solidarity. An important element in Andean cosmovision is the search for balance in family and community social relations and in the natural and spiritual surroundings. In order

to maintain or re-establish the balance, it is necessary to show a profound respect towards all other human and non-human living beings. The relations of balance are based on giving the other what is within reach and expecting in return that which is within reach of the other and, through this, enhancing complementarity in similar proportions. Thus, community norms, while regulating social relations, also constantly evolve according to the dynamics of reciprocity that living beings are able to establish – allowing expansion and innovation of knowledge, forms of organisation and technologies to sustain, for example, the cycles of agricultural production and ritual practices.

FIG. 5.5 – AGRO-RITUAL CALENDAR



Source: AGRUCO, Project Chuno epistemology II

Cyclical notion of time in Pacha: returning to the past

In the Andean perspective, everything is in movement; nothing is static. The ancestors tell us that it is important to know how to live intensively: how to give brilliance to life, to live fully in the concept of living well.

In contrast to the Western notion of time, where time is linear and goes from the past, through the present and ends up in the future, the Andean notion of time is cyclical: a present time is understood as a confluence of forces emanating from the past (which is not over) and the future (which is latently present) in a continuous process expressed in daily life. Human life does not have a teleological notion in which the realisation of a determined goal is aimed for; rather it constantly creates and re-creates the normative orientations of the part of evolution that depends on the efforts of human beings and – through this – influences the whole process of co-evolution.

The cyclical and sacred notion of time is also expressed in the annual agricultural-ritual calendar. Each agricultural activity coincides with a specific social and ritual activity expressed in a sacrifice, festival or celebration through which the living beings of the bio-physical, social and spiritual worlds communicate and strengthen their reciprocity.

Chronicle of Guaman Poma de Ayala: the Inca king drinks with the sun at the fiesta of the sun

Source: Chronicler Guaman Poma de Ayala (1615)

Rituality in the Andes

To understand the ritual activities that take place in the course of a year, it is important to see the relation between them and the yearly and seasonal rhythms of agricultural activities. But for the indigenous people of the Andes, the rituals are also intrinsically linked to the spiritual content and dynamics of the time-space unity as they are experienced in agricultural practices.

The cha'alla is a ceremony that takes place during all activities that are new: ploughing, sowing, harvesting, birth, marriage, election of new leaders. Activities that require new situations, such as asking for rain, asking for health or wealth, can also be accompanied by a cha'alla. This takes time and involves food, drinks, dance, praying and sacrifices, all of which form part of social activity through which the material world is brought into a special relationship with the spiritual world.

Fasting in Japo-Tapacari: Rituals are a means of communication between human beings and nature

3.2 Axiology: Andean values

In the Andean cosmovision the notions of 'development or underdevelopment' are not known. There is no focus on the growth of material well-being or on material or economic poverty reduction. On the contrary, people work in order to create the material and spiritual conditions to live well. Living well goes much further than the satisfaction of basic needs or access to basic goods and services; it cannot be achieved through Western 'development'. This term is considered inappropriate as it embraces a force that, if applied in indigenous communities, destroys indigenous values and culture, leading to disintegration of communal life and the resources for livelihoods, skills and knowledge.

Andean indigenous people have a multidimensional vision in which balance and harmony between individual and community, and between nature, mankind and the spiritual world are aimed for. The individual is not absorbed entirely by the community, but receives strength from and grows in the community. The central concern is not to accumulate wealth, but rather to be in harmony with nature and the spiritual world. This vision invites people not to take more than the environment can produce and reproduce. It avoids the production of surpluses that cannot be absorbed safely; it encourages the reuse and recycling of all that is produced. In the present global situation,

where people are searching for new ways of assuring better living conditions for mankind as a whole, the notion of living well might be very instructive: living well cannot be achieved without being part of a community. And a community is understood as not only including humans, but also nature and spiritual entities. This notion, therefore, places emphasis on living well together. This is not possible if others live badly or if nature is being damaged. It means that we respect and understand the other, and are united with the sacred in a relationship based on respect and responsibility.

Living well also embraces a political dimension. It implies resisting those forms of living that are destroying human and non-human communities, as is taking place in the hegemonic mainstream model of capitalism, materialism and cultural homogenisation. For this mode of living is degrading local, national and global conditions for enhancing the revitalisation and expansion of cultures. In the case of Bolivia, this search is expressed in the idea of 'communitarian socialism' (García Linera 2010), which aims to create the structural societal conditions that will allow indigenous communities to reactualise the principles of their cosmovisions. Living well has been adopted by the Bolivian government as the basic orientation for its governance and as a major challenge for the Bolivian people to pursue.

Living well: in balance with Pachamama and community

3.3 Gnoseology: Ways of learning, experimenting and teaching

Knowledge production is a socio-spiritual event, not an individual process of accumulation of information. People learn within the family, from neighbours, at the market and during rituals and festivals. Exchanges of experiences take place with elders, adults and children. No one is considered as owning knowledge, whether it refers to natural resources, philosophical production or other types of knowledge, because what anyone knows is the fruit of a collective social dynamic. Thus, topics such as patents and intellectual property rights have always been foreign to Andean indigenous peoples; they subscribe to the idea of collective property rights.

The purpose of knowledge in Andean indigenous sciences (the reason one knows) is a means rather than an end. Knowledge is understood as the result of personal forms of struggle in an endeavour to achieve the principles of living well in the social context in which each person lives. The end or purpose of knowing is therefore represented by helping persons and communities to find adequate ways that allow them to engage with all (and not only the cognitive) dimensions of life in the webs of social, material and spiritual life. This should be done in such a way that the resulting cognitive knowledge of the potential and limitations of the chosen ways becomes part of a communitarian consciousness that aims at entering even deeper into the fullness of human life, within the web that constitutes the dynamic relationship between the three domains of life. This knowledge that is retrieved cognitively and forms part of a steadily growing consciousness is not the product of transmission of abstract concepts from one person to another, but the communitarian rememorisation of a personal but socially shared effort to learn better how to handle one's own and others' forces of life in such a way that they can help to recreate – at least partially – the wholeness of Pacha within and through the consciousness of the human community.

From a Western point of view, it is possible to know everything that is within the reach of the senses. This is universal, but Andean indigenous science takes this notion further, and considers the mind and spirit as part of sensual experience, as long as the corresponding skills are developed. Thus, spiritual prac-

tices that aim to develop such skills are very important. For example, becoming aware of the meanings of dreams, intuition, contemplation, listening to the revelations provided by an ancestor appearing in a vision, meditation, fasting and the practice of rituals are fundamental parts of knowing in a much deeper sense and, as such, may be used to solve daily problems.

Andean science believes that certain knowledge is reserved for people with special gifts, which are the result of special efforts undertaken by these persons in their lives in the past and present. This is the case of Andean yatiris (shamans) or traditional physicians; their medical knowledge and the facility of speaking with plants, animals, and the spirits of humans and ancestors, as well as other special gifts are not learnt, but are rather a gift from the forces that surround us. Thus, epistemologically, these sciences believe that not everything can be known by anybody at any time.

In an interview with CAPTURED researchers, Don Prudencio, a community leader from Ucho Ucho shares his vision on the way learning and teaching takes place in his community.

"In ancestral times the main way in which we transferred our knowledge to younger people was through stories, legends and myths of the area. We learned by doing, copying the skills and ideas from the elders to the younger ones. Also rituals were important moments to learn about our worldview, our values, and the reciprocity between humans and divine beings; morality was taught in families, but also in the community. We corrected and controlled each other's behaviour in the community.

"We also had our own ways of 'taking exams', to find out what young people had learned during their apprenticeship. Contrary to the methods in schools, where the tests only determine to what extent the pupils can reproduce facts and insights, in our system the most important things to test are the skills people have acquired to do the jobs on the farm, in the household or community well, and with the right attitude of respect and reciprocity. The most important aim of teaching is to create good persons with dignity, honesty and morality.

"Indigenous knowledge and knowledge from outside have to be

validated according to whether they serve the needs of the community. It is not the scientific level of the expert that is most important; what counts is the usefulness of knowledge to the community, its complementarity with existing knowledge, and the values and morality it embodies."

Don Prudencio shares his insights about the ways of learning in the community

3.4 Epistemology: Andean knowledge and wisdom

The creative transmission and continuous innovation of Andean knowledge is always framed within the cosmovision of the community. If native indigenous cosmovision states that humans are part of nature and vice versa, then their relations are based on a non-dualist notion of reality. Complementarity and balance are basic mechanisms: man nurtures nature and is being nurtured by nature. The subject-object relationship corresponding to separation, duality and atomisation of reality, specific to Western worldviews, is not part of the Andean worldview. The epistemology of Andean indigenous sciences establishes that knowledge is fundamentally location-specific and at the same time (eventually) universal. One of the virtues of Andean indigenous knowledge is its profound and detailed knowledge of the natural surroundings: the type of soil, weather indicators and humidity. Understanding of these allows people to establish with a degree of precision the dates for sowing, the types and

species of crops to sow, the use of flora and fauna, as well as the date of the ritual. If this knowledge is applied to a different cultural and bio-physical context, there is the chance it may not work as it is not replicable under these conditions.

Finally, it is important to establish that the origin, transmission, management and specificity of native indigenous knowledge takes place within an unfavourable social and historical context that has proved aggressive towards native indigenous epistemology and ontology. In Bolivia, social recognition of the specificity of the cosmovision of indigenous peoples is a recent phenomenon. However, even though the state structures that affect indigenous peoples are being gradually dismantled, there is still the widespread perception that native indigenous peoples are culturally inferior, that their livelihood is backward and, thus, that their knowledges and sciences are anachronistic or simply superstitious. This is especially true in public and private universities. Thus, it is all the more amazing that native indigenous sciences are still operating in vast areas and in the daily lives of millions of people. The historical and social context explains to some degree why the level of development of native indigenous sciences might seem, at first sight, static, and why its ontological and epistemological elements are rapidly degrading and becoming limited to a series of daily practical tips, in danger of losing the possibility of creating an indigenous meta-knowledge.

Archaeological and anthropological research has revealed that, before colonisation, people living in the Andes had very sophisticated knowledge of mathematics and astronomy, had developed applied sciences and technology for architecture, health, agriculture and food preservation, irrigation and water management, and were masters of crafts such as metallurgy, pottery and weaving.

Mathematics and astronomy were important sciences used for architecture and construction techniques, for example in Tiwanaku, a culture dating back to 200 BC. The technology used in Tiwanaku is considered to be the basis for the cultures in and around Cusco. Buildings were constructed by applying mathematical laws and were oriented in such a way that they could serve as astronomic observatories. The techniques used to carve the stones and place them in walls still puzzle contemporary scientists.

Construction of a wall in Cusco, using carved multi-angular stones and no mortar

The colonial system destroyed large parts of this knowledge, and this process has continued in the postcolonial era, but below the surface the knowledge is still present and is seen as an important source of inspiration for the renaissance of Andean knowledge.

The Andean cross containing mathematical laws in Tiwanaku

Mathematics

Indigenous mathematics was developed to serve architecture, but was also used by the Incas to support their administrative system. It is based on a special logic, in which each number is the sum of the two previous numbers: 1, 2, 3, 5.

Khipu. Source: Chronicler Guaman Poma de Ayala (1615)

The khipu

The term khipu comes from a lexeme khipu in Simi Runa (Quechua), meaning knot or tie. It is a complex system of multi-colour hanging cords tied to a principal cord. Khipus were made of wool (from llama, alpaca or vicuna) or cotton fibres. Detailed studies have shown that the number of strings used can vary from a few pendants to as many as 1500. Khipus were known and used widely in the Andes, probably for thousands of years before the arrival of the Spanish invaders. They are a complex system that can record information on aspects as varied as management, statistics, social organisation, genealogies and founding myths. Many of the khipu still in existence were found in burial places and funerary monuments, indicating the importance of these mysterious cords in rituals associated with death.

A few years after colonists settled in the Andes, the colonial administration abolished institutions and practices deemed to be suspect or unnecessarily hazardous. These included the khipu and the specialists in their use, the khipukamayuq.

Agriculture

An important aspect of Andean architecture is the use of terraces to increase the land available for farming and allow irrigation. The steps provide flat ground surface for food production while protecting the land against erosion.

Miguel Altieri (1996) writes about traditional but contemporary Andean agriculture:

> *Despite the increasing industrialisation of agriculture, the great majority of the farmers in the Andes are peasants, or small-scale*

producers. They still farm the valleys and slopes with traditional and subsistence methods. After centuries of cultural and biological evolution, traditional farmers have developed and inherited complex farming systems, adapted to the local conditions. These have helped them to sustainably manage harsh environments and meet their subsistence needs, without depending on mechanisation, chemical fertilisers, pesticides or other technologies of modern agricultural science.

The terraces throughout the Andean slopes, and the waru-waru (raised fields) and qochas in the Altiplano are sophisticated expressions of landscape modification that have historically rendered more than a million hectares of land for agricultural purposes (Rengifo 1987). The past and present existence of these and other forms of intensive agricultural systems document a successful adaptation to difficult environments by indigenous farmers. In fact, applied research conducted on these systems reveals that many traditional farming practices, once regarded as primitive or misguided, are now being recognised as sophisticated and appropriate.

Agro-ecological and ethno-ecological evidence increasingly indicates that these systems are productive, sustainable, ecologically sound, and tuned to the social, economic, and cultural features of the Andean heterogeneous landscape (Earls 1989). Cultural adaptations that farmers have developed in the Andes include:

- Domestication of a diversity of plants and animals and maintenance of a wide genetic resource base.

- Establishment of diverse production zones along altitudinal and vertical gradients.

- Development of a series of traditional technologies and land-use practices to deal with altitude, slope, extreme climates, etc.

- Different levels and types of social control over production zones, including sectoral fallows.

Construction of terraces in the community Ch'orojo, Quillacollo Province

Andean health system

The *Kallawaya*, is a community of itinerant healers possessing great wisdom. They practise healing with herbs and rituals in the Bolivian Andes. Their holistic approach involves a long conversation with a patient and the environment in which the patient is living. They observe strict moral and religious codes and are highly respected by the people. They believe that living in harmony with Pachamama is the most important reason to maintain health. Every mountain has its own deity who protects the inhabitants.

