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Rice Biofortification: Lessons for Global Science and Development

Chapter 4

An Alliance Around an Idea: The Shifting Boundaries of HarvestPlus

Introduction

The last two chapters traced early biofortification pathways that emerged in the 1990s. While they were products of different institutional histories and areas of scientific enquiry, these early initiatives shared certain key characteristics. The first of these could be called the missionary effect: in each case these projects relied on the determination and vision of key individuals and the small, close-knit actor-networks that formed around them. Second, each project was accompanied, in its early stages, by modest expectations of success; these projects were exploratory in nature. In each case, however, as time progressed, the projects underwent gradual metamorphoses from an open, exploratory mode, through successive stages of institutional framing, 'black-boxing' and simplification, towards linear approaches that have effectively discouraged scientists from 'looking sideways',[1] to consider the multiple uncertainties emerging from this new science.

This chapter explores the processes by which these dynamics intensified once these initiatives were absorbed under the umbrella of HarvestPlus, one of the programmes selected by the CGIAR in the early 2000s to pilot a new approach to the conduct and funding of research, called the 'Challenge Program'. In accumulating these various projects, each with their own historical pathways, played out in a variety of locations, HarvestPlus was ambitious in scope, extending the actor-networks supporting biofortification research, now a global project, in many directions. Simultaneously a programme of international research and an alliance around an idea,[2] HarvestPlus appears as an exemplar of the type of interdisciplinary, multi-institutional collaboration envisaged for the CGIAR, designed to shift the role of CGIAR centres from research institutions to 'brokers' of global networks that can generate research outputs as international public goods (IPGs) amenable to adaptation and adoption worldwide.

How did previously fragmented efforts – including iron rice research at IRRI and Potrykus and Beyer's Golden Rice project – come to congregate under the HarvestPlus umbrella? While retaining as director Howarth 'Howdy' Bouis, who had managed the predecessor CGIAR micronutrients initiative from which iron rice study emerged as the flagship project (see Chapter 2), HarvestPlus was a radical departure from earlier projects in nature, scale and scope. Chapter 1 highlighted some of the broader trends in international development and nutrition that have emphasized cross-sectoral synergies and goal-oriented, micronutrient-based, nutrition programming. This chapter follows the processes through which, encouraged by these trends, biofortification moved from the outer margins of international crop research to attract support from the newly instituted CGIAR Science Council and the Bill and Melinda Gates Foundation, now one of the world's largest private philanthropic organizations.

As an alliance formed around an appealing but still largely untested idea, the HarvestPlus network appeared as fragile as it was far-reaching. In contrast, the iron rice 'family', discussed in Chapter 2, though inter-disciplinary and multi-institutional, was clearly located and grounded in a Southeast Asian, Philippine context; the Golden Rice Humanitarian Board and Network, discussed in Chapter 3, while international, have been characterized by a close-knit core managing access to knowledge and materials through institutional arrangements emphasizing vertical over lateral relations. This chapter traces events unfolding during the early years of HarvestPlus in an attempt to reveal how and why, despite its faltering progress as an research and development programme, HarvestPlus has endured as the international biofortification 'mother ship'[3] and platform for spin-off initiatives of various kinds.

Back to Basics? A Challenge Program

While the CGIAR micronutrients project (1994–9) had been a relatively modest programme, it carried a set of expectations that it would make the case for a larger scale initiative. The IRRI-hosted 'Improving Human Nutrition through Agriculture' seminar[4] in 1999 had provided a platform to share findings and build broader support; however, initially, this only extended to ADB support for the high-iron rice project. In the meantime, Howdy Bouis continued to seek support for a broader, multiple crop initiative within the CGIAR, submitting a proposal for an IFPRI-led 'system-wide programme' to the CGIAR Technical Advisory Committee (TAC). The TAC rejected this proposal on the basis that biofortification was 'not a priority area for the CGIAR'.[5]

As discussed in Chapter 1, four years later a revised proposal, now jointly sponsored by IFPRI and CIAT, was approved by the CGIAR Interim Science Council, the body that had superseded the TAC as a result of organizational reforms underway in the CGIAR. What would account for this shift in position? While the Science Council was a new structure, at this point in the transition process the Interim Science Council was composed of the same people as the TAC that had initially rejected the proposal. It is instructive, therefore, to consider the combination of factors that could have led this group of people, four years later, to reach a very different decision.

The replacement of the TAC, 'a broad mix of people with research and development background', with the Science Council, 'consisting of a few, high level science policy strategists' each recognized for their 'solid scientific stature' (CGIAR, 2001, pp1, 6), was one of the key elements of the CGIAR reform programme. This organizational change was indicative of a more fundamental shift of the CGIAR 'back to its roots' as a research institution.[6] While reflecting donor concerns about development impact the Science Council mandate embodied a re-emphasis on 'Research for development – not development *per se'* (Science Council, 2006, p7).

This new body initiated a process of 'system-level priority setting' that would guide CGIAR research for the period 2005–15 according to three criteria:

[bl]** the expected *impact* on poverty alleviation, food security and nutrition, and sustainable management of natural resources, taking into account the expected probability of success and expected impact if successful;

** the degree to which the research provides *international public goods*; and the existence of alternative sources of supply of the research; and

** the CGIAR's *comparative advantage* in undertaking the research (Science Council, 2006, pp5–6, emphasis added).

[tx]This process generated '20 research priorities for the CGIAR, organized within five priority areas' (Science Council, 2006, p6) (see Box 4.1). These included, notably, 'Priority 2C: Enhancing nutritional quality and safety'. Anticipated direct and indirect impacts of these research priorities on achievement of the MDGs were set out in some detail (Science Council, 2006, pp5–7).

[!box!]

Box 4.1 *CGIAR System Priorities, 2005–15*

Priority area 1: Sustaining biodiversity for current and future generations

Priority 1A: Promoting conservation and characterization of staple crops

Priority 1B: Promoting conservation and characterization of underutilized plant genetic resources

Priority 1C: Promoting conservation of indigenous livestock

Priority 1D: Promoting conservation of aquatic animal genetic resources

Priority area 2: Producing more and better food at lower cost through genetic improvements

Priority 2A: Maintaining and enhancing yields and yield potential of food staples

Priority 2B: Improving tolerance to selected abiotic stresses

Priority 2C: Enhancing nutritional quality and safety

Priority 2D: Genetically enhancing selected high-value species

Priority area 3: Reducing rural poverty through agricultural diversification and emerging opportunities for high-value commodities and products

Priority 3A: Increasing income from fruit and vegetables

Priority 3B: Increasing income from livestock

Priority 3C: Enhancing income through increased productivity of fisheries and aquaculture

Priority 3D: Promoting sustainable income generation from forests and trees

Priority area 4: Promoting poverty alleviation and sustainable management of water, land, and forest resources

Priority 4A: Promoting integrated land, water and forest management at landscape level

Priority 4B: Sustaining and managing aquatic ecosystems for food and livelihoods

Priority 4C: Improving water productivity

Priority 4D: Promoting sustainable agro-ecological intensification in low- and high-potential areas

Priority area 5: Improving policies and facilitating institutional innovation to support sustainable reduction of poverty and hunger

Priority 5A: Improving science and technology policies and institutions

Priority 5B: Making international and domestic markets work for the poor

Priority 5C: Improving rural institutions and their governance

Priority 5D: Improving research and development options to reduce rural poverty and vulnerability

[sc]Source: Science Council, 2006, p4.

[!box ends!]

[tx]The Science Council proposed that, after a period of transition, CGIAR members and centres should allocate '80% of the total CGIAR budget for research and related capacity strengthening' to the priority areas identified (Science Council, 2006, p6). Throughout its summary report, the Science Council reasserts the role of the CGIAR in generating research for development as 'international public goods'. The proposed shift 'away from development activities with no research content' was endorsed on that basis: 'The SC [Science Council] is confident that a stricter application of the criteria to sharpen the scope of research will open up new opportunities for longer-term impact through strategic research activities' (Science Council, 2006, p7).

A second element of the CGIAR reform process was 'the development of *Challenge Programs* that respond directly to major concerns on the global development agenda' (CGIAR, 2001, p1, original emphasis). 'The CP [Challenge Program] became one of the four pillars of the CGIAR reform programme' (Science Council and CGIAR Secretariat, 2004, p4): 'A CP is defined as: "*A time-bound, independently-governed program of high impact research, that targets the CGIAR goals in relation to complex issues of overwhelming global and/or regional significance, and requires partnerships between a wide range of institutions in order to deliver its products*"' (Science Council and CGIAR Secretariat, 2004, p4, original emphasis).

In 2001, ten proposals were identified as 'candidates for acceleration' as Challenge Programs, including a project entitled: 'Harnessing Agricultural Technology to Improve the Health of the Poor: Biofortified Crops to Combat Micronutrient Deficiency' (CGIAR, 2001, p6). At the CGIAR AGM that year, the decision was taken 'to accelerate the process with the launch of three CPs [Challenge Programs] on a pilot basis'. In 2003, three Challenge Programs – Water and Food, 'HarvestPlus' (formerly the Biofortification CP) and Generation (formerly the Genetic Diversity CP) – were launched (Science Council and CGIAR Secretariat, 2004, p4).

In 2004 the Science Council and CGIAR Secretariat synthesized lessons to date from implementing the three pilot Challenge Programs. This synthesis document (Science Council and CGIAR Secretariat, 2004) is instructive in that it provides an articulation of the principles behind the Challenge Program mechanism and an indication of how these principles are to be applied in practice. A central theme is the importance of generating 'time bound outputs of IPG nature'. This is presented in terms of an international public goods model understood as 'the comparative advantage of the CGIAR system': 'The CGIAR has potential to seek major efficiency in the application of basic science to solve similar problems in multiple domains. This can be called the "comparative paradigm", *which is precisely what the CPs are about* ... The Generation CP and HarvestPlus CP are seeking proof of concept of this "comparative paradigm" which holds promise for widespread impact' (Science Council and CGIAR Secretariat, 2004, p7, emphasis added).

