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Is International Agricultural Research a Global Public Good? The case of rice biofortification[1]

Abstract: The status of international agricultural research as a global public good (GPG) has been widely accepted since the Green Revolution of the 1960s and 1970s. While the term was not used at the time of its creation, the CGIAR system that evolved at that time has been described as a 'prime example of the promise, performance and perils of an international approach to providing GPGs'. Contemporary literature on international agricultural research as a GPG tends to support this view and focuses on how to operationalise the concept. This paper adopts a different starting point and questions this conceptulisation of the CGIAR and its outputs. It questions the appropriateness of such a 'neutral' concept to a system born of the imperatives of Cold War geopolitics, and shaped by a history of attempts to secure its relevance in a changing world. This paper draws on a multi-sited, ethnographic study of a research effort highlighted by the CGIAR as an exemplar of GPG-oriented research. Behind the ubiquitous language of GPGs, 'partnership' and 'consensus', however, new forms of exclusion and restriction are emerging within everyday practice; reproducing North-South inequalities and undermining the ability of these programmes to respond to the needs of projected beneficiaries.

Keywords: international agricultural research, CGIAR, global/international public goods, rice science, biofortification

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Introduction

The status of international agricultural research as a global public good (GPG) has been widely accepted since the Green Revolution of the 1960s and 1970s. While the precise term was not used at the time of its creation, the CGIAR system that evolved at that time has been described as a 'prime example of the promise, performance and perils of an international approach to providing GPGs' (Dalrymple 2008:349). Today, while debates about the role and value of GPGs in international development have a higher profile than in the past (Secretariat of the International Task Force on Global Public Goods 2006), these debates have, according to Dalrymple, overlooked their role in science and technology. Citing the CGIAR as exemplar, he echoes calls for increased support for a system well placed to generate widespread spillover effects (Dalrymple 2008). Within the CGIAR the GPG principle was highlighted by the CGIAR Science Council (2006) during an institutional reform process in the early 2000s, in which the system's 'comparative advantage' in GPG research was emphasised as the surest way to maximise impact and demonstrate its continued relevance. This was to be operationalised, in the first place, through the 'Challenge Program' (CP) model, a mechanism specifically designed to produce a new generation of international public goods to tackle problems of global significance through cutting-edge, interdisciplinary, cross-sectoral research (Science Council and CGIAR Secretariat 2004).

Much of the literature on international agricultural research as a GPG supports this view and focuses on how the system can enhance its implementation of the concept (Sagasti and Timmel 2008, Kaul 2008). This paper adopts a different starting point and questions this representation of the CGIAR and its outputs in terms of GPGs. In particular, it questions the appropriateness and explanatory power of such a 'neutral' concept when applied to a system born of the imperatives of Cold War geopolitics (Perkins, 1997) and whose subsequent trajectory has been shaped by successive attempts to transform the CGIAR to secure its relevance in a changing world (cf. Oasa 1997). The reforms of the early 2000s were just one chapter in this broader history. It was at this time that the newly established Science Council articulated GPG research as the *raison d'etre* of the CGIAR and the Challenge Program as a model for its implementation (CGIAR Science Council 2006). This paper uses draws on empirical material from an in depth study of rice biofortification research efforts by the CGIAR, with a focus on HarvestPlus, one of the four pilot Challenge Programs launched during this period (Brooks 2010).

The term 'biofortification' refers to technologies for enhancing, through biological processes such as plant breeding and transgenic techniques, the micronutrient content of staple crops. Biofortified crop varieties have been heralded as the new miracle seeds, able to address the problem of micronutrient malnutrition, even in remote rural areas that are hard to reach with pharmaceutical interventions such as supplementation or industrial food fortification (HarvestPlus 2004a). This paper focuses on developments around one crop, rice, arguably the world's most important crop (FAO 2003). By exploring dynamics of science policy processes in rice biofortification it highlights aspects of GPG-oriented research *in practice* that are missed by conventional GPG analyses. In particular, it highlights ways in which emerging interdisciplinary and inter-institutional hierarchies within global research 'partnerships' are undermining the realisation of the GPG 'ideal'.

This paper is structured as follows: It begins by exploring how and why the notion of international agricultural research as a GPG has been highlighted in recent years. It then summarises developments in rice biofortification within the CGIAR, between 1995 and 2005, drawing attention to a convergence between assumptions embedded in an institution shaped by the imperatives of the Green Revolution and a revived interest, today, in generic silver bullet solutions to complex global problems. Both sets of dynamics reinforce the 'lock in' to genetics-led strategies, perceived as uniquely able to deliver widespread spillover effects (cf. Hogg, 2000) . Subsequent sections highlight the effects of mutually reinforcing institutional and interdisciplinary biases on a programme of research that constructs beneficiaries in its own image, rather than seek to address to the diverse needs of particular groups. In light of this analysis, the concluding section returns to the question of GPG research, arguing that Michel Callon's (1994) conceptualisation of science as a public good provides the basis for a more nuanced analysis and critique of the more subtle ways in which public research is being undermined, but may yet be revived.