The Kallawaya is a community of itinerant healers and herbalists. Its cosmovision was inscribed in the Representative List of the Intangible Cultural Heritage of Humanity.
Photo: UNESCO/J Tubiana

Andean systems of weather prediction

Traditional Andean knowledge includes mechanisms and systems to predict weather, which is important for the planning of agricultural activities. Responding effectively to weather conditions allows people to occupy different ecological niches in the mountainous areas, where the climate varies with altitude and orientation and can sometimes be very harsh. This knowledge has enabled people to domesticate animals and plants and to raise and grow them in a sophisticated way. It has emerged over the course of thousands of years and is based on a systematic understanding of events and signals. Observation and interpretation of plant and animal life (bio-indicators) are combined with observation and interpretation of astronomic indicators (the movement of the sun, moon and stars), reading of the atmospheric indicators (shapes and colours of the clouds, direction and strength of the winds), and understanding of the signals of divinities, foresights and dreams. Decisions about planting, harvesting and other cultural practices are based on these predictions. The validity of this system is evidenced in the viability of Andean culture and its livelihood systems (Ponce, 2003).

3.5 The knowledge community: Yatiris

In the Andean world, persons possessing knowledge and wisdom play an important role in supporting community life, giving meaning to life and enhancing balance, health and fortune. Colonial and post-colonial history has not eroded the positions of these specialists in Andean rituality, who are generally referred to as yatiri in both Quechua and Aymara, the two main languages spoken in the region. The functions, expertise and ways in which yatiris are appointed vary from area to area. Some yatiris have the capacity of clairvoyance, others have the capacity to cure and heal people, and yet others know how to read the signals of the cosmos and nature.

A *yatiri* has to 'think and feel well' and has to be very disciplined and generous. These qualities contribute to a yatiri's insights, skills in the use of resources and in the judgments and recommendations he or she makes. Yatiris read signs from coca leaves, and through these can communicate with the divinities and thus indirectly enhance the fate of the community. A yatiri has

the therapeutic capacity to restore the balance between nature and humans that is manifest in a disease.

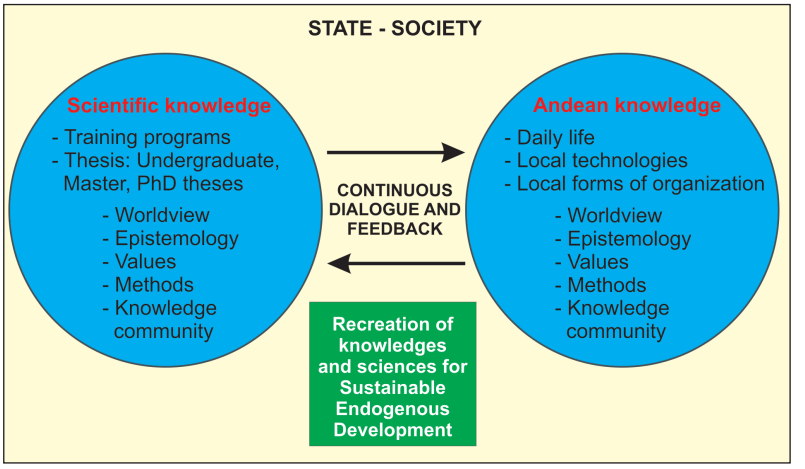
A *yatiri's* initiation is generally based on a mystic event; it is not a personal choice of an individual to become a yatiri. The choice may be indicated by birth: being a twin, being born in a certain way (e.g. standing), being born with more than the normal five fingers, or any other physical deformation. The clearest sign is being struck by lightning once or twice. After recovering consciousness, the person is deemed to be clairvoyant and have the capacities to heal and cure. As part of receiving his or her gifts the person may receive a piece of metal, with magnetic properties or of meteoric origin. A Ch'amakani is a yatiri with great authority, and superior gifts and knowledge.

Tapacrí, Cochabamaba: Crop rotation in community-owned fields minimises the risks through time and space management that makes use of climatic, ecological and biological diversity

4. INTRA- AND INTER-SCIENCE DIALOGUE

Inter-science dialogue seeks to understand the differences and the complementarity of different knowledge, perceptions and ways of generating knowledge. We believe that mainstream sciences (natural, social, conventional or alternative) can provide a point of reference for the sciences of native indigenous peoples, as much as endogenous knowledge can provide insights for mainstream science. Thus it is important to build epistemological bridges between mainstream science and other knowledges. Social science within the mainstream body of knowledge subscribes to a qualitative paradigm, which provides the most openings for steps in this direction.

FIG. 5.6 – RELATIONSHIP BETWEEN SCIENTIFIC KNOWLEDGE AND LOCAL KNOWLEDGE



Source: Vargas & Delgado, 2005.

4.1 Approaching Andean ways of knowing through inter-science dialogues

We first present the testimony of an indigenous peasant from the highlands of Bolivia, Don Facundino, who shared the following experience while narrating his life history:

When I was elected as Jilakata (traditional authority) by the community, I had to learn many things that I had not known before. As

authorities we have to be very careful, because if we fail in something, hail or frost can be attracted… You know, when I was Jilakata there was also frost! I had not behaved as they told me to do, being an authority. The potato fields were looking very sad! They were completely black. It was terrible and I cried a lot. Finally, I went to the Shaman and with him we conducted a ritual called 'water exchange'. First we climbed up to a sacred source that never dries – even in years of severe drought; from there we brought back some water to the affected potato fields. We poured this water into a completely dried well in the sector where the potato fields were situated and where the frost had hit hardest. During this ritual we chewed coca and under the guidance of the Shaman we prayed to Mother Earth to send us rain… this was the only hope left of at least partial recovery of the crops of our whole community. And then, after a long night, at daybreak, it started to rain! The plants recovered and we had a good harvest and I never failed to respect Mother Earth and the Shamans who are able to communicate with her; because of this, the community thanked me with the words 'Thank you, you fed us well!"

What does this testimony tell us? It raises an interesting question: does a relationship exist between the moral behaviour of humans and bioecological and climatic processes? Does Mother Earth really sanction the disrespectful behaviour of a traditional authority with the occurrence of frost or hail? Or, phrasing it in a more general way: is there a relationship between the spiritual life of humans and natural processes? Working with indigenous people in the Andes, Stefan Rist has explored the question: 'What can scientists say about this experience?' He suggests that mainstream sciences offer two main but partial answers about the kind of experience narrated by Don Facundino: one from the natural sciences and one from the social sciences.

4.1.1 The view of the natural sciences

The natural science-based answer is closely related to the question of what a plant is and its relationship with human influences. If we want to reach a scientific understanding of what a plant is, we have to look at how it is analysed and how knowledge about it is constructed. According to biology, a plant is seen as an expression of the genetic structure it represents and the interaction it has with the specific biophysical environment in which it grows. From this point of view, it is clear that human

influence can be exerted by modifying the genetic structure of the plant, or by changing the biophysical conditions under which the plant is growing, by activities as fertiliser application, weeding or irrigation. With regard to the climatic conditions, which – in the experience of Don Facundino – were first negatively and then positively influenced by his behaviour, the branch of the natural sciences dealing with climatology gives a straightforward answer. Weather is understood only in terms of physical forces with causal inter-relations, for example humidity, temperature, evaporation, condensation and gravity, which interact with the – equally biophysical – features of landscapes. In this view, it is clear that the disrespectful behaviour of a traditional authority in a small community in the Andes or a ritual performed for counterbalancing it cannot be conceived of as a biophysical cause capable of influencing climatic dynamics. Consequently, the possibility that human beings might successfully call for rain after frost by enacting a ritual must be rejected.

4.1.2 The view of the social sciences

Let us now have a look at the social sciences and see how they deal with the question raised by these peasants. When the social sciences deal with the kind of experience shared by Don Facundino, they use concepts such as 'symbolic', 'cultural' or 'indigenous' views. An anthropologist or sociologist will say: 'Okay, what this peasant is telling us is his own view of how the plant-human relationship is structured, but this is his subjective view.' By saying 'this is subjective', social scientists make a clear statement proposing that there are other views, which are considered to be objective. From a social science point of view, the question whether moral behaviour might have an influence on climatic processes is delegated to the natural sciences, as the social sciences generally deal with the subjectivities of the social world without being able to define any 'natural laws' of social behaviour.

As a consequence, the social sciences are able to systematise and make understandable to outsiders the reasons underlying Don Facundino's actions. They postulate and accept the coexistence of a large number of subjectivities (expressed in cultures, worldviews or cosmovisions). But with regard to the question how these subjective worldviews are related to natural processes, the social sciences leave the answer open or delegate it to the natural

sciences. Although the social sciences have the advantage that they can accept different subjectivities to explain certain social, cultural and natural phenomena, they do not really offer a sound basis for an answer to Don Facundino and his community's question whether a person's moral behaviour or a ritual can influence natural processes.

4.1.3 Philosophical implications

If we inquire a little further, we see that the underlying basis for this situation is rooted in different schools of thinking about the social and natural world. We can distinguish between two major schools. One is the constructivist view, largely upheld by mainstream social scientists, according to which everything that we think as humans is constructed by humans. When asking about the relationship between what we think or feel deep inside us and 'external reality', it is assumed that humans are unable to know whether or not their inner conceptual or emotional representations reflect reality itself, or whether external reality just consists of 'human' representations of external influences that might be of another quality than our mental constructs. Thus, the constructivist view is also a dualist view. It assumes the coexistence of a natural and a social system. Although the two systems are conceived of as interacting, it is assumed that their 'real quality' can never be revealed by human consciousness.

Another school, known as 'scientific naturalism', is directly related to the natural sciences. It is based on the methodological assumption that observable effects in nature are best explained only through natural causes, without reference to, or assumption about, the existence or non-existence of supernatural notions. It therefore postulates that everything we think or feel is imposed – in one way or another – by external nature. Although this view is more straightforward with regard to the relation between the natural and social systems, naturalist philosophy also shares a basically dualist understanding of the natural and social worlds. While it understands the social world as imposed by natural forces on our consciousness and soul, it assumes that we cannot really know whether human reactions (concepts and emotions) to natural impositions really reflect reality as it is, or whether they are just representations of the impositions originating from nature.

So we see that we have a dualist worldview underlying the natural and social sciences. Based on this dualist view of the world shared by the natural and the social sciences, we can see that the question raised by Don Facundino cannot really be answered by either because the basic assumption of these sciences about what reality is (ontology) and what humans can know about it (epistemology) postulates a separation of the two worlds, with the impossibility of really knowing whether or to what degree they are related. As a consequence, in terms of worldview or cosmovision, the 'mainstream sciences' leave Don Facundino – and together with him millions of people who live in non-dualist cultures – in a kind of ontological and epistemological void.

However, looking at the above issue, if we go beyond the mainstream thinking of the established natural or social sciences, there is surprisingly little proof to substantiate a rejection of a relationship between spiritual life and natural processes. In reality – as comes to mind when listening to Don Facundino – the dualist worldview is a hypothesis rather than something proven by experiments conducted by the scientific community. The only thing is that it has become so internalised and accepted by the mainstream scientific community and the surrounding social groups that everybody has forgotten that basic scientific assumptions are only some among many other hypotheses about the relationship between mind, matter, moral behaviour, and social and natural processes. We are faced here with 'blind spots'.

4.2 Dialogue and worldviews

The 'blind spots' concerning the ontological and epistemological foundations of the mainstream sciences endanger the interaction between the sciences and society at large: when a confirmed hypothesis is considered to be a truth, then science becomes an ideology, making it difficult to question its foundations and establish a dialogue with other ways of looking at the world. What does this mean in more concrete terms for the possibilities of engaging in a dialogue?

In the first place, we have to consider the position of science within society. Science is no longer the beacon that society should use to orient itself. Science is just part of society. That means that society has to define the place and role of scientific

knowledge production – conserving, of course, the institutional independence of research and higher education, but within a concept of co-creation of knowledge between the scientific communities and the many other groups of actors involved who also hold important knowledge, e.g. NGOs, social movements, religious or political organisations, local or indigenous communities and institutions related to the economy.

This implies that we have to opt for transdisciplinary modes of knowledge production: disciplinary science is still valid, but it should be defined from a clearly societal point of view and not as an absolute position with regard to truth. A transdisciplinary approach to knowledge co-creation, therefore, means that science becomes an instrument which, rather than only describing and explaining the world, offers choices and pathways for changing it according to societally defined values, goals and visions of development. In order to take on board problems as perceived by people in their daily lives in this manner, it becomes necessary to integrate an underlying dimension into the process of co-production of knowledge. Scientists have to find ways of relating with people who look at the world very differently than scientists do. In practice, this means that we need to cultivate an attitude of openness and that we have to forget about finding who holds 'the truth'. We should accept that truth cannot be claimed by an individual institution or by an individual person. Truth at the end of the day is nothing more than an inter-subjectively agreed-upon view on certain phenomena.

We need to look more deeply and more critically into the sciences and revise what we consider to be the latest insights that come from science, perhaps looking slightly beyond what is published in the main scientific journals. Doing so allows us to find, for example, the very interesting work of the quantum physicist and former director of the Max Planck Institute, Hans-Peter Duerr (2007). He shows how, as a highly renowned physicist, he came to the conclusion that matter is not made of matter! What exists, he states, is something that looks much more like 'mind', which creates potentialities for matter to emerge, under certain conditions.

We can also learn from people in the South: when scientists cannot find a satisfactory answer to explain certain phenomena,

merely looking forward and trying to imagine what else could be found within the existing scientific frameworks may not be the best solution. The systemic, holistic approach of other ways of knowing may offer complementary perspectives.

It is also important to look back and find out how things were in previous times, for instance before science became what it is now. Then we might encounter, for example, Johann Wolfgang von Goethe who lived in Europe at the end of the 18th century and created his own scientific method (phenomenology). This, today, would be called an alternative, more comprehensive version of non-dualist natural science.

Let us have another look at the example from Bolivia, in order to better understand what it means to engage in a transdisciplinary mode of societal co-creation of knowledge. When hail falls on the land tilled by a community, the peasants are always very sad because the plants are usually almost completely destroyed. Faced with this severe problem, they try of course to understand why they have been hit by hail. This is exactly the question they asked us within the context of the university programme mentioned above, looking for a scientific explanation. The natural sciences cannot say much about why a hail event has occurred; they focus instead on how the phenomenon normally originates: moisture rises up to very high altitudes, where it condenses due to the lower temperatures; it freezes, and when it falls, it develops high velocity, causing severe damage to crops as they are hit by the grain- or ball-sized pieces of ice. Science also says that it is difficult to predict where and when hail will fall because it is a spontaneous reaction to a very large number of natural processes and is generated within a very short timespan, making it difficult to foresee its occurrence.

Now let's look at what Bolivian peasant communities do when there is a hail event. They immediately start going from house to house to see whether there was a case of violent bloodshed in any of them. This may have been caused by a fight between people, or by an illicit abortion. Once the persons involved in this violent bloodshed are identified, they are invited to go through a series of rituals that are necessary to appease Mother Earth. As the example of Don Facundino confirms, to them it is complete-

ly clear that when hail falls, it is because the community has failed to live as they should. In other words they have created their own socio-cultural technology, made meaningful on the basis of their own worldview.