Complementing the international public goods model as the thread of continuity and the CGIAR's *raison d'être* was the principle that added value can be leveraged through engagement in strategic partnerships. This theme was further developed in the 'Business Plan' prepared for the Water and Food Challenge Program. This document outlines a 'business model' characterized by a consortium approach and open competitive grants (Rijsberman, 2002, p2). In this case the role of CGIAR centres shifts to the role of 'broker':

[dq]In this changing world the role of Future Harvest centers[7] changes from international research organizations that initiate and have primary responsibility for doing research in the developing world, *to organizations that derive their added value primarily from brokering and facilitating international research networks*. The international research centres link ARIs[8] and NARES[9] in complex multi-disciplinary research programmes with a strong focus on poverty alleviation and capacity building. The brokering role is a

substantive role that *does also require the maintenance of high quality research capacity within the system of international centres*. The nature of the role of the Future Harvest centers should, however, adapt itself to playing different roles: from (1) providing a 2-way international window on the world for large, high capacity countries such as Brazil, India or China, to (2) playing a major role in building capacity for research in countries with severely restricted internal capacities. (Rijsberman, 2002, p3, emphasis added)

[tx]This ‘strategic partnership’ theme within the Challenge Program design dovetailed with ongoing debates within the CGIAR regarding engagement with the private sector. In 2005 IFPRI convened an international dialogue on ‘Pro-Poor Public-Private Partnerships on Food and Agriculture’ (IFPRI, 2005). This was in a context of concerns about the CGIAR’s redefinition from a public research body to ‘a strategic alliance of 63 countries, international and regional organizations, private foundations supporting international agricultural research centres that work with national agricultural research systems, the private sector and civil society’. These concerns came to a head in 2002 when the Syngenta Foundation was appointed to the CGIAR board, prompting the CGIAR NGO Committee to ‘freeze its membership’.[10]

While acknowledging that public-private partnerships ‘are not a panacea for all development challenges in agriculture’, IFPRI reported ‘a broad consensus that [public-private] partnerships can create valuable synergies through knowledge sharing, joint learning, scale economies, resource pooling and risk sharing’ (IFPRI, 2005, p4). Notably, the Challenge Program mechanism was highlighted as presenting a way forward:

[dq]Partnerships with CGIAR Centres require that the CGIAR System rethink its structure and leadership. The longstanding principles of decentralization and centre autonomy are not helpful in dealing with the private sector. The system's recent creation of Challenge Programs – large, multi-stakeholder partnerships focused on major global issues, such as water for food and breeding micronutrient-dense staple crops – offer a much better model from the private sector's point of view. (IFPRI, 2005, p6)

[tx]These shifting priorities transformed the fortunes of Bouis' biofortification initiative from an interdisciplinary project 'falling between the cracks' in the CGIAR system to an exemplar of the potential offered by a new type of strategic research collaboration envisaged for a repositioned CGIAR. In 2003 the Biofortification Challenge Program, rebranded HarvestPlus, was selected as one of the three pilot Challenge Programs, which would be organized as follows:

[dq]Activities will be undertaken by an international alliance of Future Harvest Centers, national agricultural research and extension systems (NARES), departments of human nutrition and plant science at universities in developing and developed countries, advanced research institutes (ARIs) with expertise in micronutrients in plants and animals, and genomics, nongovernmental organizations (NGOs), farmers' organizations in developing countries, and private-sector partnerships. The Future Harvest Centers involved in the Biofortification Challenge Program are world renowned for their plant breeding expertise and extensive germplasm banks, strong ties to national agricultural

extension programs, and links to the human nutrition community. Thus, they are well placed to coordinate the proposed activities. However, close collaboration with institutions that offer complementary scientific expertise, skills, and experience not found within the Future Harvest Centers, is critical to a successful outcome. To achieve the goals and objectives of the Program, new ways of working together, both within the CGIAR system and with external partners, are needed. (CIAT and IFPRI, 2002, pIII).

[tx]The programme was immediately awarded US$3million in World Bank funding, under an existing agreement with the CGIAR (as part of its support for the CGIAR reform programme) to fund all the successful Challenge Program candidates.

One observer has remarked that, of all the Challenge Programs, HarvestPlus is the easiest to remember.[11] This may be because it incorporated certain key characteristics of the Challenge Program model, facilitating the enrolment the Science Council, in a way that had not been possible in the era of the TAC. Firstly, it addressed a problem that was high on the global development agenda: as discussed in Chapter 1, large-scale micronutrient interventions rate highly in terms of cost-effectiveness in an era of MDG-driven development.[12] Secondly, it addressed a problem that is complex – and therefore required, justified even, the type of heterogeneous networks and complex structures envisaged for the newly conceived Challenge Program. Crucially, such a structure presented a way forward for the CGIAR to maintain a central, if transformed, role in international crop research.

This ability of the *idea* of HarvestPlus to hold together such levels of complexity and heterogeneity, while packaging it in terms of a relatively straightforward, memorable formula, has been key to the transformation of biofortification research into the 'global' project it has become. At the same time, this repackaging resonated with an increasingly hegemonic, overarching frame for global development; a framing that has been consolidated by the arrival on the scene of a major new development actor, and the largest donor of HarvestPlus, the Bill and Melinda Gates Foundation.

[a]A Turning Point: Enrolling the Gates Foundation

In 2001 Bouis had approached the Bill and Melinda Gates Foundation (BMGF) about funding a larger scale, multi-crop biofortification programme. At this point the foundation was relatively young, with a staff of five to six people.[13] The initial assessment was unfavourable, particularly given that, at that stage, Bouis had not secured support from any major donors for such an expanded programme. In the following year, however, a series of serendipitous personal connections occurred. Sally Stansfield of the BMGF was visiting the Centro Internacional de Agricultura Tropical (CIAT – International Centre for Tropical Agriculture) to discuss the possibility of funding biofortification research on the common bean, on a single crop basis. Stansfield and Joachim Voss, then director-general of CIAT, were former colleagues at the International Development Research Centre (IDRC) in Canada.[14] Voss' decision to invite Bouis to attend the meeting to explore the possibility of extending the proposal to a multiple crop project transformed Bouis' project from an IFPRI initiative to a joint IFPRI/CIAT proposal with the full support of a CGIAR crop-breeding centre.[15]

Bouis approached the BMGF for a second time in 2003 with an altogether different result. By then, the programme had been approved by the CGIAR Interim Science Council for acceleration as a pilot Challenge Program. As such, the proposal had been assessed through the Challenge Program peer review process and allocated funding from the World Bank and other sources. The BMGF was therefore presented, crucially, with a co-funding proposition and with a project already approved through what BMGF staff regarded as a sufficiently rigorous assessment process: 'That the World Bank funding was already in place helped in discussions with the Gates Foundation. The eight anonymous, external reviews commissioned by the iSC [Interim Science Council] were made available to the Gates Foundation and this shortened the time required in their review process' (HarvestPlus, 2004b, p4).

In 2003 the BMGF approved US$25 million over four years (IFPRI, 2003). At this point, the primary donors of HarvestPlus were the World Bank (US$3 million per year), the BMGF (US$6.25 million per year) and USAID (US$2 million per year) (BCP, 2003, p1).[16] This funding was for the first phase (2004–7), which would focus on six staple crops (rice, maize, wheat, cassava, sweet potato and common bean) and three micronutrients (vitamin A, iron and zinc). The following excerpt from the programme proposal outlines a cautious approach to the use of more controversial technologies; the first phase would concentrate on the potential of conventional plant-breeding methods, with transgenic research (and additional crops) written into the second phase:

[dq]The Biofortification Program will focus on three micronutrients that are widely recognized by the World Health Organization (WHO) as limiting: iron, zinc, and vitamin A. Full-time breeding programs are proposed for six staple foods for which feasibility studies have already been completed and which are consumed by the majority of the world's poor in Africa, Asia, and Latin America: rice, wheat, maize, cassava, sweet potatoes, and common beans. Pre-breeding feasibility studies are proposed for eleven additional staples: bananas, barley, cowpeas, groundnuts, lentils, millet, pigeon peas, plantains, potatoes, sorghum, and yams. Breeding, dissemination, and impact activities, outlined in the ten-year plan, are focused on development of conventionally-bred crops. No activities involving the release of nutritionally-improved transgenic crops to farmers and consumers are proposed here or are included in proposal budgets for the initial four years for which funding is being requested. Research and development activities with respect to transgenic crops are confined to agricultural research centers and research laboratories. Transgenic methods hold great promise for improving the nutrient content of staple foods and speeding up the breeding process over what can be achieved using conventional methods. High social benefit and lower risk applications, such as the incorporation of desirable traits from crop wild relatives, will be favored throughout the program whenever transgenic methods are considered. (CIAT and IFPRI, 2002, pIV)

[b]'A new class of philanthropist'

Why was the BMGF prepared to risk such substantial funds on an as yet unproven approach? Foundation staff have referred to the 'cogent argument' presented by a proposal with potential to deliver 'attributable impact'.[17] However, it is important to place the foundation's support for this initiative within the broader context of its prioritization of 'Global Health' (Gates Foundation, 2000, p3), and, within that, for its ongoing support for conventional food fortification projects.

The BMGF had, since its launch in 1999, supported two US NGOs pioneering technology transfer of conventional food fortification technologies (Gates Foundation, 1999; Gates Foundation, 2001): the Program for Appropriate Technology in Health (PATH), known for its 'Ultra Rice' technology (PATH, 2005; PATH, 2006), and Sharing US Technology to Aid in the Improvement of Nutrition (SUSTAIN), known for its work on iron powder for fortification and for advocating the fortification of US (PL480) food aid.[18] Then, in 2002, the foundation 'announced a $50 million commitment to support the formation of the Global Alliance for Improved Nutrition (GAIN) to reduce vitamin and mineral deficiencies along children in developing nations' (Gates Foundation, 2002, p13). This alliance would work towards establishing national level public-private partnerships for food fortification in GAIN's member countries (GAIN, 2005).

A decision by the BMGF to co-fund HarvestPlus can be viewed as part of a broader investment strategy in which the foundation was spreading its risk. In 2005, the director of Rockefeller Foundation, Judith Rodin, drew attention to 'a new generation of business-minded philanthropists, led by Bill Gates'. Rodin's vision of a new Rockefeller Foundation acknowledges the influence of 'the new philanthropists' who emphasize 'the importance of being "strategic"; of leveraging the relatively small sums of money at its disposal ... through partnerships; and, above all, of achieving "impact"'.[19] Notably, these elements of a more business-minded approach to philanthropy are mirrored in changes underway in the CGIAR and in the vision underpinning the Challenge Program design. In a keynote speech at the 2007 'Global Philanthropy Forum', hosted by Google, Rodin argued that the US philanthropy sector 'must embrace Silicon Valley-style, market-based approaches'.[20] Another speaker noted that: 'Philanthropy has always had innovation in its DNA. I see that is being ratcheted up ... What was already an inventive sector now has an infusion of talent of young, energetic, socially conscious people who have gained a new wealth, a new class of philanthropist.'[21]

This reference to a new class of philanthropist has also been endorsed by Jeffery Sachs of the Millennium Project, who believes that these 'wealthy philanthropists' have the potential to 'eclipse the G8' in addressing global development problems: 'The Rockefeller Foundation was the world's most important development organization of the 20th century, and the Gates Foundation can be that of the 21st century ... Gates can make a huge difference if they hit the right model.'[22]

Announcements such as these convey high expectations of a new generation of philanthropists, who made their fortunes in the US-based high-tech industries, to succeed where others have failed in tackling enduring development problems as long as they 'hit the right model'. Who are these individuals and why do they inspire such confidence?