Global public goods research and the CGIAR

The notion of international agricultural research outputs as GPGs was implicit in the vision and design of the Green Revolution; and that of the early 'definitive centres' for crop research such as the International Rice Research Institute (IRRI) and the Centre for

Improvement of Wheat and Maize (CIMMYT) that provided the foundation for what would later become the CGIAR network of International Agricultural Research Centres (IARCs). . While the terminology of international or global public goods was not used at the time, the Green Revolution, and the international infrastructure that evolved to support it, was founded on a set of core assumptions about the scale-neutrality of the outputs of genetics-led crop research (Anderson et al. 1991). These assumptions have weathered decades of debates, both without and outside the CGIAR, about the relative merits of methodologies positioned along a continuum from generic to more site-specific approaches (cf. Biggs and Clay 1981). Today, an explicit focus on GPG-oriented research as key to achieving 'impact at scale' has refocused attention and resources towards the generic end of the spectrum, and specifically to large scale plant breeding programmes, in the belief that they 'generally rank well in terms of spillovers' in comparison with more site specific approaches (Dalrymple 2008:359).

It is important to recognise the particular geopolitical and political-economic context within which the CGIAR system emerged and took shape. It was at the height of the Cold War that agricultural development assistance came to be seen as an essential element of US foreign policy (Perkins 1997). This new focus integrated two sets of ideas about the advancement of US national interests in the Cold War era. The first was the imperative to contain communism in Asia. Investments in the modernisation of agriculture, it was argued, would generate food surpluses to feed growing urban populations and prevent unrest. Less explicit was 'a concern of US business interests, articulated through private foundations such as the Rockefeller and Ford foundations to create the conditions for the future expansion of trade and investment, which required the integration of developing-country agriculture into capitalist national economies' (Brooks 2010: 16).

Similarly, a combination of factors has contributed to the CGIAR's apparent return to its roots today. Firstly, the focus on GPG-oriented research can be seen as a response to an international development agenda now dominated by a single global framework: the millennium development goals (MDGs). Today, development success is judged according to a metric that measures progress towards a set of universal global targets, in absolute, aggregate terms, thus avoiding problematic questions of inequality and exclusion (Saith 2006). Secondly, this shift to goal-oriented development has been

coupled with a renewed emphasis on a central role of science, technology and innovation in development efforts; encouraged by the arrival on the scene of a new generation of private philanthropists (or Philanthro-capitalists (Edwards, 2008)),led by the Bill and Melinda Gates Foundation (BMGF), whose favoured strategy marries an enduring faith in science-based solutions with a 'business-minded' approach to philanthropic giving. It is in this context that a research agenda based on a series of generic, 'silver bullet' solutions with associated claims to built-in scalability has found substantial donor support (Brooks et al. 2009).

While emphasising the system's public goods research mandate those governing these new directions for the CGIAR have had to incorporate a new dimension of complexity into their definition of GPG research. A recent resurgence of donor interest in agricultural research and development has followed two decades of underinvestment in the sector, and in the public institutions - international and, in particular, national - that might otherwise have been central to this renewed effort. This decline in public research capacity has been accompanied by an expansion of the role of the transnational private sector, particularly in life sciences research. Today, many of the tools required for the kind of 'cutting edge research' to which CGIAR now aspires are the intellectual property of transnational corporations. In 2005, report by the Food Policy Research Institute (IFPRI) declared 'a broad consensus that [public private] partnership can create valuable synergies through knowledge sharing, joint learning, scale economies, resource pooling and risk sharing' (IFPRI 2005:4). Notably, the Challenge Program mechanism, which allows for 'large, multi-stakeholder partnerships focused on major global issues' was highlighted as an institutional model that would be more conducive to collaboration with the transnational private sector (IFPRI 2005:6).

How have these potential conflicts of interest been reconciled within a renewed GPG research agenda within the CGIAR? At the time it was piloted, the Challenge Program model, defined as follows, was expected to point the way: "*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 2004:4, original emphasis). In this context, CGIAR centres would play a 'brokering' role in global, heterogeneous networks

comprising a wide range of public and private institutions (Rijsberman 2002:3); an 'honest broker': steering these complex networks in directions consistent with a public goods research mandate (Brooks 2010:4).