We can see that a new dimension of reflection on development is arising, allowing us to better express what it means to work with endogenous development: it is not enough to know how things happen; indigenous and many other people want to know also – in a teleological sense – why things happen. The example also makes clear that an answer capable of satisfying both sides can only be found on the basis of a dialogue between scientific and non-scientific people, who, moreover, are capable of establishing an inter-epistemological and inter-ontological dialogue.

Considering the epistemological and ontological dimensions of the different forms of knowledge that are interacting in endogenous development allows us to unmask another myth: that science claims to have a much more 'universal knowledge' while the one held by local people is 'local' or 'contextualised' knowledge. We can see that in both cases there is an inter-relationship, a specific explanation about how what happens locally is related to a global context. So the difference is not at all a difference between 'local knowledge' and 'global knowledge'; the difference is always related to the different ways of understanding what happens locally and how this is related to the global level.

4.3 Methodological implications of endogenous development

Looking a little more closely at how the scientific and the manifold non-scientific worldviews shape the production, reproduction and socialisation of knowledge allows us to identify another important – methodological – dimension of the dialogue between different forms of knowledge.

By comparing the basic methodology of scientific production of 'objective' knowledge with how knowledge is produced in non-academic communities, the following fundamental difference can be identified: in discussions with the experts on endogenous development from Africa, India and Latin America, it was concluded that scientific methods aim to separate as systematically as possible the observer from the observed (the subject from the

object). However the methodology for producing knowledge for endogenous development tries to narrow down the distance between the observer and the observed as much as possible. Through this, endogenous knowledge ideally leads to an elimination of the boundary between object and subject. This in turn leads to the possibility for the knowing subject to experience the world from the point of view of a plant, an animal, a stone, a star, the sun or any other component of interest.

This means more concretely that if you want to understand a plant, you have to become like a plant. How can you do that? In Bolivia, but also in many other cultures in Africa or Asia, there are several methods to create the mental conditions under which it is possible to perceive the world from the point of view of a plant. Thus, during the rituals of Carnival in the Andean communities of Bolivia, people celebrate the shift in plant growth from vegetative growth to maturation by calling upon the spirits of the ancestors that are needed to help the plants 'remember' how to overcome external material growth in favour of interior processes of transformation and maturation. A main resource for accompanying this shift is the playing of season-specific music and the performing of dances. This is also expressed externally by masking the music players as plants. For a period of three or four days people really try to be a plant, to feel like a plant, to think like a plant, and with this insight they go back to their fields and decide what they have to do with their potatoes or their pastures.

What conclusion can we draw if we propose that endogenous development should be based on the societal mode of co-producing knowledge between scientific and other communities? How could that be organised?

We have seen that we have basically three forms of perceiving the world. We have the naturalist worldview that is related more to the natural sciences and the constructivist worldview underlying most of the social sciences; both of these are based on a dualist understanding of the social and natural systems. In addition, we have a third way of perceiving the world, represented by the many worldviews based on a non-dualist or a-dualist understanding of the natural and social worlds, in which the spiritual dimension of human behaviour is not systematically excluded

from understanding what happens within and between the social and natural domain.

A common ground for a dialogue between these three views can emerge if we forget about the exclusive truth claimed by the natural sciences, and if we establish a dialogue on the basis of a shared concern and the aim of coming to a shared understanding of the complex inter-relationships between the mind, matter, related domains of life, and the different ways in which communities and societies organise themselves.

4.4 Building inter-science bridges

Inter-scientific dialogues can be understood from two perspectives: the first one considers the dialogue between two scientific disciplines. For example, a dialogue between natural and social sciences. In this case, the dialogue is framed within a shared paradigm with its specific epistemology, gnoseology and ontology. The second perspective, which is much newer in academia, proposes a dialogue between mainstream scientific and other knowledges with wisdoms from around the world, specifically those of native indigenous peoples. This dialogue stems from an initial acknowledgement of the knowledge and wisdom of native indigenous peoples as an expression of a science with its own ontology, axiology, epistemology, gnoseology and knowledge community. This also forms part of so-called transdisciplinary approaches to scientific knowledge production.

To establish 'epistemological bridges' between the sciences of native indigenous peoples and mainstream sciences, specifically the social sciences within the qualitative paradigm, it is important to enumerate some of the main characteristics of these different sciences.

Thus, the ontological characteristics of the qualitative paradigm establish that the research process and the generation of science and knowledge must consider the nature of what is to be known itself as well as in the context in which it is found. Thus, knowledge and science are circumscribed by a historical and social context and by a context determined by the worldview. This determines the scale of values, the sense, and the 'whys' and 'wherefores' of research.

Furthermore, the epistemological characteristics of the qualitative paradigm establish that, insofar as the origin and transmission of knowledge is the product of human activity, it is social knowledge that has been collectively built. There are no absolute truths and knowledge is not necessarily universal. Inasmuch as science is developed through human activity, it is circumscribed by a specific historical context, and this is especially true in the realm of social sciences.

The essence of inter-scientific dialogue between the knowledge and wisdom of native indigenous peoples and modern mainstream science consists of the process of building the theories of its foundations, its possible complementarities and confrontations. Experience has shown that it is possible to build an intercultural and inter-scientific dialogue based on the daily lives of peoples as well as on mainstream scientific insights, as part of a process of social learning between the academe and native indigenous peoples. AGRUCO is happy to be part of this social learning process, and is determined to continue to support sustainable endogenous development, education and research. We hope to continue to cooperate and learn together with knowledge communities in different cultures and scientific traditions.

'The future is behind'. Aransaya Ayllu authorities during a ritual

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Chapter 6

Intra- and Inter-science dialogues: towards co-creation of sciences

Bertus Haverkort, David Millar, Darshan Shankar and Freddy Delgado Burgoa

6.1 DEALING WITH PLURALITY OF SCIENCES

From the four cases of culture specific ways of knowing presented in this book we have seen that in each case worldviews, values, ways of learning, nature of the knowledge created and knowledge communities are quite different. We have also seen that the level of sophistication of these ways of knowing and details of their articulation, the size and level of organisation of their knowledge community, the funding and the dynamics of the bodies of knowledge differ substantially. This raises the following questions:

- How can each science build on its strengths and identify and address its weaknesses?

- To what extent can the different sciences be complementary? To what extent can they be considered incommensurable? And what does that imply?

- How can co-creation of sciences be stimulated? How can we build bridges and have inter-science exchange and dialogues between sciences that have evolved in different cultures?

This chapter tries to provide some of the answers to these questions. We start by presenting insights about the historical relationships that have developed between different sciences from the perspective of a number of knowledge communities. Subsequently we will explore the options for and share preliminary experiences with intra- and inter-science exchange and learning.

6.1.1 Indian perspectives

Nature is understood in the Indian tradition to possess not merely physical and biological attributes that are sensate but also a spiritual attribute, which is seen and experienced by the mind. These three dimensions are understood to influence each other and the logic of this inter-dependent relationship suggests that the causes of physical, biological or spiritual changes may therefore have their genesis in any of the three planes.

One fundamental point of departure from Western knowledge systems thus arises from the fact that the spiritual planes of existence are non-sensory and therefore cognisable only by the mind and not by the five senses. In the Indian tradition, spirituality is a part of the normal worldview and cosmology of nature. In the Western tradition this kind of knowledge is brought into the category of religious thought (outside the scope of sciences). The spiritual dimension of nature requires a large number of symbolic expressions, transactions, rituals and processes, which appear very strange, to Westerners at least, when compared with the processes needed to deal with the physical and biological world.

For Western thought to understand Indian knowledge systems a paradigm shift will be required in the understanding of causes of change for two reasons. First, the Indian worldview considers fields and their relationships, which is essentially a macroscopic view of nature. It is not a structural or microscopic view. For these two views to be reconciled an understanding is required of the complex relationship between the macro and the micro, or the whole and the part.

Second, Indian thought throws another spanner in the works by adding a spiritual dimension into the horizon of nature, thus extending its scope and introducing a whole new set of subtle, metaphysical objects into the scheme of nature, which are not sensate and require a trained mind to experience and comprehend them. This new set of interrelated spiritual objects alongside the forces that govern them, introduces a new dimension to the theory of causality. It is challenging, and perhaps initially confusing, to invoke the communicative action advocated by Jürgen Habermas to achieve mutual learning between the mainstream and Indian sciences.

During the last three centuries, in which Europe has been politically dominant on the world stage, a strange social phenomenon has arisen in many parts of the world, particularly in countries in Africa, Asia, Australia and North and South America. The European nations succeeded in creating a huge disruption in the social evolution of the societies they colonised by imposing European traditions on the indigenous cultures. Western politi-

cians and scholars committed what history will judge to be a civilisational wrong and a gigantic cultural blunder by misleading the indigenous intelligentsia and dozens of colonised countries into believing that modernity was no longer to be a natural evolution from their own past into their present, but that it had to be imported from the advanced West. Thus a cultural divide was created between an evolving indigenous tradition that was seeking to come to terms with the present, which is the natural process of modernisation in any society, and an alien intervention from the West decrying the indigenous effort as orthodoxy, and imposing its own modern cultural constructs as the universal strategy for modernisation of all societies. In fact all living societies and communities, at all levels and at all times are continuously modernising by their adaptation to the present (UNESCO, 2005). Indeed the content of the modernisation of different societies is bound to be different. It cannot be envisaged to be mono-cultural or uniform because this would violate the natural continuity between the past, present and future. Modernisation ought to be essentially a multi-cultural phenomenon, despite what Western scientists have conditioned us to believe. In recent literature on colonial encounters there is acknowledgement of the value of traditions and local cultures and their role in shaping contemporary society (UNESCO, 2000).

Modern Indian philosophy was developed during the British occupation (1750-1947). The philosophers who gave contemporary meaning to traditional philosophy in this era included Swami Vivekananda, Sri Aurobindo, Rabindranath Tagore and Mahatma Gandhi.

Swami Vivekananda introduced Indian Philosophy (the Vedanta and Yoga) to the Western world, Europe and the US. Sri Aurobindo synthesised Eastern and Western religion, philosophy and psychology and created a substantial body of literature in English.

Rabindranath Tagore, the great Indian thinker and Nobel laureate, was of the view that, while the winds from all over the world may flow freely into our hearts, they should not be allowed to sweep us off our feet. Scientists concerned need to understand that, while all societies can share and learn from each other, the

core of their modernity must derive from their own roots.

Political philosophy most closely associated with India is the one of non-violence, popularised by Mahatma Gandhi during the Indian struggle for Independence.

Today, thousands of oral and dozens of written languages created by indigenous communities as part of their modernisation across the centuries have already become extinct (UNESCO, 2003). Many ethnic sciences, technologies, social sciences, arts, crafts, music, foods, agriculture, veterinary and medical knowledge systems evolved to meet societal needs (and several of them possessing universal attributes) are stagnating and getting lost. Profound worldviews and epistemologies that comprehend the world in unique ways are being sidelined. There is, in fact, no realistic estimate of what human civilisation is losing each year, day and minute on account of its narrow-minded pursuit of a mono-cultural modernity. It is important to reinforce the recent efforts of UNESCO and other international and national bodies that have realised the limitations of a uniform and universal modernity and have initiated efforts to save the world's cultural diversity, which is so critical for civilisational evolution.

6.1.2 African perspectives

Between 1950 and 1970, the period in which most African nations became independent from the colonial system, a strong African intellectualist movement arose. William Dubois, Franz Fanon and Leopold Senghor were three of the important intellectuals writing about and supporting struggles for African identity, colonial freedom and Pan Africanism.

William Du Bois was an American civil rights activist and Pan Africanist. Racism was the main target of Du Bois's polemics. His cause included coloured persons everywhere, particularly Africans and Asians in their struggles against colonialism and imperialism. He helped in getting freedom for several African colonies from European powers. He believed that capitalism was a primary cause of racism and was an ardent peace activist.

In his book, Black Skin, White Masks, Franz Fanon (1952) analyses the psychological effects of colonial subjugation on

people identified as Black. Fanon explains the feelings of dependency and inadequacy that Black people experience in a White world. He speaks of the divided self-perception of the Black subject who has lost his native cultural originality and embraced the culture of the mother country. As a result of the inferiority complex engendered in the mind of the Black subject, he will try to appropriate and imitate the cultural code of the coloniser. This behaviour, Fanon argues, is even more evident in upwardly mobile and educated Black people who can afford to acquire Western status symbols.

Leopold Senghor, a Senegalese intellectual and politician, created the concept of Negritude, an important intellectual movement that identified and promoted appreciation of distinctive African characteristics, values, and aesthetics. This was a reaction against the strong dominance of French culture in the colonies and against the perception that Africa did not have culture that was developed enough to stand alongside that of Europe. Building upon historical research and identifying ancient Egypt with black Africa, Senghor argued that sub-Saharan Africa and Europe are in fact part of the same cultural continuum, reaching from Egypt to classical Greece, through Rome to the European colonial powers of the modern age. Negritude was by no means an anti-white racism, but rather emphasised the importance of dialogue and exchange among different cultures, in particular European, African and Arab cultures.

The first presidents of Ghana, Kenya, Uganda, Tanzania and Senegal were intellectuals with a strong dedication to African culture. They stimulated the political and intellectual movements known as the African revolution. Kwame Nkrumah, the first president of Ghana, was an influential advocate of Pan-Africanism in the 20th century and a founding member of the Organisation of African Unity.

After the early years of independence in Africa, however, a number of political coups and political changes led to rising political authoritarianism and as a result also to declining academic freedom. The one-party systems and the Cold War forced not only politicians, but also intellectuals into Western or Eastern

political camps. The decline of African intellectualism was compounded by the brain drain from Africa and falling standards in major institutions for higher learning and research.

The Kenya-born scientist Ali Mazrui (Mkandwire, 2005) attributes the decline of the last 40 years to a lack of political distance between universities and the State, the distance of universities from African culture and their weak links with wider scholarly and scientific values in the world of learning. According to Mazrui, it is difficult to be culturally close to society in Africa since African university systems are colonial in origin and disproportionally European in tradition. Given the low status of African culture and knowledge, there is a contradiction between cultural closeness and the intellectual links with the wider world of science. He observes a new intellectual revival in Africa. One of the main factors promoting this is the pro-democracy movements emerging in at least 20 African countries. The end of the apartheid regime and of the Cold War (and the editors would add: the emerging influence of modern information and communication systems) gave impetus to these democratic developments. Southern Africans started identifying an African renaissance as political apartheid collapsed. Mazrui mentions three recent levels of Pan-Africanism: Sub-Saharan (expressed by regional integration by agencies as ECOWAS, SADC), Trans-Saharan (bringing black and Arab Africa into a partnership as embodied in the Organisation of African Unity, its successor African Union with the New Partnerships for African Development or NEPAD) and Transatlantic (that strengthens the links between Africans in Africa and those in diaspora). Mazrui states that Pan-African academic and research organisations have provided linkages between intellectual revival movements. He mentions specifically the council for the Development of Social Science Research (CODESRIA) based in Dakar and the African Association of Political Science based in South Africa.