The BMGF is the largest private foundation in the US and considered the leader of this new phenomenon. It was formed in 1999 from the consolidation of the William H. Gates Foundation (founded by Bill Gates Sr.) and the Gates Learning Foundation (founded by founded by Bill Gates Jr. and his wife, Melinda French Gates) (Gates Foundation, 1999, p3). By January 2005, Bill and Melinda Gates had 'endowed [the] foundation with more than $28.8 billion ... to support philanthropic initiatives in the areas of global health and learning'.[23]

William (Bill) H. Gates Jr. was co-founder and former chairman of the Microsoft Corporation, where he became 'known for his aggressive business tactics and confrontational style of management'.[24] Melinda Gates had worked as a project manager at Microsoft from 1987 to 1996.[25] In 1994 she married Bill Gates and in 1996 she left Microsoft, after the birth of their first child. One commentator has suggested that 'her mix of grace and gravitas has tempered the brash image of her tech-tycoon husband, and has eased acceptance of their ambitious agenda for ending health inequities'.[26]

In 2006, Warren Buffet, Bill Gates' 'friend and bridge partner' set a new precedent by announcing that he would donate his fortune to the BMGF – and not to his own foundation – doubling its budget overnight (Okie, 2006, p1086) The then BMGF co-chair, Patty Stonesifer, wrote in that year's annual report:

[dq]On June 26, Warren Buffett announced an astonishing pledge to the foundation – 10 million shares of Berkshire Hathaway Inc. stock worth more than $31 billion at the time ... Giving away money isn't hard. But giving it away effectively sure is. We were already making about $1.4 billion a year in grants. Last year, the total jumped to $1.6 billion, thanks to Warren's pledge, and we'll be giving away a projected $3.2 billion a year by 2009. We're not making the jump all at once; our annual grant making will increase by about one-third in each of the next three years. (Gates Foundation, 2006, p3)

[tx]Known as 'the Gatekeeper', Stonesifer had been a key member of the BMGF team since the early days, bringing 'a new style of leadership to philanthropy'.[27] Her biography clearly shows her membership of the 'new class of philanthropist':

[dq]In 1997, at the age of forty, Patty Stonesifer left her executive position at Microsoft for early retirement as a multi-millionaire. While Stonesifer was looking forward to spending time with her two teenage sons and working as a part-time consultant for DreamWorks SKG, Bill and Melinda Gates were working on a project to provide donated computers to public libraries in poor neighborhoods. The Gateses invited Stonesifer to tour several libraries that would benefit from the initiative, and, feeling obliged, the former 'Microsoftie' accepted. It took just one trip to a small town in South Dakota, where the local Rotary had pooled their money to buy the library a single computer, for Stonesifer to agree to head up the Gateses' library project. With no previous professional philanthropic experience beyond her own million-dollar donation in 1998 to the Multi-Service Centers, a Redmond, Washington-based family crisis program to which she had

volunteered a considerable amount of time, Stonesifer has become a central figure in the Gateses' philanthropic work.[28]

[tx]Despite a relative lack of previous 'professional philanthropic experience', Stonesifer had clear ideas about how an endowment such as that of the Gates can be mobilized to make an impact:

[dq]Stonesifer points out that although Gates's assets are vast, a gift of just $350 each to every American would extinguish his fortune. *'You can do a lot with the money', Stonesifer says, 'or you can dribble it away*. One reason why Bill and Melinda are committed to giving it back is that it makes most sense when you divide it into what it can do. As a giant bucket, it's kind of an irrelevant number'.[29]

[tx]While presenting a break with the past, however, these new philanthropists have retained one key characteristic from the previous generation: a belief in the potential of technological solutions to provide lasting solutions to intractable, complex problems. A quote highlighted in the BMGF's 2000 *Annual Report* is illustrative: 'For a long time, I've had a love for how science and technology can be integrated with public policy to solve unbelievably difficult and important problems facing the human condition' (Rick Klausner, Executive Director, Global Health, quoted in Gates Foundation, 2002, p12).

Similarly, a 'letter from Bill and Melinda Gates' posted on the BMGF website states: 'We also believe in the power of science and technology to improve people's lives. In recent years, the world has made tremendous advances in fields ranging from biology to information technology, and yet not everybody is benefiting from these innovations. Our goal is to help apply science and technology to the problems of the neediest people.'[30]

This belief in the potential of science and technology, combined with a new 'business-minded' approach, found its clearest expression in the foundation's 'open innovation' model. In 2003 the BMGF launched its 'Grand Challenges for Global Health', inviting grant applicants to participate in a process of open competition. One of the successful bidders was an international research consortium proposing to conduct a programme of biofortification research that promised to be more ambitious and high-risk than HarvestPlus:

[dq]Launched in 2003, the initiative unfolded in two stages. First, an international scientific board issued a call for ideas: What scientific and technological innovations, it asked, could have the greatest impact on health in the developing world? After reviewing more than 1,000 ideas, the board identified 14 Grand Challenges that, if solved, could save millions of lives in developing countries. These challenges include, for example, vaccines that don't require refrigeration, vitamin-fortified staple foods, and more effective and easy-to-use diagnostic tools. In the second stage, the board issued a call for research proposals based on the 14 Grand Challenges, and scientists from 75 countries submitted more than 1,500 funding requests. In June, the Grand Challenges initiative announced grants totalling $436.6 million to support 43 projects. One would develop a chemical to prevent mosquitoes from smelling humans, which could stop them from

being able to transmit disease. Another would design a hand-held diagnostic device that could be used in developing countries to test a drop of blood for a battery of diseases. Four others would develop new varieties of cassava, rice, sorghum, and bananas fortified with high levels of essential nutrients. These staple foods dominate diets in many developing countries but lack key vitamins, minerals, and other nutrients. (Gates Foundation, 2005, p13)

[tx]'Grand Challenge No.9' (GC9) aimed 'to create a full range of optimal, bioavailable nutrients in a plant'. While distinct from HarvestPlus, Bouis sees GC9 as a HarvestPlus 'spin off'.[31] In contrast to HarvestPlus, however, which at least in its first phase concentrated on raising micronutrient levels through conventional plant-breeding methods, the four successful consortia bidding for the GC9 grants had all proposed transgenic research projects. Furthermore, while HarvestPlus aimed to enrich a range of crops with single micronutrients, the GC9 grantees had the more ambitious goal of stacking multiple nutrients into a single plant.

Almost as soon as HarvestPlus began its operations, therefore, it became clear that it was just one player on a fast evolving landscape of international research. Or, as one BMGF representative commented, HarvestPlus was 'not the only game in town'.[32]

[a]Establishing HarvestPlus

For the HarvestPlus programme team, 2003 was 'the year of getting organized'.[33] This was according to a programme structure that had been set out in the proposal, as follows. Notably, activities would be 'organized by crop', reflecting the core organizing principle of the CGIAR network of research centres:

[dq]A governance and oversight mechanism, led by CIAT and IFPRI, is intended to facilitate these more complex collaborative arrangements ... An external, inter-disciplinary Program Advisory Committee (PAC) of experts from developing and developed countries is being formed to recommend strategic research priorities, oversee project progress, and implement a transparent competitive grants process ... A program leader, a breeding and biotechnology coordinator, and a nutrition coordinator, comprising a three-person Program Management Team (PMT), will coordinate the overall project ... Program activities will be organized by crop, under crop team leaders responsible for coordination. Regional and cross-crop coordination will be facilitated by the PMT and the relevant crop team leaders. (CIAT and IFPRI, 2002, pIV)

[tx]A series of programme planning meetings followed. In October of that year, the programme name was changed from the Biofortification Challenge Program to 'HarvestPlus', a name considered 'more appealing to the general public'.[34] In a presentation to the CGIAR AGM, the name change was explained as follows:

[dq]We took the decision to change the name of the Biofortification Challenge Program to HarvestPlus as a way to reach out more effectively to the public. We felt that this was

important in terms of (i) sustaining donor support for a 10-year program, (ii) defending/explaining controversial activities related to development of transgenic crops, and (iii) meeting one of the goals of the Challenge Programs to raise the public profile of the Future Harvest Centers. Not everyone agreed with the decision; several scientists were reticent to use such an 'imprecise' title. However, the decision-making process was highly participatory, the decision approved by a large majority, and accepted and behind us.[35]

[tx]During this time, the HarvestPlus network was extending – through competitive bidding processes – to new partner institutions that had not been a part of its precursor projects. Concerns were raised that this process may be straining, rather than strengthening, interdisciplinary relations:

[dq]Interdisciplinary exchange/communication is crucial for the success of HarvestPlus. Such interactions become increasingly productive as experience is gained, that is over time and at a series of meetings. HarvestPlus has some advantage that experience was gained by a subset of the collaborating institutions in precursor projects, but many new non-CGIAR collaborators have participated in the planning meetings in 2003 ... Understanding across disciplines is hindered by technical language which either is not commonly understood, or has different connotations to different disciplines ... This all takes time and the give and take of interacting on repeated occasions ... The optimal situation in terms of team building is one in which the partner institutions are all known

at the start of the planning process. Competitive bidding can hinder this process of team-building.[36]

[tx]By 2004, a range of collaborative arrangements and programme activities were initiated or underway. Notably, HarvestPlus and a new strategic partner, the International Atomic Energy Authority (IAEA), jointly issued bids for bioavailability studies using stable isotopes, with grants awarded to three US land-grant universities: Iowa State, Wisconsin-Madison and University of California (UC) Davis. In addition, a 'reaching end-user' component was added to the programme, with additional funds sought (and later secured) from the BMGF for this purpose.[37] For the HarvestPlus project management team 'the time came sooner than we thought. [At a meeting in] June 2003 the end-user people said "you have to start now"':[38]

[dq]In the original proposal, it was an important oversight to postpone collaborative interaction with institutions/implementers related to 'Reaching and Engaging End-users' (that is, moving the biofortified varieties from the research station to consumers) until after nutritionally-improved varieties had been tested and proven for their potential to improve micronutrient status and ready for distribution. Additional funding is needed (and is being sought) for these activities, especially in view of 'fast-track' opportunities in particular for disseminating orange-flesh sweet potatoes, and to some extent for high-iron beans and high-zinc wheat as well.[39]

[tx]However, while orange sweet potato was ready to be ‘fast-tracked’ (with a product inherited from predecessor projects such as Vitamin A for Africa – VITAA), in the event, high-iron bean and high-zinc wheat were not. For example, varieties identified as high-zinc in Peru appeared to lose this trait once transferred to Africa, raising questions about GxE[40] effects, so it was ‘back to the drawing board’.[41] At this stage, therefore, HarvestPlus reaching end-user activities went ahead for just one crop, orange sweet potato.[42]

During the course of this ‘year of getting organized’, therefore, a number of tensions, built into in the HarvestPlus Challenge Program design, began to surface. The extension of the network to new collaborators, often through processes of competitive bidding, jarred with implicit notions of partnership that had governed relations within the smaller networks that had nurtured a vision of ‘scaling up’ biofortification research for many years. At the same time, previously accepted – if not wholly resolved – interdisciplinary relations that had evolved within the more informal environment that characterized these networks were unsettled by the new arrangements.

Compounding these strained relations was a new focus on ‘impact’, now explicit in the directives of the Science Council and the BMGF, at a point when research was at too early a stage to demonstrate it. In light of this, the expectations attached to the ‘fast-tracking’ of certain projects, and the implications of their mixed success, became increasingly problematic. It is in light of these new tensions and pressures that we return to the Philippines and pick up the threads of the iron rice (IR68144/MS13) and Golden

Rice stories, outlined in Chapters 2 and 3, which, though separate until now, were beginning to converge.

[a]HarvestPlus Comes to IRRI

The first HarvestPlus rice crop meeting was held at IRRI in October 2003,[43] convened by Swapan Datta, who now combined his new role as HarvestPlus rice crop leader with his existing responsibilities for Golden Rice adaptive research at IRRI. At this point the iron rice bioefficacy study, using IR68144, supervised by Glenn Gregorio (IRRI) and Angelita Del Mundo (UPLB), was in its final stages and initial findings regarding biological impact were positive (see Chapter 2). This emerging evidence of 'proof of concept' was well timed for the new HarvestPlus programme and the high-iron rice project 'was fast tracked to get data out, to say, there, it's a viable thing'.[44] This was in line with a 'dual approach' discussed earlier, in which the 'early development of "fast-track" varieties that would convincingly demonstrate the validity of the biofortification strategy' was combined with 'a more lengthy parallel development of varieties combining the best nutritional and agronomic traits in each crop' (HarvestPlus, 2004c, p5).

By 2005, however, a number of changes were taking place. After the initial boost delivered by the iron rice study, IR68144, now released by the Philippines National Varietal Improvement Board as MS13,[45] was proving something of a liability, as more cautious, qualified assessments emerged (Padolina et al., 2003). As discussed in Chapter 2, just as these 'black boxes' were reopening, the research 'family' that had, until this point, been steering the project was beginning to disperse. This left a vacuum, as those remaining found themselves caught up in a numbers game, with different stakeholders in the iron rice project – old and new – each advancing their own understanding of the project findings and their implications.

In the same year, as discussed in Chapter 3, IRRI took the controversial step of recruiting Gerard Barry[46] as Golden Rice network coordinator, head of intellectual property and HarvestPlus rice crop leader. These events again shone a spotlight on a project that had come to represent, for IRRI, the promise and dilemmas of rice biofortification: Golden Rice. According to critics, Barry's appointment signified both a point of departure for IRRI as a public research institute and a thread of continuity in terms of Barry's (and, by extension, the biotechnology sector's) involvement with the Golden Rice project. While at Monsanto, he had played a key role in negotiating free licences for the company's IP claims in relation to Golden Rice:

[dq]To critics that degree of control over the introduction of Golden Rice into Asia is merely a continuation of Gerard Barry's Monsanto trajectory – a trajectory that can be traced from the time the corporation realized the incredible PR potential of Golden Rice. According to Ingo Potrykus, 'only [a] few days after the cover of "Golden Rice" had appeared on TIME Magazine, I had a phone call from Monsanto offering free licenses for the company's IPR [intellectual property rights] involved. A really amazing quick reaction of the PR department to make best use of this opportunity.' Barry played a key

role in the subsequent negotiations – negotiations which in the end drew in a further five biotechnology companies keen to follow Monsanto's example.[47]

[tx]As discussed, Barry's arrival coincided with the departure of Datta from IRRI and from the Golden Rice project[48] – a project which Datta had shepherded from its origins in the ETH laboratory to the IRRI campus in 2001 – and his replacement as the lead transgenics scientist by Philippe Hervé, joining IRRI from CropDesign,[57] a leading agricultural biotechnology company.[49] Hervé oversaw the refurbishment of IRRI's transgenic laboratory at a cost of US$1.5 million.[50] He was joined in 2007 by Susanna Poletti, a postdoctoral fellow arriving from ETH, Zurich, specializing in transgenic approaches to iron biofortification.[51]

With the departure of Gregorio in January 2006 to take up a new position at WARDA,[52] the high-iron rice 'family' had fragmented to the point that it was no longer the voice of high-iron rice at IRRI. Responsibilities for high-iron rice breeding and Golden Rice adaptive research were transferred to Parminder Virk who, prior to joining IRRI in 1999, had spent more than ten years as a research scientist at Birmingham University in the United Kingdom.[53] By 2006, therefore, a new 'international' team had replaced the essentially Filipino research network at the heart of the earlier rice biofortification efforts. In 2006, IRRI published its Strategic Plan for 2007–15. For the first time, a strategic goal (and associated programme) 'to improve the nutrition and health of poor rice consumers and rice farmers' was included, incorporating an objective on biofortification (IRRI, 2006, pp32–3). Barry was appointed to lead this programme.[54]

These staff changes represented an almost wholesale shift from a Filipino research ‘family’, oriented towards field-based research, to a more impersonal, international network, emphasizing laboratory-based science. While located within the same institutional setting of IRRI, these respective networks lived in different epistemic worlds. In this case, of all the loose ends left open by the departing iron rice family, it was the issue of iron content – its precise measurement and optimization – that would exercise the minds of the members of this new network. In light of these epistemic shifts, we now return to an issue central to HarvestPlus, the creation of interdisciplinary relationships. The following section focuses on two interdisciplinary struggles that took place around this time.

[a]Interdisciplinary Encounters

As already discussed, HarvestPlus is both a formal programme and ‘an alliance committed to an idea, a common goal’.[55] One commentator has acknowledged that, ‘Howdy [Bouis] did an amazing job, creating partnerships without offending anyone ... He had a lot of knowledge and a vision but didn’t impose it, instead worked with [people] created *partnerships* ... created buy-in’.[56] While key to building support for and credibility of HarvestPlus as an interdisciplinary initiative, such alliance building would later generate challenges at moments when these evolving partnerships were called upon to reach ‘consensus’ in uncertain, unfamiliar or contested areas.

It is at these moments that the tensions inherent in the assumed 'IPG nature' of biofortification research surface, rendering the actor-networks and attempts at black-boxing visible. The following sections highlight two such moments. The first of these focuses on negotiations that took place at the 'centre' of HarvestPlus over programme-wide breeding targets. The second brings the implications of this first encounter back to iron rice research at IRRI, which was now in the hands of the new international network.

[b]Negotiating breeding targets

A critical interface within HarvestPlus existed between agriculture and nutrition, specifically between plant breeders and nutritionists. These tensions surfaced during the negotiation of programme-wide breeding targets: the target levels of micronutrient content set for each HarvestPlus crop that would direct plant breeders in the respective breeding centres. With HarvestPlus framed as a public health intervention, the principle had been to set breeding targets at a level that would achieve a significant biological impact on the health of targeted populations. However, it soon became clear that these targets would be difficult to achieve within the timeframe of the programme's first phase. A debate ensued as to whether to put in place intermediate targets, at 50 per cent of the final target, as a first milestone. As one HarvestPlus member recalled: 'Nutritionists set the targets ... Then plant breeders breed to those targets. [But then the question came up] what if we cannot breed to those targets? ... the question of incremental targets ... HarvestPlus has decided to allow that. [But it's an] ongoing question: to what extent can it be incremental?[57]

This description of an ongoing, open decision-making process differs from the interpretation of a nutritional specialist who had been involved in the project. In contrast, the following account highlights the critical role of power relations between the disciplines, each with their respective institutional underpinnings (or lack of them), in shaping interdisciplinary outcomes. In this case, though HarvestPlus is ostensibly a public health initiative, driven by nutritional targets, these early interactions reveal how these ideas-in-principle were taken up and then transformed through the organizing principles of an agricultural research system constituted from single crop breeding centres:

[dq]Whenever nutrition throws up a challenge, they move the goalposts! [In discussions about levels needed for biological impact] plant breeders realized how difficult ... then the debate about intermediate targets came up. [But] you either have the level for biological impact or you don't. If intermediate targets are allowed ... two risks of running on intermediate varieties ... [first] people conclude nutrition doesn't work ... or [second] they conclude nutrition isn't important ... [The idea that you] just need to breed up shows a huge weakness ... ignores the social science side ... what makes people tick?[58]

[tx]Nutritionists had warned of the longer-term consequences of allowing varieties bred to the lower targets to be released and certified as 'biofortified' crops.[59] The case of IR68144, discussed in Chapter 2, demonstrated how expectations could be built up around a – still experimental – rice variety, despite its questionable 'high-iron' status.

Nevertheless, plant breeding is a long process – developing a new variety takes several years – so the decision to allow intermediate targets enabled plant breeders to proceed, apparently on their own terms. At this point, the crucial concession was made to the customary practice of 'breeding up', through a series of incremental, achievable steps, towards desired targets – in this case based on nutrient levels. Plant breeders explain this strategy in terms popular analogy of crop varieties as a succession of improved models, 'like Honda cars.'

The decision to 'shift the goalposts' and incorporate intermediate breeding targets into programme plans (see Pfeiffer, 2006) was a turning point in the unfolding of HarvestPlus as an experiment in interdisciplinary collaboration. These events followed a similar pattern as in the formative stages of the CGIAR micronutrients initiative, discussed in Chapter 2, in which an interdisciplinary research agenda 'tailoring the plant to fit the soil', in which new questions about GxE interactions were at the forefront, was reduced to the straightforward enhancement of required micronutrient levels 'in the seed' through genetic means.

Through a similar set of dynamics, a complex set of questions about plant-human interactions, though central to the issue of impact at the bodily level, was removed from the table by this concession to plant breeders' normal ways of working. The significance of this concession, while played down by IFPRI-based HarvestPlus staff, was not lost on nutritionists. As a boundary negotiation (Gieryn, 1999), the settlement over intermediate targets served to de-link plant breeders' efforts from programme priorities regarding the impact on human nutrition and health. At the same time, these developments ensured that the programme remained dominated by a plant-breeding agenda which, as discussed in Chapter 2, continues to pervade CGIAR system.