This African renaissance is welcomed by contemporary African philosophers like Paulin Hountondji in Benin. He also makes critical remarks (Hountondji, 2003): The experience of Western domination in Africa leads to various degrees of inferiority in the cultures themselves. There were other voices, however, both

within these cultures themselves and from the dominant, especially the European cultures that rejected these claims to superiority and put Western civilisation back in a far more modest place. African voices have been part of this new concert. A danger here, however, could be that non-Western cultures are over idealised and romanticised. The relationship between North and South in the production and use of knowledge is unequal. Knowledge production in Africa is not used to benefit African societies. We write our novels, scientific and technical articles for the Western public and scientific journals, in Western languages. Our African public is a minority. This is something that needs to be changed! African philosophers should, instead of focusing on satisfying the intellectual curiosity of non-Western readers, develop a plural discussion amongst themselves on the issues that are of relevance today. We have to describe the existing worldviews, and critically appreciate these in terms of their effects on our day-to-day lives. These effects may be positive or negative. For example, the position of traditional leaders, the corruption and manipulation that takes place, and the position of women.

The CAPTURED initiative in Ghana is not the only academic initiative. Similar programmes exist in Burkina Faso, Benin, Nigeria, Botswana, Uganda, South Africa and a Pan African programme is in preparation.

NEPAD has a special programme for securing and using Africa's indigenous knowledge base[1]. It presents this programme in the following way: 'Africa has a relatively rich body of indigenous knowledge and related technologies. This is embodied in the continent's cultural and ecological diversities and has been used by the African people for thousands of years to solve specific developmental and environmental problems. Despite their contributions, indigenous knowledge and technologies are not adequately promoted and protected in most African countries. Institutions to safeguard the rights of indigenous knowledge holders are weak in most countries. In addition, there are weak links between the formal R&D institutions and local communities that hold and use the knowledge. This has denied Africa the opportunity to better understand and use its indigenous

1. www.nepadst.org/platforms/bio.shtml

knowledge base. African leaders have recognised and stressed the importance of protecting and promoting indigenous knowledge and technologies to solve specific problems and improve the continent's economies.'

The overall objective of the programme is to strengthen Africa's capacity to harness and apply as well as protect indigenous knowledge and technologies. It has scheduled two projects: a project for the Development of an African Databank on Indigenous Knowledge and Technologies and one on Promoting the Integration of Indigenous Knowledge and Practices in Education Curriculum.

In conclusion, it is fair to say that despite the different initiatives, so far, there is no Africa-wide programme that implements and or coordinates the different initiatives for strengthening endogenous African sciences. The African universities have not yet fully embraced the potential of endogenous education and research. But, in individual universities interesting programmes are being developed and at the policy level attention for endogenous development and indigenous knowledge has grown and is leading to promising initiatives.

6.1.3 Latin American Perspectives

Paolo Freire, Ivan Illich and Orlando Fals Borda are some of the prominent South American intellectuals who have contributed to a redefinition of education and research in the Latin American context. Freire built on the work of Frantz Fanon. In Pedagogy of the Oppressed (1970) he differentiates between the two positions in an unjust society – those of the oppressor and the oppressed – arguing that education should allow the oppressed to regain their sense of humanity.

Freire believed education to be a political act that could not be divorced from pedagogy. Teachers and students must be made aware of the 'politics' that surround education. He is known for his attack on what he called the 'banking' concept of education, in which the student was viewed as an empty account to be filled by the teacher. According to Freire, the system of dominant social relations creates a culture of silence that instils a negative, silenced and suppressed self-image into the oppressed.

The learner must develop a critical consciousness in order to recognise that this culture of silence is created to oppress.

In his book Deschooling Society (1973), Illich gave a critical discourse on education as practised in 'modern' economies. Illich posited self-directed education, supported by intentional social relations, in fluid informal arrangements, rather than universal education through schools.

Orlando Fals Borda was a Colombian researcher and sociologist and important Latin American thinker on development. His perspective built a singular bond between science and politics that dramatically changed the relations between society and knowledge. He also played a key role in the foundation of CLACSO (Latin American Social Science Council) at the end of the 1960s. An essential part of his effort centred on the construction of a perspective from the border and the periphery, focusing on the conditions of subordination found in the societies of the Latin American countries. Fals Borda developed an ethical conception of subversion based on a method of analysis and a praxis called 'positive subversion' through the idea of compromise. He also contributed to the development of critical interpretations, for example analysing the effects of modernity and colonialism on the South.

Fals Borda was one of the founders of Participatory Action Research (PAR), a form of experimental research that focuses on the effects of the researcher's direct actions of practice within a participatory community, with the goal of improving the performance quality of the community or an area of concern (Fals Borda, 1981). Participatory Action Research involves the use of a systematic cyclical method of planning, taking action, observing, evaluating (including self-evaluation) and critical reflection prior to planning the next cycle. It is a collaborative method to test new ideas and implement action for change. It involves direct participation in a dynamic research process, while monitoring and evaluating the effects of the researcher's actions with the aim of improving practice

The 'research' aspects of PAR attempt to avoid the traditional 'extractive' research commonly carried out by universities and

governments where 'experts' go to a community, study their subjects and take away their data to write their papers, reports and theses. Research in PAR is ideally by the local people and for the local people. It is designed to address specific issues identified by local people, and the results are directly applied to the problems at hand. PAR proceeds through repeated cycles, in which researchers and the community start with the identification of major issues, concerns and problems, initiate research, originate action, learn about this action and proceed to a new research and action cycle. This process is a continuous one. Participants in Action Research projects continuously reflect on their learning from the actions and proceed to initiate new actions on the spot. Outcomes are very difficult to predict from the outset, challenges are sizeable and achievements depend to a very large extent on the researcher's commitment, creativity and imagination. PAR builds on the critical pedagogy put forward by Paolo Freire as a response to the traditional formal models of education where the 'teacher' stands at the front and 'imparts' information to the 'students' who are passive recipients. This was further developed in adult-education models throughout Latin America.

The Latin American Council of Social Sciences (CLACSO) is a non-governmental international institution created in 1967 which holds a formal consulting relationship with UNESCO. At present, it brings together 313 research centres and graduate and post-graduate training programmes in the social sciences located in 25 countries in Latin America and the Caribbean, United States and Europe. The Council aims at promoting and developing research and training in the social sciences; strengthening exchange and cooperation among organisations and researchers from in and outside the region; and proper dissemination of the knowledge produced by social scientists among social movements and forces, and civil organisations. Through such activities CLACSO helps rethink the issues related to Latin American and Caribbean societies, from a critical and pluralistic approach. It has a special Poverty and South-South Program of academic cooperation between Africa, Asia and Latin America.

Fals-Borda was able to effectively incorporate the community action component into the research plans of many traditionally trained researchers. It was not until then that communities

started to fully appreciate the benefits of this approach, which had initially seemed too abstract for many. PAR has evolved through the 1990s and into the 21st century as it has been applied to various fields within international development. For example, participatory plant breeding (PPB) and participatory technology development (PTD) are two techniques that make use of PAR approaches. Practitioners have also recently tried to move away from the word 'research' because of its extractive connotations and abstract meaning to many community and group members. Thus new names (with some new elements) are being used, such as 'participatory learning and action' and 're-valuative action research', a methodology to strengthen indigenous knowledge developed by AGRUCO.

As regional coordinator of both COMPAS and CAPTURED, AGRUCO is a leading Latin American institute in the field of endogenous development, endogenous education and research. Its enthusiasm and professionalism is an important asset for Latin American movement for inter-science dialogues in the continent. While mutual exchange between the countries of Latin America is facilitated by the common languages of Spanish and Portuguese, the lack of familiarity with English sometimes hampers intercontinental exchanges.

6.1.4 Other endogenous perspectives

Beyond the cases presented in this book there are quite a number of initiatives and programmes for revitalisation, re-valuing and strengthening endogenous knowledge and sciences. The World Indigenous Nations Higher Education Consortium (WINHEC)[2] provides an international forum and support for indigenous peoples to pursue their own systems of higher education and research. It organises conferences and provides accreditation of indigenous universities and research standards. In this section we mention a few examples from this network. They illustrate the new ways in which endogenous sciences are being positioned, articulated and given a place in universities and policy debates.

2. http://www.win-hec.org

Canadian experiences

In Canada in the last decade an enormous change in education for indigenous people has taken place. Previously it was common practice to force Western education upon indigenous children. Children were removed from their communities and educated in residential schools in order to give them an exposure to Western values and way of thinking. Marie Battiste is a Mik'maq scholar and leading proponent of indigenous knowledge and education in Canada, and has been leading the process of getting special educational programmes for indigenous peoples in Canada. According to her, the most important educational reform is to acknowledge that Canadian schools teach a silent curriculum of Eurocentric knowledge. To affect reform, educators need to make a conscious decision to nurture indigenous knowledge, dignity, identity and integrity by changing the school philosophy, pedagogy and practice. These programmes accept the different learning modalities required for indigenous pupils: they affirm traditional ownership of traditional knowledge, lifestyle and traditional teaching, encourage research and innovations in classroom work by developing research and capacity building in indigenous knowledge and pedagogy. Inherent in this approach is the realisation that ritual, myth, vision, art and learning the art of relationship in particular environments facilitate the health and wholeness of individuals, families and communities. In Saskatchewan this educational concept is called School Plus. It represents a new holistic environment to meet the needs of the youth, not just as a cognitive exercise, but as an experience that embraces the psychological, physical, emotional and cultural needs of children (Battiste, 2000, 2002).

In 2008, the Government of Canada committed to reforming First Nation education. Reforming First Nation education efforts have resulted in significant achievements being accomplished through the reform agenda, such as the establishment of partnerships with provinces and First Nations. As well, new programmes were created to support First Nations to improve students' outcomes. The government is working with First Nations groups and other willing partners to develop options, including new legislation, to improve the governance framework and clarify accountability for First Nation elementary and secondary education. In 2011, the Minister of Aboriginal

Affairs and Northern Development[3] and the National Chief of the Assembly of First Nations launched an engagement process on the development of options, including legislation, to improve the governance framework and to clarify accountability for First Nation elementary and secondary education. A National Panel completed its engagement activities including roundtable discussions and key meetings with parents, students, elders, teachers, provincial officials, as well as online engagement activities for anyone interested in this issue. The Panel's final report provides the government with valuable feedback and recommendations on the next steps that could be taken to improve educational outcomes for First Nation students living on reserves.

The Canadian Aboriginal Learning Knowledge Centre[4] is composed of a consortium and a National Advisory Committee of more than 80 organisations and individuals from across the country working together to create a path for the improvement of Aboriginal learning in Canada. It was created to provide a collaborative national forum that would support the development of effective solutions for the challenges faced by First Nations, Métis and Inuit learners.

First Nations people in USA

Devon Abott and Angela Cavender (2004) examine ways the academy in the USA can be indigenised; to carve a space where indigenous values and knowledge are respected; to create an environment that supports research and methodologies useful to indigenous nation building and to compel institutional responsiveness to indigenous issues, concerns and communities.

A leading scholar in indigenous education, Gregory Cajete, a Tewa Indian from New Mexico has pioneered reconciling indigenous perspectives in sciences with a Western academic setting. His focus is teaching 'culturally based science'. He gives a description of indigenous science:

It is a broad category that includes everything from metaphysics to philosophy to various practical technologies practiced by

3. http://www.aadnc-aandc.gc.ca/eng
4. http://www.ccl-cca.ca

indigenous peoples both past and present. At its most inclusive definition indigenous science may be said to include practically all of human invention before the advent of Cartesian-mechanistic science. These include areas such as astronomy, healing, agriculture, study of plants, animals and natural phenomena. Yet Indigenous science extends beyond these areas to also include a focus on spirituality, community, creativity, appropriate technology which sustains environments and other essential aspects of human life. Further, indigenous science includes exploration of basic questions such as the nature of language, thought and perception, the movement of time, the nature of human feeling, the nature of human knowing, the nature of proper human relationship to the cosmos and a host of other questions about natural reality. Indigenous science is the collective inheritance of human experience with the natural world. It is a map of reality drawn from the experiences of thousands of human generations which gave rise to a diversity of technologies for hunting, fishing, gathering, making art, building, communicating, visioning, healing and being. These theoretical frameworks and perspectives offered by various authors provide just a snapshot of views on ecological education. Diverse approaches and manifestations are possible given basic frameworks. Local adaptations to relevant community-based knowledge systems will enrich educational experiences for students and educators alike. Common to all theories is the idea that building practical curricula for ecological education involves getting out of the classroom into nature, and extending the support network of the educator to include other community members knowledgeable about local traditions. Similarly, in the Aboriginal communities, opportunities for inclusion of traditional knowledge holders to interact with formal educators will result in a broadening of experiences for students, stronger relationships between community members and schools, and an expanded base of experience for educators. Within school systems, educators, administrators and other key people need only consider the alternative to not building an ecologically aware and active public to find motivation to begin or expand their efforts in ecological education. (Cajete, 1994).

Barnhardt and Kawagley describe the experiences of the indigenous peoples in Alaska. Through the Alaska Rural Systemic

Initiative (AKRSI), a state-wide network of 20 partner school districts was formed, involving a total of 176 rural schools serving nearly 20,000 predominantly Alaska Native students. Using an educational reform strategy focusing on integrating local knowledge and pedagogical practices, they conclude that:

While Western science and education tend to emphasise compartmentalised knowledge which is often de-contextualised and taught in the detached setting of a classroom or laboratory, indigenous people have traditionally acquired their knowledge through direct experience in the natural world. For them, the particulars come to be understood in relation to the whole, and the "laws" are continually tested in the context of everyday survival. Western thought also differs from indigenous thought in its notion of competency. In Western terms, competency is often assessed based on predetermined ideas of what a person should know, which is then measured indirectly through various forms of "objective" tests. Such an approach does not address whether that person is actually capable of putting that knowledge into practice. In the traditional native sense, competency has an unequivocal relationship to survival or extinction – if you fail as a caribou hunter, your whole family may be in jeopardy. You either have it, or you don't, and it is tested in a real-world context. Indigenous people do a form of "science" when they are involved in the annual cycle of subsistence activities. They have studied and know a great deal about the flora and fauna, and they have their own classification systems and versions of meteorology, physics, chemistry, earth science, astronomy, botany, pharmacology, psychology (knowing one's inner world) and the sacred. For a native student imbued with an indigenous, experientially grounded, holistic world view, typical approaches to schooling can present an impediment to learning, to the extent that they focus on compartmentalised knowledge with little regard for how academic subjects relate to one another or to the surrounding universe.

The incongruities between Western institutional structures and practices and indigenous cultural forms will not be easy to reconcile. The complexities that come into play when two fundamentally different worldviews converge present a formidable challenge. The specialisation, standardisation, compartmentalisation,

and systematisation that are inherent features of most Western bureaucratic forms of organisation are often in direct conflict with social structures and practices in indigenous societies, which tend towards collective decision-making, extended kinship structures, ascribed authority vested in elders, flexible notions of time, and traditions of informality in everyday affairs. It is little wonder then that formal education structures, which often epitomise Western bureaucratic forms, have been found wanting in addressing the educational needs of traditional societies.

The activities associated with the Alaska Rural Systemic Initiative have been aimed at fostering connectivity and complementarity between the indigenous knowledge systems rooted in the native cultures that inhabit rural Alaska and the formal education systems that have been imported to serve the educational needs of rural native communities. (Barnhardt & Kawagley, 2005)

Maoris in New Zealand

Linda Tuhiwai Smith, a leading theorist on Maori in New Zealand, writes in her book, Decolonizing Methodologies, that from the perspective of the indigenous peoples, the term 'research' is inextricably linked to European imperialism and colonialism. According to her 'research' is probably one of the dirtiest words in indigenous vocabulary.

She writes: "It galls to us that Western researchers and intellectuals can assume to know all that is possible to know of us on the basis of brief encounters with some of us. It appalls us that the West can desire, extract and claim ownership of our ways of knowing, our imaginary, the things we create and produce and then simultaneously reject the people who created and developed those ideas and seek to deny them further opportunities to be creators of their own future and own nations… Scientific and technological advances place peoples and other marginalized and oppressed groups at extreme risk. Research is still on for DNA, cures for Western diseases, and other ways of finding enlightenment and meaning. The mix of science, cultural arrogance and political power continues to be a serious threat to indigenous peoples…. The imperative of corporations and governments to promote technology as a solution to our lives is the

same imperative which suppresses and destroys indigenous alternatives.' (Smith, 2007).

As an alternative, she presents the notion of 'indigenous research'. This research emphasises indigenous concerns, indigenous practices and indigenous participation from the perspective of both researchers and researched:

This research can also be considered as a form of the resistance struggle of dominated and colonialised peoples. For the most of the past 500 years indigenous peoples have one major interest: survival. Survival from the effect of a sustained war with the colonisers, from the devastation of diseases, from the dislocation of their territories, from the oppression of living under unjust regimes; survival as a sheer basic physical level and as peoples our own distinct languages and cultures. Learning how to survive and how to adjust to new threats has been and remains a very important activity. Decolonisation of the mind is part of a new survival strategy. And, the present day movements go beyond the decolonisation aspirations of particular indigenous communities, towards the development of global indigenous strategic alliances. (Smith, 2007)

Since the late 1960s a research agenda of indigenous peoples has been developed at Waikato University[5]. This agenda connects local, regional and global efforts which are moving towards the ideal of a self-determining indigenous world. The research agenda is conceptualised as constituting a programme and a set of approaches that are situated within the decolonisation politics of the indigenous peoples' movements. The agenda is focused on the goal of self-determination. This is more than a political goal; it is a goal of social justice expressed through and across a wide range of psychological, social, cultural and economic terrains. It necessarily involves the processes of:

- Transformation and collective change of psychological, social, political, economic realities.

- Decolonisation of political, social, spiritual and psychological domains.

5. http://www.waikato.ac.nz

- Healing aiming at physical, spiritual, psychological social and collective restoration.

- Mobilisation as peoples at local, regional, national and global level.

In this indigenous research agenda four conditions and states of being are to be enhanced: Survival of peoples as physical beings, of languages, of social and spiritual practices, social relations and art; Recovery of indigenous territories, rights, histories technologies and knowledges; Development of the economic, social, spiritual and knowledge systems; self-determination.

6.1.5 Preliminary conclusion

This book does not provide room to cite more examples. But the examples presented in this section illustrate the fact that endogenous education and research is a worldwide phenomenon. They are no longer isolated initiatives but form part of a strong and as yet, partly interconnected international movement. They show that the initiatives that emerge from indigenous peoples' emancipatory activities in countries like Canada, USA, New Zealand and those that respond to the changing needs from international scientific cooperation in countries like Ghana, India and Bolivia, dovetail in many ways. There are the struggles against the conventional scientific and educational concepts, approaches and structures, systems of accreditation. Each of them cope with limited resources, the challenges to design curriculum and research methods in indigenous languages and within culture specific contexts, the weak articulation of the own scientific foundations, the need to strengthen the own scientific communities. A major stumbling block often mentioned is the opposition by mainstream academics and policy makers against efforts by indigenous scholars to establish the scientific credentials and limited financial and human resources.

But the overall picture is that there is a growing enthusiasm from indigenous knowledge communities and slowly but gradually increasing support from international policy bodies and mainstream institutions.

6.1.6 Mainstream perspectives

As Anton Haverkort has indicated in his contribution, mainstream science has gone through a long historic process of changes. Starting with the Greek Aristotelian approach where observation, common sense and logical reasoning were applied, and continuing through the Scientific Revolution of the Enlightenment during which the rational, mathematical-analytical and empirical approach was refined, mainstream science today places emphasis on measurability in quantitative terms, and specialises in reductionist research in a great number of disciplines.

In the 20th century the vision on science was further scrutinised and refined. Karl Popper (1980) criticised the approach of the logical empiricists. He postulated his critical rationalism, asserting that absolute truth and scientific certainty are illusions. Scientific knowledge is only an approximation of the truth. This approximation can be pursued by trial and error. The process of falsification is the key in scientific research. Only knowledge that can be falsified, but has not been falsified (yet), is relevant knowledge. Scientific progress takes place when wrong theories are rejected. Each knowledge community can expand its intellectual frameworks by conjecture and refutations.

Thomas Kuhn (1962) considered scientific development as a social process: he recognised the important role of the worldviews held by scientists and the social process of scientific changes. He asserted that scientific perspectives are based on number of assumptions. These assumptions cannot be tested or, in Popper's terminology, falsified. Rather, they determine what can be tested. Kuhn calls these frameworks of assumptions paradigms. A paradigm is a consistent worldview with its models, theories, assumptions and methods, shared by a scientific community. Real new knowledge emerges if the validity of the dominant paradigms is widely challenged and starts to be replaced by new paradigms: paradigm shifts. Examples of such paradigm shifts are: the Copernican shift towards a heliocentric view of the universe; Newton's metaphor of the world and human body as a mechanical machine; Darwin's theory of evolution, Einstein's theory of relativity, quantum physics and chaos theo-

ry. In general, scientists who uphold the status quo resist a paradigm shift. Questioning the evidence of the science of a particular knowledge community often creates uncertainty and threatens the existing status and power positions. In the past, occasionally, scientific innovators have been killed (Socrates) or persecuted (Galileo). Some only published their insights after a long period of waiting for a safe moment (Copernicus, Descartes). Many only gained recognition after a long period of rejection or ridicule (Einstein). Within a paradigm there is consensus on what constitutes good science, based on certain exemplary instances of research. Each paradigm is based on shared metaphysical assumptions that as such basically cannot be tested. Sciences with different paradigms cannot be compared because fundamental (ontological) differences exist about the nature of the reality and because there are no common concepts and no common language that can be used to compare the sciences on a one to one basis; they are incommensurable. In theoretical terms: different paradigms are incommensurable if one science cannot be translated into another.

According to the Stanford Encyclopedia of Philosophy[6], Kuhn's main goal was to challenge the idea of scientific progress as cumulative, arguing that what is corrected or discarded in the course of scientific advance was never really scientific in the first place, and he based his challenge on the notion of incommensurability. Instead of understanding scientific progress as a process of change toward some fixed truth, Kuhn suggested that scientific progress should be understood without reference to a fixed, permanent goal. Different scientists apply ontologies and values differently, and they may even pull in different directions, so that there may be rational disagreement between scientists from incommensurable paradigms.

Jürgen Habermas (1984) distinguishes three strategies for dealing with differences in society, which he termed 'the instrumental, the strategic and communicative rationality'. Through instrumental rationality the world can be known by objective observation. The more we know about the relationship between cause and effect, the better we know what buttons to push to

6. http://plato.stanford.edu/entries/incommensurability

shape reality according to our wishes. In this form of rationality scientists point the way forward. From the perspective of strategic rationality the world is a jungle in which one tries to survive. Outcomes are not the result of controlled actions, but of the pushing and pulling between different parties, their negotiations or fights. The one who does not win will be the loser. Communicative rationality is at stake where people realise that they depend on each other for their survival. For concerted action they must learn how to communicate. Habermas argues that the key to emancipation is to be found in communication that entails free moral discourses between individuals and deliberative discourses amongst equal citizens. He develops the concept of communicative action, which serves to transmit and renew cultural knowledge, in a process of achieving mutual understandings. This coordinates action towards social integration and solidarity and is the process through which people form their identities. Communicative action is self-reflexive and open to a dialogue in which participants in an argument can learn from others and from themselves by reflecting upon their premises and directing aspects of their cultural background knowledge to question suppositions that typically remain unquestioned.

Bruno Latour is a French sociologist of science, who has made a study of the way in which contemporary science is developing. In his early work (Latour & Woogar, 1979) he built on the notion of social constructivism, developing the actor-network theory. This posits that scientific facts are not in the first place objectively true; rather they are the result of agreement within the social or scientific community. Important activities of scientists are therefore negotiation, networking and lobbying to obtain social recognition for the results of their research.

Swiss philosopher Paul Feyerabend demystified the elitist position of scientists and went as far as to reject the existence of universal methodological rules. In Against Method, Feyerabend (1975) asserts that objective science is an illusion, as all observation, perception and interpretation is based on more or less deficient instruments and theories. What is considered to be a 'fact' is basically an agreement within a school of scientists. There is not one universally valid method of

research ('anything goes') and the monopolistic claims to truth made by conventional science are not justified. History of sciences shows that there are different roads towards truth. Feyerabend criticises Western science for its arrogance and imperialism. Western science is one and only one of the possible sciences. The export of Western sciences and technologies has not only brought wellbeing to indigenous peoples. He advocates a stop to the one-way traffic, proposing instead a mutual learning process.

The notion of endogenous development is not a major issue in mainstream science, but it is certainly on the agenda of politicians and social scientists. The European agricultural policy has shifted from an emphasis on maximising food production to optimal and sustainable production in combination with rural development where there is place for biodiversity, and regional cultural diversity. Van der Ploeg (2008) writes about the role of peasantry as a politically active and innovative force and he foresees a process of 're-regionalisation' of agricultural production and consumption, triggered by food scarcity, increased energy prices, transport costs and consumer preferences. With the impending abolition of the European agricultural policy, global trade liberalisation and the pursuit of food sovereignty and biodiversity, endogenous development may arise from the initiatives of the (peasant) farming population.

6.1.7 Reconciling different perspectives: co-creation of sciences and transdisciplinarity

How can the different perspectives on the diversity of sciences be reconciled? Can the differences be bridged and is there an existing approach that can be used in this respect? To address these questions we take a closer look at the notion of co-creation of sciences and the approach of transdisciplinarity.

Co-creation of sciences

Any science can enhance its own foundations through intra-science research and developments, and by engaging in exchange and mutual learning with other sciences. The processes of exchange and mutual learning of sciences is a move away from the processes where science and technologies are transferred

from the mainstream to the 'margins'; it is a move from domination, control by mainstream and rejection and substitution of endogenous sciences towards processes of complementarity, synergy leading to coexistence of a plurality of sciences. In other words, it is the move from scenario 1 to scenario 2 as presented in Chapter 1, paragraph 5 of this book. In scenario 2, each of the sciences involved controls its own dynamics and ways to apply and modify its knowledge.

We label this process as co-creation. It could also be referred to as co-evolution, but to avoid the suggestion of a Darwinistic determinism we prefer co-creation.

Co-creation of sciences is thus a process where different sciences are engaged in interaction and joint learning, in sharing research methods and results, and as a response adapt their own paradigms and together create a plurality of sciences where complementarity may exist alongside incommensurability.

The term co-creation is also being used in bussiness literature (Prahalad 2004) as an activity where firms involve customers to develop new and adopt existing products. In this context co-creation is a way where firms and active customers share, combine and renew each other's resources and capabilities to create new forms of interaction, service and learning mechanisms. Our use of the term has a similar connotation: different sciences share, combine and renew each others paradigms to innovate research, theories and educational systems.

Building on the positions and perspectives from the different knowledge communities, and taking into account our own experiences as expressed in the four cases in this book, we come to the following propositions related to inter-science dialogue and co-creation of sciences.

- None of the four sciences presented in this book, or for that matter any other science, can claim to present absolute truth or scientific certainty. Each of the sciences has its strong and weak points, and are more or less consistent within their own metaphysical assumptions (based on Popper).

- Given the great differences in worldviews and paradigms of the different knowledge communities, there is no justification for assessing or falsifying a science according to the parameters and criteria of another science (cf. Kuhn). Assessment and falsification can only be done by sciences that share the same paradigm.

- Building on the way the four sciences have articulated their own foundations, it is possible to go beyond rational, instrumental and strategic comparison of the plurality of sciences and move towards a communicative mode of inter-scientific cooperation (following Habermas).

- Scientific enhancement and paradigm shifts within each of the scientific traditions are possible and can be realised through intra-science and inter-science dialogues and research (as suggested by Feyerabend).

- Today's world presents complex challenges related to e.g. environment, climate, food, economy, poverty, health, peace, energy. As no science can claim absolute truth, diversity of sciences is considered an asset and as a positive factor for cultural and scientific sustainability. A plurality of (complementary and incommensurable) sciences will be better able to address the problems in this world than one mainstream science on its own (Darshan Shankar in this book).

- Other scientific traditions, such as Maya, Chinese, Australian Aboriginals, Arab and Amerindian traditions, could be included to make use of the potentials of these sciences and to achieve co-evolution of sciences at global scale.