[b]Iron rice revisited

As outlined in Chapter 2, iron rice research undertaken under the ADB-funded programme had been acknowledged for its 'proof of concept' value, and, in particular, its provision of an 'iron bioavailability number for the Filipino diet', a tentative claim that was subsequently reinterpreted as so definitive that 'no more money [would] be spent on it'.[60] Beyond this, IRRI officially had distanced itself from IR68144 as a product and, in particular, from the promotion of MS13, and moved on to screening other varieties for higher levels that would (at least) meet the intermediate targets, now set centrally through HarvestPlus. In continuing the search for suitable breeding parents, the IRRI scientists now working on the project established a boundary between the former breeding work, which screened rice grains in their unmilled form, and their own approach, which was to screen after polishing: 'Most of the work Glenn [Gregorio] did was on brown rice. Now we've moved on to polished rice.'[61]

As mentioned earlier, this focus on the isolation and optimization of grain iron content appealed to a newly established international network that had formed around the iron rice research at IRRI, following the dispersal of the iron rice 'family'. New machines were purchased and refitted to facilitate higher levels of precision.[62] This new focus precluded the exploration of other analytical loose ends that the new iron rice team had inherited from earlier research. The most obvious of these related directly to the boundary-in-the-making between brown and white rice.

One of the lessons from the preparatory studies undertaken by Gregorio and his colleagues prior to the bioefficacy trial was the critical role of post-harvest practices 'in enabling the grain to retain its Fe [iron] content' (Gregorio et al., 2003). In light of this, research into post-harvest practices and, in particular, the merits of alternative milling strategies offered an alternative, or complementary, avenue of enquiry. Given that much of the iron content of the rice grain resides in those parts that are removed by the milling process, some IRRI scientists suggested this as a surer route to achieving the iron levels required.[63] In the event, establishing a boundary between former work on brown rice and the HarvestPlus research on polished rice effectively ruled out this option, at least using HarvestPlus funds:[64]

[dq]We only measure it on polished rice, [we're] not interested in brown or under-milled ... when people want quality rice they want it milled to extreme whiteness, it has to be in that form ... Well there's some interest in it, but we're not going to spend resources on that. Brown rice is more expensive. If people are eating brown rice already they don't have many problems ... we are targeting populations who want ... polished rice. To try to convert people to under-milled rice, when millers want a very tight process ... people pay for high quality whiteness, so trying to figure out intermediate milling, like a default or accidental situation is not something we're interested in spending energy on.[65]

[tx]This choice of focus, however, shone an uncomfortable spotlight back on to the problem of iron content. Since previous studies had confirmed that much of the grain iron content was lost in the milling process, IRRI scientists began to express doubts as to whether HarvestPlus breeding targets, even the intermediate targets, would be achievable through conventional breeding methods.[66] Following this reasoning, a dual strategy was chosen: to begin exploratory research on transgenic approaches in parallel with ongoing conventional breeding work.[67] In this case, the programme-wide breeding targets would act as the impartial arbitrator between the merits of the two research pathways. Thus, breeding targets that had been the subject of such heated debate among actors in at the 'centre' of HarvestPlus were now understood as the product of interdisciplinary 'consensus', the last word on nutrient levels required to achieve the necessary impact.[68]

While conducted in parallel, the two iron rice research pathways – employing plant breeding and transgenic approaches – were being conducted under very different sets of pressures and constraints. While the conventional breeding work was behind schedule (having been diverted for some time by the apparent success of IR68144) the transgenic work did not have to produce results until well into its second phase. Furthermore, IRRI scientists have had the opportunity to learn lessons from the experience with Golden Rice, 'controlling their own starting material' to ensure it is 'IP free' and 'marker-free'.[69] Moreover, scientists had some reason for optimism regarding the potential bioavailability of iron in transgenic high-iron rice in light of recent findings demonstrating that bioavailability of iron in ferratin[70] – the chosen source material – is comparable with that of iron in ferrous sulphate, a common fortificant (Davila-Hicks et al., 2004).

The transgenic iron rice research was taking place in the newly refurbished transgenics laboratory. Everything about the design, layout and aesthetics of this new laboratory suggests a clean break with the past and an attempt to establish a new working culture – a culture within a culture. As a former employee remarked:

[dq]I'm surprised that it's blue. The colour of IRRI is varnish ... varnished wood and white paint, not blue! [The new lab] is renovated for genomics ... from tissue culture and genetic engineering to genomics and DNA. Formerly [we were] just producing transgenic [materials], we didn't know about the expression, whether it's stable. [In the old lab different activities were] all in one room. In the new lab there's one room for each step – DNA, tissue culture [to prevent] contamination. [In the old lab] the library was at the back ... we used to have parties there!'[71]

[tx]Debates about whether iron rice research at IRRI would have to 'go transgenic', however, removed from the frame a set of enduring questions about biofortification research; questions that began with its early conceptualization in terms of a food systems paradigm. As discussed in Chapter 2, the early definition of biofortification as a matter of 'tailoring the plant to fit the soil' (Bouis, 1996b, p5; Bouis, 1995b, p18) implicitly acknowledged the role of GxE variation as a dynamic to be exploited, rather than simply observed, as in the case in much conventional plant breeding practice (Simmonds, 1991).

However, a statement by one of the scientists in the international iron rice network that iron content could be treated as any other quantitative trait, and thus GxE would be taken care of through normal multi-locational testing procedures, once optimal cultivars had been identified, indicated that the continuation of plant breeding for enhanced iron levels was following business as usual in formal plant breeding research. This was despite outstanding questions about the role of environmental variation in determining grain iron content, to the extent that, as discussed in Chapter 2, experienced scientists from other crop science disciplines had gone as far as to question whether the genetic half of the equation was at all significant in determining iron content.[72] Others have suggested that, at the very least, research into the environmental and cultural factors optimizing expression of iron might assist in the initial identification of suitable breeding parents.[73]

Nevertheless, discussions at IRRI bypassed these more nuanced debates and, instead, polarized around the ‘transgenic or not’ question. In this case, the ultimate outcome was seen as resting on whether plant breeders would be able to ‘weave their magic’ (Gregorio, 2006, p80) and generate a conventionally bred variety that reaches the required target in a race against the clock. If they were unsuccessful, it followed that transgenic iron rice would inevitably emerge as the single pathway. However, as the next section reveals, this is not simply a choice between the (objective) merits of two opposing technologies. To understand what is at stake in these debates, it is necessary to return to the issues of evolving institutional cultures and research partnerships in practice, as providing the context within which members of international research networks, such as those forming around iron rice, make such choices.

[a]Brokers or Gatekeepers? Organizational Tensions and 'Global Science'

Biofortification initiatives evolving during the 1990s had done so in a context of 'longstanding principles of decentralization and centre autonomy' within the CGIAR – principles that in the 2000s had been identified as barriers to building strategic partnerships, especially with the private sector (IFPRI, 2005, p6). Initiatives around orange sweet potato (by the Centro Internacional de la Papa [International Potato Center] – CIP) and high-iron rice (by IRRI), for example, were clearly located in single centres, working with local partners, towards goals shaped by national or regional contexts and priorities. Meanwhile, Bouis had provided a level of coordination and support (within a modest budget). The success of HarvestPlus in gaining approval as a Challenge Program was therefore a point of departure – away from its earlier decentralized practices (and albeit qualified successes) – towards an as yet unrealized ideal, conceptualized as the CGIAR's 'comparative paradigm'. More than this, the role of Challenge Programs such as HarvestPlus would be to provide 'proof of concept' for this paradigm (Science Council and CGIAR Secretariat, 2004, p7).

A comparison between the ADB-funded high-iron rice research at IRRI and evolving rice biofortification research under HarvestPlus is instructive here. As Chapter 2 highlighted, earlier iron rice research was characterized by a research 'family', grounded in a local context and focused on field level results and impacts. In this case, an interdisciplinary team grappled with a series of uncertainties and surprises, responding to these in ways that reflected the context and location of their research subjects and intended beneficiaries. In contrast, biofortification research under HarvestPlus was directed by targets set in a distant location for an anticipated impact on imagined populations. In this case both research avenues – transgenic research and conventional plant breeding – were being pursued with reference to these remote targets rather than the 'field' on their doorstep.

At the same time, this centralizing tendency written into HarvestPlus was reshaping relations between IRRI and its partners. Scientists within IRRI and participating NARS contrasted the lateral relations based on mutual trust and camaraderie that had characterized the ADB-funded project[74] with the sudden relegation of NARS scientists, 'when HarvestPlus came in',[75] to a role in which they conducted field trials and duly submitted their results, but were not party to subsequent discussions. As one NARS scientist explained:

[dq][The set up] was instituted from IRRI [now we] have to identify donors based on polished rice. Now, for almost a year [we] have been conducting replicated trials for varieties with high iron and zinc. IRRI identified the varieties and composed the nurseries. [After the trials we] submitted grain samples to IRRI for testing. But unfortunately, until now ... no results of the grain analysis ... so ... we can't do the

hybridization yet ... don't know from among these materials [which] has high iron ... waiting for more than one year.[76]

[tx]An observer from the nutrition community made a similar observation, linking these emerging dynamics to cherished notions about CGIAR centres as 'centres of excellence': 'The proportion of HarvestPlus funding going to national institutes is *miniscule*. HarvestPlus is not developing the NARS to do the work. That's the challenge of interdisciplinary work ... [the] CG mentality [is] "*we are the centres of excellence*"'.[77]

As discussed in Chapter 1, in Challenge Programs such as HarvestPlus, the CGIAR sought to bridge disciplines from the 'classic cluster' of crop sciences (Anderson et al., 1991, p74), particularly plant breeding, with human science disciplines that lay outside the confines of its expertise. In this case, notions of the CGIAR centre as a 'centre of excellence', while arguably already outdated (Chataway et al., 2007), had become more problematic. However, while official HarvestPlus discourse highlights interdisciplinary collaboration, with CGIAR centres acting as 'brokers' rather than experts, the experiences recorded above suggest a reluctance to relinquish this cherished position, so the role of broker is transformed into that of gatekeeper.[78] As discussions in Chapter 3 have revealed, a precedent for this role-shift already existed in the shape of the Golden Rice project (by now, as discussed in Chapter 3 and in the later sections of this chapter, in the process of extending to the ProVitaMinRice Consortium), in which a highly hierarchical set of 'partnership' arrangements had become normalized over time.