Conditions for co-creation

As argued above in different ways, inter-cultural contacts can lead to domination and control and to the disappearance of cultures and ways of knowing. But, if the inter-cultural contacts are spurred by curiosity and take place with respect, they can also lead to mutual learning and synergy, and thus towards the co-creation of a plurality of cultures and sciences. In CAPTURED we have learned that communication between different sciences is not easy, and we have had different experiences

along the way. Some of us found that gaining acceptability for endogenous research and education in the mainstream academic community was a difficult process; we encountered confusion, rejections and surprises in our search for accreditation and funding because of the dominant position of (neo-)positivism; we had to search for words and concepts that adequately expressed our differences and, where possible, helped to bridge them and developed new methods in research and education. Yet, our experiences in inter-cultural and inter-science exchange have led us to conclude that communication between different culture-specific sciences is possible and can be beneficial when the following conditions are fulfilled:

- Each science that participates is willing and has the opportunity to examine its own foundations, and is interested to learn from others about worldviews, values, ways of learning, accumulated knowledge and theories, and the way the knowledge community is organised.

- Each science is prepared to search for its weak points and to look for ways to improve them through intra-science activities and inter-science dialogue.

- The dialogues seek synergy and opportunities for mutual learning, as well as identifying contradictions, exclusions of positions and an included middle (see below under transdisciplinarity).

- The participants are prepared to question, challenge and criticise each science in order to determine those aspects of the science and value systems that can be modified and improved. Popper's terms of conjecture and refutation can be interpreted within inter-cultural contexts.

- No science is considered a priori superior or inferior. Neither endogenous nor mainstream sciences are romanticised or rejected a priori.

- Respectful dialogue does not imply the unconditional acceptance of all differences. It implies the willingness to listen, the openness to learn and to be responsive, the capaci-

ty to criticise and willingness to accept criticisms when necessary (Fay, 1999).

We realise that these conditions present an enormous challenge for the partners in the process. They go against common understanding of the superiority of mainstream science and the assumption that endogenous sciences are flawed by fundamental weaknesses. Inter-science dialogues require resources and methods that are difficult to mobilise and they do not easily fit existing protocols for accreditation, funding and research methods. Embarking on this challenge also requires a mental attitude of accepting vulnerability, curiosity and modesty, and determination on the part of the actors involved.

It is important to continue to systematise the concepts and theories upon which endogenous forms of knowledge are based in order to share and improve on them and to build a more comprehensive picture of the richness, limitations and scope of culture-specific ways of knowing, and to learn about the different ways in which endogenous sciences can be strengthened. Intra-science dialogues should precede inter-science dialogues so that the participating scientific communities are aware of their own foundations, can formulate ways in which their science can improve its own learning and research activities, and benefit from exchange, dialogue and co-creation with mainstream science and with other sciences on the planet.

Co-creation and professionalism of scientists

Creating the conditions for this co-creation of sciences is a major challenge for the different sciences that exist in the world today. So far experiences in this respect are limited, but research by the Centre for Development and Environment at the University of Bern (Pohl et al., 2010) reveals that co-production of knowledge between academic and non-academic communities is a prerequisite for research on sustainable development paths. Researchers investigating sustainability face three challenges in such co-production: addressing power relations; interrelating different perspectives on the issues at stake; and promoting a previously negotiated orientation towards sustainable

development. The study further reveals that co-production of knowledge requires that researchers have:

- A pluralist understanding of cognition and interpretation of the world.

- Are sensitive to underlying power relations between, as well as within sciences.

- Have skills for integrating different interests, different thought collectives and corresponding practices, values and interpretations in the search for more sustainable solutions and skills that facilitate collective learning processes.

These conclusions can be translated in the curriculum of students in endogenous development, research and education.

Transdisciplinarity

What specific approach and methods can be used to achieve co-creation of sciences? We have experienced that we do not yet have a fully mature toolkit. We need to develop the approach as we accumulate experiences. But co-creation of sciences can benefit from the insights and experiences of transdisciplinarity, a relatively new approach for addressing science in complex situations.

Transdisciplinarity connotes a strategy that concerns itself with what is between the disciplines, across the different disciplines, and beyond all disciplines and relates different ways of knowing to each other within a holistic approach. Its goal is ambitious: to understand the present world in all its complexities.

We elaborate on this approach below, relying heavily on work by Nicolescu (2004) and Hirsch et al. (2008).

Basarab Nicolescu has built a theoretical foundation for the concept of transdisciplinarity. He regards transdisciplinary research as research that includes cooperation within the scientific community and debate between the research community and society at large. Transdisciplinary research therefore transgresses boundaries between scientific disciplines and between

science and other societal fields, and includes deliberation on facts, practices and values.

Through transdisciplinary encounters, different levels of reality exist simultaneously. No level of reality constitutes a privileged place from which one is able to understand all the other levels of reality. This principle of relativity creates a new perspective on science, religion, politics, art, education and social life: one which is trans-cultural, trans-religious, trans-scientific. There is no fundamental level of reality, but a coherence of all levels of reality. Every level is characterised by its incompleteness: the laws governing each level are just a part of the totality of laws governing all levels. And even the totality of laws does not exhaust the entire reality.

A transdisciplinary style of research can only arise if the participating experts interact in an open discussion and dialogue, accepting each perspective as being of equal importance and relating the different perspectives to each other. Working together in a transdisciplinary way is difficult because participating scientists are often overwhelmed by the amount of information in everyday practice and because of the incommensurability of concepts and specialised languages in each of the fields of expertise. To excel under these conditions, scientists need not only in-depth knowledge and know-how of the disciplines involved, but they also need skills in moderation, mediation, association and transfer to initiate and promote a critical, yet constructive dialogue. Participatory processes in transdisciplinary practice require carefully structured, sequenced and selected negotiations and interactions. Mutual learning that bridge roles and positions without dissolving them is important. In order to give sufficient attention to values and stakes at all stages of transdisciplinary processes, collaborations and negotiations should be dominated by a mutual learning attitude, not by positions.

The logic of the included middle

In the Aristotelian logic of exclusion of contradictions (there is only one level of reality: A and non-A cannot both be true at the same time and place), manifestations of reality appear as a struggle between two contradictory elements: true or false, good or

evil, right or left, heaven or hell, alive or dead, women or men, rich or poor, white or black.

The logic of the included middle (a third term, T, exists, which is at the same time A and non-A) is exercised at another level of Reality, where that which appears to be disunited is in fact united, and that which appears contradictory is perceived as non-contradictory. The logic of the included middle is a tool for an integrative process: it allows us to bridge two different levels of Reality.

Hans Hurni and Urs Wiesmann (in Hadorn et al., 2008) write that transdisciplinary research is appropriate when searching for science-based solutions to problems that have a high degree of complexity in terms of factual uncertainties, value loads and societal stakes. Through bridging different scientific and social knowledge components it can significantly improve the quality, acceptance and sustainability of such solutions. Transdisciplinarity implies that the precise nature of a problem to be addressed and solved is not predetermined and needs to be defined cooperatively by actors from science and the life-world. To enable the refining of problem definition as well as the joint commitment to solving or mitigating problems, transdisciplinary research connects problem identification and structuring, searching for solutions, and bringing results to fruition in a recursive research and negotiation process. Transdisciplinarity thus dismantles the traditional sequence leading from scientific insight to action. For them, efforts to enhance transdisciplinarity should be accompanied by and embedded within societal debate on the role of science in society, particularly when dealing with factual uncertainties. At the same time, the scientific community is urged to constantly renew the debate on the role of values and stakes in research.

Delgado (2012) considers transdisciplinarity as an improvement to inter-disciplinarity as it includes a process of self-learning and action research related to complex reality. As it explicitly makes space for knowledge from different cultures it can be seen as a form of inter-cultural and inter-science dialogue. The transdisciplinary research approach involves the following five steps:

1. Problem definition by taking into account the different worldviews, value perspectives and methods of arriving at knowledge of different stakeholders: in the case of agriculture the problem definition would include the perspectives of small farmers, women, youth, commercial farmers, spiritual leaders, food processors, traders and consumers as well as a broad range of technicians, policy makers and scientists.

2. Integration of natural and social sciences. The biological, technological, physical aspects as well as the economic, social and legal aspects are analysed and integrated.

3. The perspectives and knowledge of academic and of non-academic actors are integrated.

4. The solutions are to be found in a social learning process, where different actors each have their own learning path and exchange the new insights and lessons being learned.

5. The final results lead to new solutions and can be implemented collectively or individually under conditions that acknowledge multi-stakeholder realities.

We can conclude that co-creation and transdisciplinarity offer promising approaches, but the specific ways to apply them needs to be developed. Co-creation of sciences is a challenge for innovative professionals, scientists and all other stakeholders.

6.2 INTRA-SCIENCE LEARNING AND DEVELOPMENT

6.2.1 Endogenous development, education and research in CAPTURED

In Ghana, Bolivia and India the universities participating in the CAPTURED programme have started undergraduate and post-graduate training in endogenous knowledge development, and the programme has stimulated the production of training materials for endogenous education. This is a response to the felt need to build up capacities in the universities to support endogenous education and research. Five years after its inception, the CAPTURED programme has more than 50 PhD students doing research devoted to understanding and enhancing endogenous knowledge. In each of these universities deliberate actions are being taken to strengthen the capacities of university staff to carry out endogenous education and research.

PhD students in Ghana are conducting research on topics such as the role of traditional institutions in natural resource management, traditional knowledge related to agriculture, health, management of natural resources and governance systems. The information on the sciences of Northern Ghanaian peoples presented in this book is based on the fieldwork of the authors in rural communities, and will be updated, enriched and diversified as a result of the research of the students. Participatory action research is done with close involvement of indigenous experts, resulting in increased identification with and ownership of local knowledge processes, and this will enhance the endogenous knowledge and science base.

In India, the NGO, FRLHT, has done pioneering work to revitalise Indian health traditions and is now a nationally recognised centre of excellence in this domain. It has undertaken important research in an attempt to understand the scientific basis of a number of traditional health practices and is on its way to acquiring university status.

The academic activities of AGRUCO in Bolivia have built on the knowledge and wisdoms of a multitude of indigenous

nations. Their experiences show that students who graduate in the fields of endogenous development and agro-ecology become valuable professionals and their research has contributed important insights into endogenous sciences. At present the approach is supported by the national government of the pluri-national state of Bolivia. The approach has also been introduced in Peru, Ecuador, Colombia, El Salvador and Guatemala.

In the Netherlands, research on developing agricultural technologies to help increase agricultural productivity so as to enhance food security and improve the standards of living of the farmers started in Wageningen more than 100 years ago. Education and extension activities were built up in concert with on farm and more formal research. The research programme presented in this book is not part of CAPTURED, is innovative, and its results are subject to societal scrutiny and legal restrictions, which in turn challenge the researchers to engage in dialogue with policy makers, NGOs, the general public and other scientists.

The CAPTURED programme offers the opportunity to enhance endogenous development, education and research in an international context. Experiences can be shared, materials exchanged, and innovative concepts and methods can be developed jointly.

6.2.2 Approaches to and methods of intra-science learning

As supporting endogenous research, education and development is a sensitive activity, CAPTURED has developed a specific code of conduct that addresses the risks involved and avoids undesired effects. Research does not take place on people, but takes place by and with people. The prime beneficiaries of the research are the knowledge community itself. This means that understanding people's worldviews and values are essential for the understanding of their science. Indigenous and local experts play a key role in in assessment of knowledge, teaching, learning and research. External researchers, such as PhD students or NGOs, can play a supportive role, but the endogenous knowledge community owns the process and its outcomes. Before external researchers start this type of research, a clear dialogue with a local knowledge community takes place

to ensure prior informed consent on the objectives, methods and beneficiaries of the research. Results are therefore always be presented in ways that they can be understood, verified and assessed by the endogenous knowledge community and the possibilities to use and apply the outcomes of the research are explored. If publications are part of the process, co-authorship acknowledging external and endogenous actors is appropriate. Researchers should be open to learning with local peoples and experts: the intention is to learn empathically from the local knowledge systems and to enter into a respectful and constructive dialogue with local leaders and experts. In working with communities, many of the conventional approaches used by research should be adopted to suit local needs and systems, as these approaches are not always appropriate for enhancing endogenous development and learning.

Examples of intra-science learning

Strengthening endogenous institutions. In Ghana experiences are being built up on working together with traditional institutions (chiefs, elders, traditional spiritual leaders, experts in health care, and agriculture), to make a joint analysis of the way these actors perform certain roles in the traditional communities. Water management, land use, management of forest and tree resources, reinforcement of peace and justice and rituality are examples of the context in which these roles exist. By examining the strong and weak points of the way these functions are performed, possibilities for improvement can be identified and the interface between traditional and formal institutions can be improved.

Establishing associations for healers

In India, FRLHT has promoted the establishment of associations of traditional healers. The situation that was initially encountered involved very little exchange and mutual learning between the different healers such as bone-setters, midwives, herbalists and ethno-veterinary practitioners. The associations that were set up bring together the existing knowledge, and form a platform to assess the weak points and identify ways to improve these, and to assess innovations that emerge from the knowledge community. By setting quality standards, the association of healers can also improve the quality of the work of the

members. Negotiation with government agencies and commercial organisations in the health sector can help in improving the interface between the traditional health sector and the formal sector. Transfer of knowledge from the elder practitioners to the younger ones can be enhanced, and traditional healing practices, such as those for treating snakebites, have been revived.

Documenting local technologies and knowledge

In Bolivia AGRUCO has set up a system for documenting local knowledge by the local knowledge holders; it has helped in assessing the quality of these technologies and in the dissemination of knowledge in local languages and in Spanish using different media.

Peer review

In Wageningen any new research is screened by means of a peer review. Persons with knowledge and experience assess the quality of the research outcomes: the quality of the methods used, the effectiveness and the safety of the innovation.

Involving local experts in research and education

In Ghana a traditional healer and village chief have been awarded an honorary doctorate by the UDS. In Bolivia and India, community experts and traditional scholars are involved in assessing students' theses, and take part in university seminars and lectures. They are thus encouraged to express their knowledge in a systematic way and to expound on their views in the innovative research process.

Education in local language

In Bolivia inter-cultural primary education has placed emphasis on the use of indigenous languages. In Ghana rural radio programmes use local languages and cover traditional events.

Bringing local knowledge through schools

In Peru children learn about Pachamama, local food items and processing of them.

Understanding and strengthening traditional forms of communication

In Ghana traditional dances, songs, music and performances

take place during community activities such as funerals, durbars and the enstoolment of chiefs. Understanding the symbols and meanings expressed in traditional communication can enhance communication with students and development agencies of NGOs and governments. Such activities can be enhanced and strengthened, and lead to stronger cultural identity and community based developments.

Conflict resolution based on traditional institutions and mechanisms

In Ghana inter-tribal conflicts have been neutralised, by using cultural drama techniques to apply indigenous concepts of peace and reconciliation.

Training women and leaders

In Ghana NGOs have provided training to women and traditional leaders in leadership functions, traditional food practices and community organisation.

Village-based exchange

In all countries attempts have been made to organise exchange between villagers. In Bolivia this is an integral part of AGRUCO's training activities.

Marketing traditional food items and crafts

In Bolivia marketing of dehydrated potatoes and home-made weaving products has been enhanced.

Organising festivals and fairs

In Bolivia and Ghana, NGOs and universities have been involved in supporting food fairs and agricultural shows, where local people present their products and exchange them with other producers and stakeholders. Seed fairs are often held in Bolivia and India and contribute to enhancing local control and improvement of agro-biodiversity.

Formulating criteria for territory and living well

In Bolivia local experts and organisations have been involved in the identification of local criteria for territory and for living well. The notion of land as a community-based resource leads to community rules on its use; these deviate from those of the

formal sector, where individual land ownership is more common. This exercise has re-valued and strengthened territorial organisations and their mechanisms.

Giving new functions to traditional customs

In India and Ghana traditional notions of totem have been given new functions in efforts to protect nature and biodiversity.

Passing on and applying traditional architecture

In India Vaastu is a traditional body of knowledge for designing, constructing and orienting houses and other buildings. The campus of FRLHT has been built according to Vaastu principles.

Strengthening traditional art forms

In Ghana rural women have been supported in improving their traditional arts of wall painting and pottery.

The list of activities is longer, but the experiences reveal that in general the endogenous communities welcome the revival or reinterpretation of traditional customs and knowledge. They also indicate that local communities are interested in modernising and adapting traditional practices. The most important problems encountered are the lack of familiarity of external students and/or researchers with these customs and with ways to build on them for endogenous development, education and research.

A constant concern remains how to avoid and prevent outsiders from dominating the process or bringing in inappropriate knowledge from outside.

6.2.3 Lessons learned on intra-science dialogues and learning

The CAPTURED partners have learned much about enhancing intra-science dialogues and learning. Although the approaches chosen by the partners are different, a number of common lessons have been distilled:

Language matters

Local values, beliefs and the technicalities of certain traditional practices are expressed in local languages through specific

expressions and words, the meaning of which cannot simply be translated. These can only be understood as an expression of the worldviews and logic of the local people. Sometimes language is gender specific, or certain words or concepts may only be used by certain caste, class, or other social category. Also body language can contain important information. Respect, joy and interest (and their opposites) can often be read through body language, but this can only be understood within its own cultural context. Humour and jokes can be used to express certain sensitive issues in a non-threatening way, and again these can only be understood in the cultural context. In trying to formulate development jargon in local languages we are challenged to reflect on what we really mean by these concepts and how they can be expressed using local concepts.

It is therefore essential that education and research take place in indigenous languages. International languages such as English and Spanish often do not have terms that express emotional, spiritual and cultural intricacies. Educating children in these international languages is important to give them access to the world and knowledge beyond their community, but they should be the second language of education. (Delgado & Escobar, 2006) Education in the mother tongue strengthens cultural identity, enhances the endogenous knowledge base and provides a stronger foundation upon which to receive and appreciate external knowledge.

The lessons from Bolivia indicate that beyond the conventional (undergraduate and postgraduate) education carried out in the classrooms and lecture halls of the university, universities can develop 'in situ' training in the community so that access to university training is improved and the content and methods used can be specific to the local conditions.

Care should be taken that students and researchers do not glorify, romanticise or reject endogenous knowledge or mainstream knowledge. Sometimes students or researchers may be carried away by their enthusiasm for endogenous education and research or by mainstream science. Finding the right distance and a constructive, critical attitude to both endogenous knowledge and mainstream knowledge is an important learning process.

Capacity development

Most members of staff of universities in the South have undergone mainstream training and education only. Not everybody is convinced of the value of endogenous development and many of them do not have sufficient understanding of the concepts, strengths and weaknesses of endogenous knowledge, nor do they have the attitudes and skills to teach on the subject. For a university to make the transition from being an agent of mainstream science to a university that combines mainstream science with endogenous education and research, the capacities of university staff have to be developed. This is a reason why, in the CAPTURED programme, priority has been given to education of and endogenous research by young professionals, who can subsequently be involved in endogenous education and research.

Developing culturally sensitive educational and research tools

Few training materials for endogenous education and literature on the methods for endogenous research are found on the shelves of university libraries. To a large extent these have to be developed in concert with the training and research programmes. Culturally sensitive training methods, training guides, hand outs, and visual and audio materials have to be developed for each culture-specific knowledge community.

Methods to do research with people (and not on people) and methods for action research that invigorates endogenous knowledge need to be developed. A pitfall of endogenous research is the use of research methods and research parameters from the mainstream, resulting in assessment of endogenous knowledge by outsiders, who may not understand, or be agreed on by the endogenous knowledge community, leading to (unwanted) further marginalisation of endogenous sciences (Smith, 2007).

The experiences so far indicate that designing appropriate research methods is the most difficult part of endogenous research. A method needs to be rigorous; it should lead to relevant new knowledge, or enhance the dynamics of endogenous knowledge. The methods should produce results, be safe, show cultural sensitivity and relevance, and have to be appreciated and understood both by the academic community and the endoge-

nous knowledge community. Endogenous research goes beyond documentation of the existing situation; in most cases its ambition is to strengthen and improve endogenous knowledge.

In this respect there is a long way to go. Available quantitative research methods may be applied, but on condition that the research is not done on people, but with people. Qualitative methods are available (participatory action research methods can be used as well) but often need further elaboration and refinement to be able to make the step where endogenous knowledge communities are supported to enrich their own knowledge.

Doing research is a specialised job, and many argue that this is the domain of universities. But in endogenous research the main beneficiary of that research should be the endogenous knowledge community. Therefore, the members of a community should always agree with and understand the methods and research questions; as the methods often have to be developed – because the research methods are not available 'off the shelf'– it is often necessary to go through an exploratory phase in which research is carried out on the preliminary research questions and preliminary research methods. Evaluation of what emerges from this process, and an assessment of whether the code of conduct is being complied with, will determine the final formulation of research questions and methods.

The results should be presented to the knowledge community as well so that they can decide how best to make use of these. Research methodologies therefore always have a phase of design, which has to be shared with the knowledge community, and a phase of feedback of the results to the knowledge community.

Indeed, even the learning path of the researcher, as he or she gets to grips with the subject and method, can be seen as important research. Making these lessons explicit may help other researchers and enrich the body of knowledge and methods on endogenous research.

Ways have to be found to respect the notion of knowledge as a community-based resource (and not a privately owned resource)

and to respect its sometimes sacred and/or secret nature. Research results should therefore be community owned, be accessible in a local language or through local forms of communication, and publications should be co-authored by the researcher and endogenous experts.

In mainstream research peer reviews are important ways to assess the scientific rigour and relevance of the outcome of the research. Peer review can also be used in endogenous research. PhD students can support each other, and give each other feedback and suggestions. Experiences in the CAPTURED programme of exchange between students in Ghana, Bolivia and India show the great value of peer review, both within each country and between countries and cultures.

Enhancing the quality of endogenous sciences is a responsibility and challenge for each of the partners involved in the respective programmes. Each of them goes about this in a specific way that responds to the context of the particular endogenous knowledge community and the university involved.

This chapter now turns to explore ways of going about interactions between different scientific traditions.

6.3 BUILDING BRIDGES BETWEEN SCIENCES

6.3.1 Preliminary insights from different sciences

The case studies in this book have used different methods for the articulation of the foundations of their sciences: introspection, participatory action research, joint reflection with indigenous experts and fieldwork have taken place in different cultures. These efforts show a great diversity of ways of knowing and practising sciences.

Each of the partners has used a similar format to describe their own way of knowing and yet each description has followed a course that is appropriate to its own special character. The table below summarises the results of this endeavour.

DIFFERENT SCIENCES AND THEIR POSSIBLE LEVELS OF CO-CREATION

Science factors	Sciences of Gruni and Dagari Ghana	Ayurvedic Science India	Andean Science Bolivia	Wageningen science: Cisgenetic potato research
Worldviews	Ancestor-centered. Sacred nature.	Interconnection of unmanifest and manifest worlds.	Pacha-centered: interrelated and sacred spiritual, human and spiritual worlds.	Matter, genes, mechanistic causality.
Ways of learning	Ancestral communication. Sacrifices. Community. Soothsaying.	Intuition, perception and inference by free and unbiased minds. Experiments.	Rituality, Festivals, Community learning. Visions of yatiri's and other leaders and experts.	Rational. Positivist. Empiric. Quantitative. Specialised. Reductionist.
Theories and Knowledge concepts	Nature habitat for Spirits. Good & evil forces.	Tridoshas. Pancha Karma. Balance. Potency. Reincarnation.	Reciprocity within Pacha.	Pyramid of sciences. Crop ecology. Biology and gene technology.
Values	Respect for ancestors and elders. Ethnicity, Generosity. Nature. Harmony.	Mental freedom. Detachment. Enlightenment.	Living well. Social cohesion, identity, reciprocity and redistribution in social economy.	Secular. Competition. Anthropocentric. Private ownership of knowledge. Durability. Global concerns.
Validating Community Knowledge	Healers, chiefs, festivals, elders, local experts.	Association of healers. Gurus, Ashrams. Ayurvedic Colleges.	Community-based learning and testing of visions and experiences.	Government-controlled schools, formal accreditation. Public and private funding. Peer reviews, patents.

Exchange and joint learning

We see that the sciences presented here differ substantially for each of the five 'factors'. Following the conventional notion of scientific universalism, we might be tempted to conclude that the qualitative and conceptual differences are too great to even consider embarking on a process of dialogue. Our experience shows, however, that mutual exchange between knowledge communities can help the individual communities and can lead to a better positioning of the sciences in relation to each other. Domination and control can make way for inter-science dialogue and co-creation of sciences. Inter-science dialogues can help in building bridges between sciences.

A bridge connects two sides that are separated and allows for interaction and exchange. It unites but does not unify. It is built based on an understanding of the intricacies of each side or bank. Strong banks need little in the way of extra foundations, but soft banks need extra efforts to build strong foundations.

The notion that different sciences are incommensurable does not mean that bridges cannot be built. Kuhn and Feyerabend (Stanford Encyclopedia of Philosophy) agree that incommensurability does not imply incomparability. Comparison of theories is merely more complicated. It cannot be made fully, 'point-by-point'. It is not an algorithmic procedure or one that requires translation into neutral language of observation. Different epistemic values, such as universality, accuracy, simplicity, fruitfulness may pull the exercise in different directions, allowing for the possibility of rational disagreement. According to Kuhn, incommensurability is far from being a threat to rational evaluation of truth claims that it has frequently seemed. Feyerabend has explicitly argued that incommensurable alternatives actually offer a better means of comparing the merits of theories than the mere development of commensurable alternatives. His unorthodox image of scientific progress is delineated as an increase in a set of incommensurable alternatives, each forcing the others into greater articulation. And, following Nicolescu's notion of the included middle, we would say that none of the four realities can claim the exclusive truth, and even if they may seem to be contradicting or excluding each other, we have the chance to look for a level of reality that provides space for more than one reality.

In fact each of the four knowledge communities in this book express this notion one way or another. The Ayurvedic example makes the case for medical pluralism. These insights in fact also could be used to search for agricultural pluralism, legal pluralism, or pluralist ways to deal with natural resources. The Andean case seeks ways to build epistemological bridges and the Ghana case searches for complementarity. Also the Wageningen approach embraces greater interaction between Wageningen science and other sciences and is open to learning from this.

To explore the potentials and limitations of inter-science dialogues and co-creation of sciences, below we will present possible options for building bridges in each of the science factors: worldviews, ways of learning, theories and knowledge concepts, values, and technologies and the validating knowledge community.

6.3.2 Bridging worldviews

The worldviews expressed by the four knowledge communities are very different. The Wageningen community of plant scientists considers the world as a material reality, which can be understood through the laws of physics, chemistry and biology and be expressed in mathematical terms. It looks at genes as the basic building blocks of life and considers linear cause and effect relationships in the bio-physical domain. The social world is seen as a complex sociobiological reality that creates the space for funding, research and educational systems and establishes legal rules for the application of the research findings. The other scientific communities consider the reality of existence in three domains: the material, the social and the spiritual domain. But the ways in which they understand the spiritual domain and perceive the relationship between the three domains are quite different. In the Andes, Pachamama is the sacred space-time embracing the cosmos and the earth that seeks reciprocal relationships between mankind, animals, plants, nature and the physical world, and where duality and a cyclical concept of time are important. The Vedic notion of reality in India is that of the interconnection between the intangible and manifest world. The intangible world is not bounded by time or space, is eternal and pervades all aspects of the manifest world. In the knowledge communities of the Gruni and Dagara in Ghana, the ancestors play a prominent role, ethnicity and age are important

determinants of a person's identity, and nature is sacred.

Without doubt, these four worldviews are partly incommensurable, as none can be expressed completely in concepts or terms of the other. In inter-science dialogue for the co-creation of sciences, none of these science communities would exclusively claim to present the truth. Rather, being aware and informed about the differences in worldviews helps to understand the other and this can help in the communication.

In the case of the Andean science, the authors mention the example of the indigenous explanation for crop damage by hail. This was understood to be a reaction of Pachamama to incorrect moral behaviour of people. That poses the question: Does a relationship exist between the moral behaviour of humans and bio-ecological and climatic processes? Does Mother Earth really sanction the disrespectful behaviour of a traditional authority by unleashing frost or hail? Or, in more general words: Is there a relationship between the spiritual life of humans and natural processes? In the chapter on Andean science, Rist explores the answers that come from the natural sciences and the other from the social sciences. He concludes that, from a mainstream scientific perspective, the possibility that human beings might successfully call for rain after frost by enacting a ritual and the idea that there is a link between moral behaviour of people and climatic phenomena like hail or frost must be rejected.

But if the transdisciplinary notion of the included middle is applied here, the possible link between morality of people and sustainability, in its bio-physical and in its socio-economic and cultural dimensions, could be studied in a more general way. It could address the question: Which of the problems of the present-day world – poverty, hunger, war, criminality, discrimination, social disintegration, pollution, erosion, drought, extinction of plants and animals, climate change to name a few – can be attributed to human behaviour? How can these relations be understood, and to what extent can the notions of morality, and the values of the different cultures be scrutinised, adapted and shared to reach a more just and sustainable global order?

6.3.3 Bridging values

The value orientations that emerge from the three non-Western cases in this book reveal the following. In Ghana importance is attached to community and ethnic relationship and respect for (sacred) nature); in Bolivia importance is attached to reciprocity with the sacred time-space and living well in balance with Pachamama; in India mental freedom and detachment play a role. In general, the spiritual dimension of these worldviews and the concomitant values are absent in the Western scientific value orientations, where private ownership of natural resources and knowledge are commonly accepted, where individualism, consumption and competition play a role, and where sustainability is a rather new, but now pressing issue.