These tensions have implications for the practice of science, both within CGIAR centres such as IRRI and its national partners. Sumberg (2005) has drawn attention to the way in which incentives and pressures channelling NARS efforts and limited resources towards international collaborative projects are diverting these national institutions away from research that might respond to local agro-ecological conditions. These dynamics are intensified in the Philippine context, given the late entry of PhilRice into the community of NARS in the region, in the context of accumulated disappointments and misunderstandings over the expected contribution of IRRI to Philippine agriculture (Perlas and Vellvé, 1997). In view of this legacy, and the current reality in which NARS are pulled into international ‘collaborations’ as a way of attracting much needed funds, these dynamics within HarvestPlus reinforced these asymmetric relations and provided yet another reminder that PhilRice remained, in effect, ‘IRRI’s younger brother’.[79]

This shift has been accompanied by transformation to a more ‘top down’ approach to the conduct of science, as the iron rice project changed hands from a grounded, located iron rice ‘family’ to the laboratory-based realities of the international network, that has reshaped iron rice research under HarvestPlus. For IRRI’s new iron rice network, context-responsive, ‘bottom up’ research has no place in a programme that has retained aspects of the traditional ‘centre of excellence’ role, while deferring to a global framework and set of targets whose empirical relationship with projected improvements in human health and welfare is no longer questioned. As one IRRI scientist asserted: ‘Bottom up ... doesn’t work ... [It results in] messy measurement ... [which you] cannot replicate. In biotech, we are used to a lot of controls. For example ... iron content ... at

IRRI ... everyone measures iron in a different way. This is the difficulty with bottom up. I can't understand why such a simple thing ... so important ... cannot be standardized'.[80]

Notably, this scientist saw the GxE conundrum as one that called for more rigorous application of standardized controls, rather than greater attention to site specific interactions. Meanwhile, as soil scientists continued to raise questions, not only about GxE interactions, but appropriate strategies for dealing with them (Simmonds, 1991), these views are unlikely to be heard within the international networks. In this case, the plant breeders' reassurances, that GxE is 'taken care of', close the black box around such questions.

This privileging of the universalizable over the site-specific (Biggs and Clay, 1981) – from the formalization of central breeding targets to the treatment of GxE uncertainties within iron rice research at IRRI – has, of course, been an enduring theme in the CGIAR trajectory, as discussed at length in Chapter 1. Of particular note is the way in which IRRI had provided the platform for a new actor-network to selectively appropriate and reframe an earlier initiative, of which a locally based research 'family' had taken such ownership, to assume membership of an evolving global science community. Implications of these shifts for the practice and quality of science – in particular the intensification of black-boxing of uncertainties that has proliferated under such circumstances – have been explored in this section. The next section discusses emerging policy and impact questions.

[a]Constructing Demand, Predicting Impact

The status of HarvestPlus as a pilot Challenge Program incurred built-in expectations that it would prove to be an exemplar of the international public goods model. These expectations are ambitious, given the multiple uncertainties inherent in biofortification research. While building on prior experiences inside and outside the CGIAR system (Low et al., 2001; Corpuz-Arocena et al., 2004; Johnson-Welch et al., 2005; Haas et al., 2005), on closer inspection these earlier projects raised as many questions as they answered. This was not surprising given the complex ecological, socio-economic and cultural dynamics that mediate local nutrition outcomes. In one of the papers that launched the CGIAR micronutrients initiative that preceded HarvestPlus, Calloway cautioned that: 'the target population is not homogenous so one remedy is unlikely to serve all. To intervene efficiently and effectively requires knowing fairly precisely what a population lacks and why. That knowledge is no less necessary for selecting crop-modification strategies than for formulating policy' (Calloway, 1995, p21).

The definition of 'Reaching and Engaging End-users' in HarvestPlus literature as a matter of 'moving the biofortified varieties from the research station to consumers' (HarvestPlus, 2005a) indicates that Calloway's concerns have gone unheeded. Instead, the notion that consumers are to be faced with a straightforward choice of whether to 'switch' from non-biofortified to biofortified crops – for part or all of their total consumption – has gained currency within HarvestPlus: 'Two basic assumptions are possible ... (i) a certain percentage of consumers switch completely to the biofortified crop, while the remainder consume only the unfortified crop, and (ii) all consumers replace a certain percentage of their consumption with the biofortified crop and continue to consume some unfortified crop in parallel' (Stein et al., 2005, p20).

The way in which the 'end-user' question has been framed in terms of consumer choice;[81] whether, and to what degree, to consume fortified and/or unfortified rice is reminiscent of early assumptions underpinning the roll-out of Golden Rice, as discussed in Chapter 3. These assumptions endure, despite the characteristically heterogeneous and segmented nature of rice markets in Southeast and South Asia, in which a multiplicity of varieties, milled to varying degrees, coexist in a 'marketplace' populated by numerous small-scale rice farmers, millers and vendors.[82] Furthermore, as discussed in earlier chapters, instrumental 'consumer choice' models fail to take account of the myriad ways in which the cultivation, harvesting, preparation and consumption of rice shape and reflect social and cultural life (for example, see Hornedo, 2004, p5).

The decentralized nature of all aspects of rice markets therefore compounds the essentially local character of nutritional outcomes, which are invariably mediated by local biological and ecological conditions in addition to the socio-economic and cultural factors that shape the production and consumption of food. Furthermore, while ostensibly 'food-based',[83] biofortification is nevertheless 'a health intervention, using food as an intervention to administer extra nutrients'. In this case, dissemination of biofortified varieties calls for a specificity and rigour in targeting and needs assessment beyond that normally required from the agricultural research community: 'As a health intervention, there are implications ... first you must first identify the need ... target group, and second [it] needs regulation ... in which the Ministry of Health has something to say. [When there is a clearly defined need] then you can justify your risk'.[84]

Yet these realities are at odds with the imperative of HarvestPlus to produce IPGs that will generate demonstrable 'impact'. Instead, HarvestPlus documents refer to constructed 'populations' such as the 'nutritionally disadvantaged' (CIAT and IFPRI, 2002, p5). Groups such as the poor, particularly those living in rural areas of developing countries (CIAT and IFPRI, 2002, pp4–14), and women and children in particular, are assumed as beneficiaries (Stein et al., 2005). In this case, HarvestPlus is envisaged as extending the 'choice' available to the 'poor' and 'nutritionally disadvantaged' as individuals in the marketplace, in an economistic vision of technology-society relations.

HarvestPlus has been presented as inherently 'pro-poor', by targeting staple crops, since the diets of poor people contain proportionally more staple foods, and by its strategy of plant breeding, which can reach further into remote rural areas than a strategy based on post-harvest food processing (CIAT and IFPRI, 2002). In this case, it is assumed that incorporation of biofortification into the national varietal release mechanisms in developing countries will automatically produce pro-poor outcomes.[85] Similarly, the increased micronutrient requirements of certain categories of women and children are translated into beneficiary status (Stein et al., 2005). However, it is well established that the special requirements of these groups call for concentrations of micronutrients, such as those available in pharmaceutical supplements and micronutrient-dense complementary foods, and are unlikely to be offered by biofortified staples.[86]

This construction of dislocated, generalized populations complements the construction of the end-user as rational consumer, to provide the baseline for the elaboration of an econometric approach to predict impact, *ex ante*. This approach is an adaptation of a framework originally developed by Roukayatou Zimmermann at the Zentrum für Entwicklungsforschung (ZEF – Center for Development Research), University of Bonn, and Matin Qaim at the University of Hohenheim, to present 'the potential health benefits of Golden Rice' (Zimmermann and Qaim, 2004). Qaim, one of the more recent recruits to the Golden Rice Humanitarian Board,[87] has co-authored a number of papers extending an adapted version of this framework to inform the approach to 'impact and policy' issues within HarvestPlus (Stein et al., 2005; Stein et al., 2006).

The sophistication of this economic analysis, however, belies its reliance on simple causal pathways linking anticipated shifts in 'consumer choice' with expected health outcomes; then extrapolating economic impact, using the 'standard' epidemiological unit of the disability-adjusted life year (DALY, see Chapter 2):

[dq]To measure the economic impact of biofortified staple crops on public health, both the number of DALYs lost under a hypothetical scenario, in which people consume biofortified crops, needs to be calculated. In addition to the information needed to calculate DALYs under the *status quo*, developing a hypothetical scenario where people

consume biofortified crops requires further information; specifically, the contribution of biofortified crops to a reduction in micronutrient malnutrition, and hence to an improvement in public health, needs to be specified. (Stein et al., 2005, p8)

[tx]In this case a rationale constructed to justify the roll-out of Golden Rice as a product has been extended to inform impact analysis for a range of biofortified varieties planned under HarvestPlus. While couched in the language of a public health and pro-poor development, HarvestPlus continues this tradition of ‘reaching end-users’ with predetermined products in such a way as to reinforce assumptions that international biofortification efforts have potential to generate impacts from outputs of an ‘IPG nature’. This approach to conceptualizing impact combines the narrowing effects of two disciplinary lenses, those of crop science and agricultural economics. Both have contributed to a blind spot within the international biofortification enterprise in general, and HarvestPlus in particular, around the ways in which these efforts are likely to have an impact (or not) on the health and welfare of actual human subjects.

However, as discussed in Chapter 1, this approach to ‘impact’ reflects global trends in which dominant ways of thinking about nutrition, health and development privilege centralized, global goal-setting, standardized epidemiological analysis and an overriding concern with cost-effectiveness and the removal of constraints to individual productivity. In this case, this approach to the question of impact is part of a global biopolitics in which the universalizing assumptions of agricultural science, with its overarching plant genetics frame from which the international public goods model is derived, and international nutrition, with its predisposition towards a ‘fixed genetic potential’ approach (Pacey and Payne, 1981), combine with the individualizing effect of neoclassical economics to detach constructed populations from any sense of geographic, socio-cultural or political location.

[a]Impact and ‘Spin-Offs’

As HarvestPlus neared the end of the first phase, it was becoming clear that programme outputs would be limited. Delays had been experienced, not only in rice, but also in the wheat and bean adaptive research.[88] While the orange sweet potato component was progressing well, enabling the programme team to experiment with ‘reaching end-user’ strategies, the project infrastructure and outputs had largely been inherited from the earlier USAID-funded VITAA (Vitamin A for Africa) project (Low et al., 2001). By early 2006, donors were expressing concerns about the time it was taking biofortification to ‘come to scale’: ‘We’ve been hearing about biofortification for a long time but it still hasn’t come to scale ... [they say it] will be another five to ten years ... What’s holding it back?’; ‘Orange sweet potato is the only success story, and that’s questionable.’[89]

Given these concerns, how would donors assess the impact of HarvestPlus at the end of its first phase? Would their support continue into the second phase? At this point, the focus of attention for the HarvestPlus project management team shifted from a fragile ‘core’ to the prospect of generating ‘spin-offs’ as a more genuine measure of impact. In this case, attention focused on emerging national biofortification programmes initiated in India, Brazil and China (Bouis, 2006).[90]

Taking the example of the HarvestPlus-China programme: this was conceived in 2004 ‘after the active communications among Dr. Howdy Bouis, Professor Yunliu Fan and Professor Xingen Lei’. Fan’s enrolment, as a ‘respected academician of the Chinese Academy of Engineering Sciences’ has proved crucial to gaining the support of Chinese scientists to a programme that had yet to secure substantial support from the Chinese Government, as was that of Xingen Lei of the nutrition faculty at Cornell University who, as a respected Chinese scientist and US-based HarvestPlus collaborator, played an important bridging role. Early organization and progress of the programme are described by HarvestPlus as follows:

[dq]To initiate the program in China, HarvestPlus programme committed $350,000 for pilot research for the Chinese scientists. The projects were required to be target [sic] on improving Fe [iron] and vitamin A bioavailability in rice, corn and wheat, with 1:1 matching support from home institutes. A total of 16 applications from 39 institutes were submitted to the program office on February 1, 2005 for initial evaluation. In April 2005, 7 projects were selected by the program office and advisory committee for funding. These projects will be conducted by multiple institutes, with very specific target nutrients (Fe or vitamin A) and population. Several field leaders and teams have carried on field investigations and held project organization meetings. All laboratories are currently

working with HarvestPlus program scientists on verifying the nutrient analysis in the selected samples.[91]

[tx]In September 2007, HarvestPlus-China held its second annual meeting, which I attended. At this meeting, jointly chaired by Fan and Bouis, participating Chinese scientists presented their work. In addition to Bouis, several senior HarvestPlus programme staff, crop leaders (including Gerard Barry as rice crop leader) and collaborators (including Ross Welch and Robin Graham) attended. Notably, Welch and Graham are also members of the HarvestPlus-China Program Advisory Committee, within a programme structure that mirrors that of HarvestPlus.

While Bouis and other external participants were clearly impressed with the scientific output within a relatively short timescale, concern was growing that the Chinese government had so far committed minimal funding. Fan stressed the need for patience, while continuing with a ‘do and ask’ approach, ‘to show outcomes ... get convincing scientific data, then get funds from central government’.[92] For HarvestPlus representatives, however, the imperative was to show that, despite limited progress in generating biofortified varieties to date, the programme had achieved impact through its generation of spin-offs. In this case, the prospect of leveraging funds from the Chinese government was seen as crucial to establishing this argument. HarvestPlus representatives therefore advised the Chinese scientists to take a pragmatic approach towards building the case for funding: ‘Start at the end point and work back. Maybe you don’t have time to wait for a CACO-2 result.[93] The ownership ... the needs of the project here ... align timelines. [You need to] make certain leaps of faith ... fill the gaps in later'.[94]

At the same time, the extension of the HarvestPlus network to the China programme further consolidated the black-boxing of results that, closer to the core, were still in doubt. IRRI's high-iron rice study, in particular the nutrition study, was recommended as an effective, proven method for strategic use and communication of research to attract funding. In this case the positive aspects – in particular the success of the bioefficacy study[95] conducted in the Philippines in delivering 'proof of concept' and so attracting donor support – were highlighted. In addition, the previously contested 'bioavailability number' drawn from the study was presented as a definitive result: '[You need to] determine the bioavailability number in the Chinese diet. We have it for the Philippine diet. Go back, pick a study that will have a huge effect ... [Use] stable isotopes, you define the diet ... and how you define the communication value'.[96]

The case of HarvestPlus-China suggests an attempt by the HarvestPlus leadership to create a programme largely in its own image. In this case their efforts have had limited success, particularly in terms of their chief aim of bolstering the core of HarvestPlus by demonstrating its power to leverage funds from new sources. Instead, the most significant outcome may have been be the extension of networks supporting previously contested or qualified findings and approaches, so these have been further black-boxed as definite findings and proven methods.

[a]Business as Usual? The ProVitaMinRice Consortium

While attempts to demonstrate the added value of HarvestPlus as a platform for 'spin-offs' generated mixed results, as illustrated by the limited national recognition given to HarvestPlus-China, for example, progress of the earliest HarvestPlus 'spin-off' may be more indicative of the dynamics and future direction of biofortification research, in which a close-knit, international network, initially formed around the goal of promoting Golden Rice, is playing an increasingly central role.

Following its decision to fund HarvestPlus in 2003, the BMGF launched its 'Grand Challenges for Global Health' initiative. One of these challenges – Grand Challenge No.9 (GC9) – was to create a full range of optimal, bioavailable nutrients in a plant (Gates Foundation, 2005, p13), in other words to produce a multi-nutrient biofortified crop. Four proposals were selected, for research on rice, sorghum, banana and cassava. One of the four grantees was the ProVitaMinRice Consortium (PVMRC), which aims to engineer 'rice for high beta-carotene, vitamin E, protein, iron and enhanced iron and zinc bioavailability'. At the centre of this 'new' consortium were key players from the Golden Rice project, including one of the co-inventors, Peter Beyer, at Freiberg University, as lead scientist. However, in a similar manner to HarvestPlus, the PVMRC has extended to include additional US universities (Michigan State and Baylor), NARS in the Philippines (PhilRice) and Vietnam (Cuu Long Institute), and the Chinese University of Hong Kong. [97]

In addition to vitamin A and iron, which were already priorities within HarvestPlus, this programme introduced two additional nutrients. Lysine – an enduring 'relic' (Bryce et al., 2008, p1) from a nutrition era dominated by the protein paradigm – was again back on the agenda. Vitamin E was introduced, as a nutrient in its own right (though, notably, it is difficult to find any mention of vitamin E deficiency as a public health priority in developing countries) and as an alternative route to solving what has been a persistent problem for the Golden Rice project, the stabilization of beta-carotene: 'Tocopherols and tocotrienols constitute Vitamin E, an essential component of the diet, and have the additional benefit that they help stabilize provitamin A within the food matrix owing to their strong antioxidant properties' (Al-Babili and Beyer, 2005, p571).

In the early stages, consortium members were each pursuing 'proof of concept' research on an individual nutrient or aspect of this complex programme.[98] However, the overall programme was presented as an interdisciplinary, multi-nutrient initiative, since the expectation was that, at a later stage, the genes and constructs produced from this upstream research would be pyramided into the Golden Rice 'finished product'. As one scientist working for the consortium observed: 'It's only Vitamin A that pulls it all together, in relation to rice. Vitamin A is also the common denominator of all staple crops in GC9 ... cassava, banana, sweet potato'.[99]

The centrality of Golden Rice to the design of the PVMRC was reflected in institutional arrangements governing the programme, in which an expanded Golden Rice Humanitarian Board had assumed the role of general oversight, as 'an external advisory board'.[100] As outlined in Chapter 3, this governing body was originally formed for a specific purpose: to facilitate the release of proprietary knowledge and materials according to the terms of a 'humanitarian licence'. However, over time it has grown in size and broadened its mandate, first over the Golden Rice project and now extended to the PVMRC. Meanwhile, the structure and timing of meetings, linking HarvestPlus, PVMRC and the Golden Rice Humanitarian Board, are indicative of continued 'mission creep', together with the emergence of new hierarchies:

[dq]Both HarvestPlus and [CG9] are governed by the Humanitarian Board in terms of research directions. During [PVMR] Consortium meetings and HarvestPlus meetings the Humanitarian Board is there as an R&D board. [In 2005 a series of meetings were organized] back-to-back: The HarvestPlus main meeting ... then the Humanitarian Board meeting ... then the Humanitarian Board meets each [PVMRC member] at a time ... At the last meeting Humanitarian Board came three days after ... We were advised what to present to them ... then we were asked to leave ... so they can discuss.[101]

[tx]This convergence of networks challenged distinctions between the different projects – HarvestPlus, Golden Rice and the PVMRC – distinctions that exist on paper but not in practice. In reality, the networks supporting these respective projects are interwoven, with back-to-back meetings an inevitable logistical outcome. Nevertheless, when placed in the broader context of an overextended network, it is the hierarchical character, and the ordering of particular actors within those hierarchies, that raises the most serious concerns. In particular, the omnipresence of the Golden Rice Humanitarian Board as the

default governing structure points to the vulnerability of an overextended network to the possibility of fragmentation and capture.

[a]Conclusion

HarvestPlus evolved from the earlier CGIAR micronutrients initiative, a relatively modest program driven by the commitment of a group of individuals. In the process, it has absorbed a range of regional initiatives within an ambitious global vision, buoyed by a reassertion of the CGIAR's comparative advantage as a generator of international public goods, achievable through a 'return to its roots' in upstream research. Reframed as a Challenge Program, HarvestPlus embodies the tensions inherent in a new way forward identified for the CGIAR, in which the interests and agendas of heterogeneous actors are to be reconciled within 'strategic partnerships' and channelled towards pro-poor ends.

This chapter has followed the evolution of HarvestPlus as a process of network extension and overextension, relying, not on empirical assessments of needs of particular people in particular places, but on the abstraction and aggregation of dislocated populations deemed 'at risk' from malnutrition-related diseases. This is made possible through the overlapping of disciplinary world views of a universalizing plant genetics frame and an individualizing, neoclassical economics frame, each of which fails to recognize the location of people, malnourished or not, within socio-economic, cultural and geographic contexts. This 'blind spot' continues to pervade the international biofortification enterprise in ways that those central to it are unable to see. Recognizing the limited achievements of the HarvestPlus initiative in its own stated terms, its coordinators look instead to 'spin-offs' to reflect indications of success back to the core project.

However, underlying these developments is an enduring set of assumptions about the role of CGIAR centres as 'centres of excellence'; assumptions that conflict with the new role of 'broker' that architects of the Challenge Programs, a key element of recent CGIAR reforms, envisage for its research centres. Though nutrition and health are recognized as lying outside the CGIAR's area of expertise, nevertheless, as the interdisciplinary negotiations outlined in this chapter highlight, CGIAR scientists involved in HarvestPlus have been successful in transforming the programme design and goals in such a way as to reassert the traditional 'centre of excellence' status of the CGIAR centres within the programme.

This type of selective interpretation and appropriation, at the level of the breeding centre, of a global agenda intended to transform the CGIAR is, of course, just the kind of dynamics against which Eicher and Rukuni have cautioned (2003, p24). Meanwhile, an overextended network may be in danger of fragmenting, as the core group driving the Golden Rice project plays an increasingly influential role in shaping the boundaries between the various projects that populate the global biofortification landscape. In this case HarvestPlus has a role to play as the public face of biofortification, while 'business as usual' continues.

Notes

1. Interview, Cornell, 31 January 2006.

2. Interview, HarvestPlus, 17 January 2006.

3. Interview, IRRI, 20 February 2007.

4. The seminar, discussed in Chapter 2, was documented in a special edition of *Food and Nutrition Bulletin* (vol 21, no 4, 2000).