In international relations one can observe that Western value systems are generally considered relevant, important and sometimes beyond debate. Democracy, freedom of speech and religion, no discrimination on the base of gender, race, sexual orientation and religion, free markets, human rights, right to education and access to health services are often taken for granted as starting points in international cooperation. Many of the constitutions, legal systems and administrative structures in developing countries are still largely based on the systems of their former colonial masters. But, as under the surface many indigenous people adhere to different values, such formal legal systems and systems of governance based on alien values have only a weak link with indigenous population groups. Not knowing about, understanding or accepting the differences in values between cultures makes international cooperation and also inter-science dialogues very problematic.

The notion of international development cooperation that emerged after the colonial period has led to a great number of programmes and projects where in general it was the funder that to a large extent determined the goals of the programmes. Cooperation took place with educated persons from the recipient countries who, through their education and acculturation, either adhered to Western values, or accepted them as a fait accompli. But, as has been shown and substantiated by many studies in the COMPAS programme (Haverkort et al 2002), in many cases the local people did not understand or not appreci-

ate development programmes, as these did not comply with their value system.

The examples in this book of the local notions of living well as expressed in Bolivia, and also referred to in the Ghanaian case, illustrate the great gap between Western donor-driven programmes (e.g. as expressed in the Millennium Development Goals) and values of local people. The present Bolivian government embraces these indigenous values and has accepted them as the basis for the policy of living well. One of the challenges facing Bolivian politics is how to bring together the values of the indigenous people and those of the non-indigenous people in a constructive and peaceful way. In India the Ayurvedic system exists as a parallel system to the Western biomedical system. Next to Western biomedical hospitals and health care systems, there are several codified indigenous systems as well as folk health practitioners. But the Indian government bases the enforcement of its rules for recognition, accreditation and regulations on the use of drugs on Western notions of medicine and its values. The Wageningen case shows that in the West values also play an important role in establishing the criteria for funding of research, and the particular case of cisgenic breeding also illustrates the difficulties encountered in getting the technology accepted by consumers and policy makers due to differences in values about food security, food safety, ownership of intellectual property and the question of to what extent we should be able to control life processes.

All these experiences show that, with respect to values, diversity and variations exist. These variations are partly the result of different socio-cultural conditions. Understanding and accepting the differences as a starting point for dialogue can lead to mutual exchange that accepts the differences, explores ways to deal with them or to bridge them.

6.3.4 Building methodological bridges

The ways in which societies arrive at and shape their knowledge, learning, teaching and experimenting again differ widely. In Ghana ancestral communication, the insights of soothsayers and community-based informal learning are mentioned. In India knowledge is acquired through the senses and the mind,

where yoga provides ways to help free the mind of biases so that it can come to knowledge by becoming one with the object of knowledge. Also in Bolivia the knowledge is produced and transferred in the communities, where rituals, festivals and visions of enlightened persons play a role. The Dutch knowledge community uses positivist, rational, empirical knowledge, emphasising quantification.

In each case the authors indicate the relevance of mainstream methods and mention some weaknesses of indigenous knowledge. Millar describes the parallels and differences between farmers' research and mainstream research. From this it follows that farmers learn in a community-based way but lack the systematisation that characterises mainstream research. There are no written documents and no strict rules or peer-review mechanisms. He also mentions some severe weaknesses of the endogenous science in Ghana: the subjectivity, the lack of written records, the social conflicts, destruction of traditional leadership and communities, corrupt leadership, unsustainable use of natural resources, repression of marginalised groups (women), ambiguous patterns of land use and unregulated urbanisation. He maintains that replacing ancestral knowledge with mainstream knowledge has also brought benefits, but the one-sided focus on the material world and materialist values is a serious omission.

In the internal dialogue in CAPTURED, Delgado suggests that subjectivity is not a weakness, but rather an asset, as intuitive knowledge is very enriching and is seen as an important complement to objective knowledge. Delgado writes that in Andean science, knowledge is at the same time fundamentally location specific and ultimately universal. One of the virtues of native indigenous knowledge is its profound and detailed knowledge of the natural surroundings. For example, the type of soil, weather indicators and humidity allows people to establish to a degree of precision the dates for sowing, the types and species of crops to sow, the use of flora and fauna as well as the date of the ritual. This location specificity of knowledge explains that if this knowledge is applied in a different cultural and biophysical context, it may not work: it is only replicable under similar conditions.

In contrast, in mainstream sciences, methods and theories must be universally applied and replicable. Anton Haverkort suggests that the successful contribution of Wageningen to increasing the productivity of food systems, and thereby the ability to feed an ever-growing population, was made possible by the pyramid of knowledge. So he suggests that other sciences develop a system to accumulate, to build pyramids of knowledge, to make observations and assumptions that are quantitative or at least qualitative, and to make a desired outcome a result of a more mechanistic approach based on a systems analysis.

In general it can be said that in mainstream scientific methods the observer is systematically separated from the observed (the subject from the object). The methodology for producing knowledge in endogenous research often tries to narrow down the distance between the observer and the observed. Through this, endogenous knowledge may lead to an elimination of the boundary between object and subject and leads to the possibility for the knowing subject to experience the world from the point of view of a plant, an animal, a stone, a star, the sun or any other component of interest.

Bridging these methods will not be an easy task. In fact, in all countries in the world the mainstream methods for research and education are being applied, and rather than complementing indigenous methods, they tend to substitute them. The degree of compatibility between indigenous ways of learning and mainstream methods is often low.

The transdisciplinary way to deal with this dilemma is to accept that different methods and modes of research exist in different knowledge communities and to appreciate that the resultant knowledges may each throw a different light on a part of the Reality. Co-creation however also challenges the different knowledge communities to learn from each other and to test some of the approaches of the other in their own context.

6.3.5 Building bridges in theories and knowledge concepts

The four cases present very different knowledge concepts, technologies and theoretical frameworks. In Ghana and Bolivia knowledge is highly location specific, whereas the Ayurveda and

Wageningen approach are based on universal laws of sciences, and aspire to have a widespread or even global applicability.

In Ghana endogenous knowledge has many expressions in agriculture, health, metallurgy and other areas, and is linked to ethnicity and ancestor-centred worldview where nature is sacred. In Ayurveda the medical theories are based on a sophisticated notion of the cosmos where manifestations of matter range from subtle to gross. These refer to concepts such as karma, dosha, five elements, hot and cold, brain and mind. Being healthy is a state in which these phenomena are in balance. And in the Andes, knowledge focuses on and is related to reciprocity with Pachamama, the dual and complementary sacred time-space with its four spaces and three domains, complementary pairs and rituality. Notions of time also differ. The Western notion of time is linear, coming from the past and going through the present towards the future. In Ghana time is considered to be cyclical, going from the present to the past, and in the case of Bolivia it is seen as a spiral, time always turns back to where it has been before and can incorporate experiences of the past. In India time is considered in long timespans, and these can be transcended by meditative and yoga practices.

In each of the three non-Western cases, the formal systems for education and research are dominated by mainstream science. Therefore, the main concern expressed by each of the CAPTURED partners is the relationship between their endogenous knowledge and mainstream science. They all seek dialogue to understand the differences and the complementarity of knowledge, perceptions and ways of generating knowledge. They do believe that Western sciences (natural, social, conventional or alternative) can have a role as a point of reference of the endogenous sciences. Thus it is important to find the epistemological bridges with mainstream sciences. But building bridges with other endogenous sciences is equally, or possibly even more important.

Shankar and Nair present their position concerning the way the different ways of knowing can be handled in the case of health sciences. In their chapter they state:

- Integrative medicare can be implemented by establishing

> multi-knowledge-based poly-clinics and hospitals, which can provide a multi-cuisine cafeteria approach to health services, located under one roof. This strategy for functional integration will require mutual respect and understanding and creating an environment for cross-referrals amongst medical professionals trained in different systems. It will involve an appreciation of the strengths and limitations of different medical systems and, based on this appreciation, a carefully worked out code of ethics for referrals. Such a plan of functional integration can immediately provide better options and informed choices to millions of healthcare seekers and one need not wait for the more complex research-led, epistemological integration to be completed. It is anticipated that the outcome of such transdisciplinary research will be very rewarding. It can result in the creation of new, multi-cultural, knowledge products that can perhaps make original contributions to the world of medicine.

This approach of multi-knowledge application and professional plurality could also be applied to sciences from different cultural backgrounds in fields like agriculture, natural resources and governance.

An Indian study on the use of copper devices to treat water provides an example of an inter-science exchange of research results. The results of the research show that copper indeed purifies water, ridding it of harmful bacteria. As copper vessels are too expensive for rural people, FRLHT has designed a small copper device with which water stored in plastic or ceramic vessels can also be treated. The further testing and application of this technology in Africa and Latin America may help to substantially decrease water-related health problems in these continents too.

Research on the effect of traditional African dance music on the human mind could benefit from knowledge on mantras (chanting) in India. Indigenous knowledge on the effects of particular plants on human or animal health in each of the three continents could lead to improved health practices.

6.3.6 Linking knowledge communities for co-creation of sciences

The endogenous knowledge communities that have been presented in the African, Indian and Latin American cases are often community and/or ethnically based and are not, or only weakly, organised in a formal way. In many cases communities have local experts who at the same time have spiritual skills and capacities. There is sometimes a (strong) link between rational knowledge and spiritual capacities. Mechanisms for peer review and exchange at national level are generally weak and at international level virtually absent. Government interference or support, if at all existent, is generally weak and often has more of a tendency to impose control than to stimulate progress.

In the case of the Wageningen knowledge community, formal organisation and strictly controlled mechanisms for assessing the progress in learning and assessing the outcomes of research dominate the scene. The government sets standards for education and the research community, through a system of peer review, ensures quality of research. As knowledge of certain type is a privately owned commodity, private funds and corporate organisations direct the research process in some cases. Networks at national and international levels are organised for each (sub-)discipline and for cross-disciplinary fields, such as farming systems and food security, which have their own (peer-reviewed) magazines and conferences.

CAPTURED offers an opportunity to articulate and compare different scientific communities and the 40 to 50 PhD students will add impetus to the process. Each piece of research will, in one way or another, contribute to a further understanding of each of the endogenous sciences involved, and its strong and weak points. The existing research programme will lead to a better positioning of the science communities and it is hoped that at some point this book will be revised and updated as results emerge from undertaking endogenous research.

Programmes for endogenous education and research can lead to broadening the cultural base of university education and to new paradigms in educational pedagogy, science, technology and development at both national and international levels.

Activities that can be given special attention in this respect are:

- Exchange of researchers, exchange of students and of indigenous experts from different knowledge communities on a systematic and long-term basis.

- Sharing of, commenting on and joint development of curriculum, training materials and teaching methods of schools, colleges and universities in different scientific traditions.

- Joint, cross-cultural research on themes like health, agriculture, governance of natural resources and policy and institutional analyses, where each of the science factors determining the different paradigms involved will be subject to exchange, testing and development.

- Strengthening the scientific foundations and theory building for transdisciplinary and transcultural sciences as well as for each endogenous science involved.

- Outreach and up-scaling the experiences of endogenous education and research to other universities worldwide.

- Setting up of an overarching global (transdisciplinary) educational, research and learning community for peer review, peer support and joint theory building in endogenous sciences, leading to well-founded scientific publications. This would involve a think tank, international consultants, participation in international dialogues, writing, editing and publishing.

- Inter-science dialogues: presenting the outcomes to international forums and actively inviting key mainstream scientists to interact with programme scientists.

- These may eventually lead to the establishment of national and international institutes for endogenous education and research.

6.4 CONCLUSION

The choice for endogenous development and for co-creation of different forms of knowing implies a number of shifts in the way sciences are being developed in the world. It implies a shift from the notion of one superior and universal science that replaces other sciences, towards a notion of a plurality of sciences, each with its own strong and weak aspects. It is a shift from a one-way adoption of mainstream science towards a search for improvements of different sciences through intra-science learning and action and inter-science exchange and joint learning. It is a shift from the logic of exclusion to a logic of inclusion, from the approach of single scientific disciplines to transdisciplinary and participatory action and research.

Such shifts will not happen overnight given the scale of the task to be accomplished, the appeal of and resistance from the dominant system, the lack of capacities for supporting endogenous education and research, the funding issues, and lack of operational methods that in the short-term can be brought into endogenous research and interscience exchange.

We realise that the contributions to this book have only presented limited information about the worldviews, the values, methods, accumulated knowledge and endogenous knowledge communities. We are only at the beginning of the process of endogenous research and education. But we are confident that, in the long run, co-creation of sciences will occur, as the benefits are obvious. The initiatives that have started in the CAPTURED programme and in New Zealand, Canada, the US, and in other countries with substantial indigenous populations have reached a point of no return. Many of them are now able to continue their programmes without external donor funding; the response of the indigenous knowledge community is very encouraging, and the results achieved in terms of number of students trained and the relevance of the research results is very promising. The growing sensitivity to and expressions of cultural identities and the increase in possibilities for international communication will be autonomous factors that facilitate further endogenisation of higher education and research.

The authors and editors of this book encourage young professionals, students, and indigenous experts and leaders to contribute to this process, and co-create a plurality of sciences that builds on the diversity of worldviews, values and methods in different knowledge communities and brings civilisational sustainability closer.

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This book presents ways of knowing in a number of knowledge communities in countries across the globe: Ghana (Ancestral knowledges of the rural Dagaba and Gruni ethnic groups), India (Classical Indian health science: Ayurveda), Bolivia (Pacha-centred knowledges of the Aymara and Quechua communities of the Andes), and the Netherlands (mainstream cisgenic potato research at Wageningen University and Research Centre).

The presentation is done from the perspective of the knowledge-holders themselves. It describes their worldviews and ways of learning, the dominant values, the knowledges that have been accumulated by the different communities and ways in which these communities agree about the validity of their own knowledges.

The authors have sought ways to express and enhance the different sciences by articulating their foundations and exploring their strengths and weaknesses and possibilities for improving endogenous ways of knowing. Intra-science learning and action and inter-science dialogue lead to the co-creation of a plurality of sciences.

Today's world presents complex challenges: environmental degradation and climate change, feeding the world's ever-growing population, reviewing the fundamentals of our world economic system, fighting poverty and health problems, creating peace and security and meeting the demands for energy and commodities. We will need to call on all available resources to address these challenges, including the wealth of endogenous knowledges that have served many societies for thousands of years.

A plurality of sciences presents the best option for addressing the plurality of global problems and for enhancing civilisational sustainability.

This book is addressed to students, scientists, policy-makers and everyone who is interested in the international and inter-cultural dimensions of science, transdisciplinarity, scientific plurality and co-creation of sciences.

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