5. Interview, Science Council member, 19 January 2006.

6. Interview, Science Council member, 19 January 2006.

7. This is a recent term used within the CGIAR to refer to CGIAR centres. See: www.cgiar.org/who/structure/system/fhao/index.html (18 March 2008).

8. Advanced Research Institute: this term refers, mainly, to universities and other research institutions in the North. In practice many of the ARIs in these networks are US land-grant universities.

9. National Agricultural Research and Extension System: this is an alternative term to the more commonly used NARS, recognizing the importance of extension in agricultural innovation.

10. CGIAR quoted at: www.gmwatch.org/print-profile1.asp?PrId=295 (18 March 2008).

11. Work in Progress seminar discussion, Institute of Development Studies, University of Sussex, 4 December 2007.

12. For example, see: www.copenhagenconsensus.com/Default.aspx?ID=158 (18 March 2008).

13. Interview, HarvestPlus, 27 January, 2006.

14. The IDRC is a long term supporter of micronutrient programmes, such as the Ottawa-based Micronutrients Initiative (MI): www.micronutrient.org/english/view.asp?x=1 (29 September 2009).

15. Interviews, HarvestPlus, 27 January, 2006, and University of Sussex, 27 January, 2006.

16. USAID was increased to US$3 million per year in 2004 (HarvestPlus, 2004c, p25). It is interesting to compare the overall figures with Bouis' original projection in 1996 of a one-time spend of US $10 million over four years (Bouis, 1996).

17. Interview, BMGF, 30 November 2005.

18. www.sustaintech.org/txtactivities.htm (27 July 2007).

19. www.rockfound.org/initiatives/index.shtml (23 July 2007).

20. www.rockfound.org/about_us/news/2007/0412rodin_google.shtml (18 March 2008).

21. Jane Wales, World Affairs Council of Northern California, quoted at: www.rockfound.org/about_us/news/2007/0412rodin_google.shtml (18 March 2008).

22. Jeffrey Sachs, quoted at: www.rockfound.org/about_us/news/2007/0408philanthropy.shtml (27 July 2007).

23. www.microsoft.com/presspass/exec/billg/bio.mspx (18 March 2008).

24. http://news.bbc.co.uk/1/hi/business/3428721.stm (8 August 2007).

25. www.nndb.com/people/533/000044401/ (18 March 2008).

26. http://online.wsj.com/public/article_print/SB116371407515425544.html (8 August 2007).

27. www.usnews.com/usnews/biztech/charities/articles/8stone.htm (18 March 2008). Stonesifer stepped down from her position as CEO of the BMGF in 2008.

28. http://foundationcenter.org/pnd/archives/19991116/003030.html (18 March 2008).

29. http://foundationcenter.org/pnd/archives/19991116/003030.html (18 March 2008).

30. www.gatesfoundation.org/AboutUs/OurValues/GatesLetter/ (18 March 2008).

31. Interview, HarvestPlus, 27 January 2006.

32. Interview, BMGF, 30 November 2005.

33. Interview, HarvestPlus, 27 January 2006.

34. www.cgiar.org/pdf/agm03stake_biofortificationcp_update.pdf (25 July 2007).

35. www.cgiar.org/pdf/agm03bus_harvestplus_bcp.pdf (25 July 2007).

36. www.cgiar.org/pdf/agm03bus_harvestplus_bcp.pdf (25 July 2007).

37. www.cgiar.org/exco/exco8/exco8_harvestplus_report.pdf (25 July 2007).

38. Interview, HarvestPlus, 27 January 2006.

39. www.cgiar.org/exco/exco8/exco8_harvestplus_report.pdf (25 July 2007).

40. The technical and policy uncertainties raised by alternative interpretations of GxE (genotype by environment) interactions are discussed in Chapter 2 and again in later sections of this chapter.

41. Interview, HarvestPlus, 27 January 2006.

42. Interviews, HarvestPlus, 17, 26, 27 January 2006.

43. www.cgiar.org/pdf/agm03stake_biofortificationcp_update.pdf (25 July 2007).

44. HarvestPlus interview, 26 January 2006.

45. IR68144 refers to the iron-dense rice germplasm generated by IRRI and used as the experimental material for the nutritional study (Haas et al., 2005). MS13 refers to the

name given to the variety, released in the Philippines, derived from IR68144 (Padolina et al., 2003). See Chapter 2 for further discussion of these events.

46. Suman Suhai of Gene Campaign, at: www.genecampaign.org/News/golden-rice.htm (18 March 2008).

47. www.gmwatch.org/profile1.asp?PrId=294 (18 March 2008).

48. www.genecampaign.org/News/golden-rice.htm (18 March 2008).

49. ‘CropDesign was founded in 1998 as a spin-off from VIB, the Flanders Institute for Biotechnology, and was financially backed until 2006 by a consortium of venture capital funds led by GIMV. In 2006, CropDesign was acquired by BASF Plant Science and is since then integrated in the international research network of BASF Plant Science. CropDesign currently employs about 70 people at its facilities in Gent, Belgium’: www.cropdesign.com/general.php (1 June 2008).

50. Interview, IRRI, 15 June 2006.

51. www.irri.org/about/irridir/staffbio.asp (18 March 2008).

52. See Chapter 2 for a more detailed discussion of the departure of Gregorio and other members of the iron rice ‘family’, and its consequences.

53. ‘Parminder Virk was senior research fellow, Punjab Agricultural University, India (1984–85); visiting fellow, University of Birmingham, UK (1985–86); and research fellow, University of Birmingham, UK (1987–99)’: www.irri.org/about/irridir/staffbio.asp (1 June 2008).

54. www.irri.org/about/irridir/staffbio.asp (18 March 2008).

55. HarvestPlus interview, 17 January, 2006.

56. Interview, World Bank, 24 January 2006 (original emphasis).

57. Interview, HarvestPlus, 17 January, 2006.

58. Interview, nutritionist, 28 March 2006.

59. Interview, nutritionist, 28 March 2006.

60. Interview, IRRI, 1 June 2006. As discussed in Chapter 4, the issue of whether the bioefficacy trial did, in fact, provide such a definitive 'bioavailability number' is contested, since the claims of Haas et al. are more modest in this respect (Haas et al., 2005).

61. Interview, IRRI scientist, 30 May 2006.

62. Interviews, IRRI scientists, 25 and 30 May 2006.

63. Interview, IRRI scientist, 25 May 2006.

64. IRRI's Strategic Plan for 2007–15 includes a target to increase consumption of brown or under-polished rice (IRRI, 2006, p32). However, the decision not to include it within the HarvestPlus programme left it vulnerable to the uncertainties of core funding.

65. Interview, IRRI, 29 May 2006.

66. Interview, IRRI scientist, 25 May 2006.

67. Interview, IRRI scientist, 30 May 2006.

68. Interview, IRRI scientist, 30 May 2006.

69. Interview, IRRI scientist, 18 December 2006.

70. These findings were from studies using soybean ferratin. However, similar results may be possible with rice ferratin contained in the plant leaves (but not in the grain). IRRI scientists have been exploring both options (Interviews, IRRI, 18 December 2006).

71. Interview, PhilRice, 5 June 2006.

72. Interview, IRRI scientist, 30 May 2006.

73. Interview, PhilRice scientist, 7 June 2006.

74. Interview, PhilRice scientist, 30 May 2006.

75. Interviews, NARS scientist, 16 January 2007; IRRI scientist, 7 December 2006.

76. Interview, NARS scientist, 16 January 2007.

77. Interview, nutritionist, 28th March 2006 (original emphasis).

78. Mackintosh et al. (2008) have drawn attention to tensions and conflicts between the roles of ‘broker’ and ‘gatekeeper’.

79. Personal communication, IRRI scientist, 23 May 2006.

80. Interview, IRRI scientist, 18 December 2006.

81. For example, recent ‘end-user’ research on biofortified orange sweet potato and maize has explored the use of ‘choice experiments’ in analysing the factors that influence choices between products with nutritional benefits (due to higher levels of pro-vitamin A) vis-à-vis other characteristics, such as appearance (colour) and texture. Findings were presented by J. V. Meenakshi, Impact and Policy Coordinator for HarvestPlus, at a STEPS Centre Seminar at the University of Sussex, UK, on 9 May 2008. See: www.steps-centre.org/events/stepsseminars.html (1 June 2008).

82. Interview, IRRI, 25 May 2006.

83. Florencio (2004) highlights the problematic nature of the term ‘food-based’, enabling its use by, for example, the industrial food fortification lobby, preferring the more precise term ‘dietary-based’ referring to changes in diet composition.

84. Interview, WHO, 14 March 2006.

85. While this research was in progress, exploratory discussions were taking place at IRRI regarding the possibility of partnering with NGOs and/or other development

organizations to deliver biofortified varieties through targeted pro-poor interventions such as food-for work programmes (IRRI interview, 2 June 2006).

86. Interview, WHO, 14 March, 2006.

87. www.goldenrice.org/Content1-Who/who_Matin.html (17 March 2008).

88. Interviews, HarvestPlus, 17 and 27 January 2006.

89. Donor interviews, 2 February and 25 January 2006.

90. www.harvestplus-china.org/english/swqh.htm (25 July 2007); www.harvestplus.org/pdfs/HPIndiaMOU.pdf (17 March 2008).

91. www.harvestplus-china.org/english/swqh.htm (25 July 2007).

92. Plenary question and answer session, Second Annual Meeting of the HarvestPlus-China programme, 18 September 2007.

93. A method for bioavailability testing *in vitro*, developed at Cornell University (Glahn, 2002).

94. Rice crop breakout group discussion, Second Annual Meeting of the HarvestPlus-China programme, 18 September 2007.

95. In this case the advice was to commission a bioavailability study using stable isotopes, rather than the more time-consuming bioefficacy study.

96. Rice crop breakout group discussion, Second Annual Meeting of the HarvestPlus-China programme, 18 September 2007.

97. www.goldenrice.org/Content2-How/how10_PVMRC.html (9 June 2007).

98. Peter Beyer (one of the Golden Rice co-inventors) conducted research on Vitamin E transformation; Michael Grusak (Baylor) on iron bioavailability; Dean Dellapenna (Michigan State) on nutritional genomics; Samuel Sun (Hong Kong) on lysine

transformation. Meanwhile adaptive research on Golden Rice is ongoing at Cuu Long, PhilRice and IRRI (see Chapter 3 for further details).

99. Interview, NARS scientist, 16 January 2007.

100. www.goldenrice.org/Content2-How/how10_PVMRC.html (9 June 2007).

101. Interview, NARS scientist, 16 January 2007.