The remaining sections of this paper analyse the case of international rice biofortification research, in the CGIAR and its partners, as an exemplar of an evolving model for global 'public goods' science that remains fraught with challenges and contradictions. As such, it goes beyond more obvious questions of public versus private sector ownership and control to explore the effects of a fundamental accountability deficit, inherent in the Challenge Program design as a 'virtual centre'[2], on the conduct of research and practice of development by and within these increasingly complex networks. The biofortification case is of particular interest given its recognition as the most successful Challenge Program (Science Council and CGIAR Secretariat 2004), and subsequently identified as one of fourteen 'best bets' for 'scaling up' in the coming years (von Braun et al. 2008). Furthermore, the case of *rice* biofortification research in the CGIAR is particularly illuminating due to its intersection with a parallel BMGF-funded biofortification 'Grand Challenge'[3], launched in the same year as HarvestPlus, and the much older Golden Rice project, whose role as a pioneering example of a public-private partnership forged in the pursuit of humanitarian goals has been contested in recent years (Potrykus 2001).

Rice biofortification: a brief history (1995-2005)

Biofortification research had been an ongoing, if somewhat marginal activity within the CGIAR since CIMMYT scientists first began working on 'Quality Protein Maize' (QPM) or in the early 1970s (Bouis 1995). However, difficulties arose in the breeding research (the yields of early high lysine varieties were disappointing) and from the singular emphasis on protein (after a re-evaluation of international nutrition priorities) which led CGIAR scientists to conclude that the programme had been 'a major misallocation of resources' (Bouis, 1995a, p5). Nevertheless, the idea of biofortification – this time for micronutrients – resurfaced during the early 1990s following a series of international conferences, notably the 'Ending Hidden Hunger' conference in Ottawa in 1991, which concentrated the efforts of the international nutrition community towards micronutrient deficiency as a global problem (dela Cuadra 2000). A small network of scientists from

[2] Interview, HarvestPlus Advisory Board member, 18th September 2007.
[3] http://www.grandchallenges.org/IMPROVENUTRITION/CHALLENGES/NUTRIENTRICHPLANTS/Pages/Rice.aspx (11th May 2010).

within and outside the CGIAR began to form around the potential of breeding micronutrient-dense staple crop varieties[4]. Initially drawing on concepts and methods from 'food systems' research (Combs et al. 1996), these scientists envisaged a 'new paradigm' for agricultural research (Welch and Graham 1999) in which agriculture would be mobilised as 'an instrument for human health' (Graham 2002).

Rice biofortification research within the CGIAR during the 1990s and early 2000s was concentrated in two major initiatives: a regional iron rice research initiative coordinated by IRRI and involving national partners in South and Southeast Asia and the high provitamin A 'Golden Rice' project led by scientists from ETH, Zurich and Freiburg University. The iron rice initiative was initially supported by the CGIAR micronutrients project (1994-9) (Bouis et al. 1999), a modest, IFPRI-led initiative, sustained largely by the commitment of its coordinator and chief advocate, Howarth Bouis and later absorbed into a regional programme supported by the Asian Development Bank (ADB)[5]. Also in the early 1990s, a group of scientists from ETH, Zurich and Freiburg University, Germany secured funds from the Rockefeller Foundation[6] for a project which aimed to produce rice with elevated levels of provitamin A. Unlike trace elements such as iron and zinc, which are taken up by rice and other crop plans and therefore found, to a greater or lesser degree in the grain, vitamin A (in its precursor carotenoid forms), while present in many other crops, is largely absent from rice. So, while iron rice research at IRRI followed a conventional plant breeding route, the 'Golden Rice' project, as it became known, would chart a new course in transgenic rice research. In 1999, to the surprise of their donors and even the scientists themselves, they announced their achievement; a yellow-coloured rice strain with provitamin A in the endosperm (Ye et al. 2000).

Since that time, the role of 'Golden Rice' as the iconic science-policy controversy of the decade, routinely summoned by both sides in debates 'for and against' GM crops, has been extensively documented (Potrykus 2001; Nash 2001; Jasanoff 2005; BIOTHAI (Thailand) et al. 2001; Taverne 2007). These debates intensified with a transfer of ownership of the Golden Rice materials and technologies from the public institutions that had conducted the research, to the corporate sector, in this case the Syngenta

[4] Interview, Harvest Plus, 27th January 2006
[5] Improving Nutrition of Poor Women in Asia: Counterpart Project: 5945 - REG: Rice Breeding to Reduce Anaemia in Asia (2001-3). www.adb.org/documents/prf/nutrition.asp (10th November 2005).
[6] The Golden Rice research was funded by Rockefeller Foundation under the International Rice Biotechnology Programme (IRBP).

Company, justified as necessary in order to negotiate an unforeseen maze of intellectual property restrictions that threatened to block further progress (Potrykus 2001). Nevertheless, through an innovative series of institutional manoeuvres, the status of Golden Rice as a global public good was restored by means of a 'Humanitarian License' which would, under the guidance of a 'Humanitarian Board', allow public research institutions in developing countries free access to the proprietary technologies under certain conditions (Potrykus 2001; Toeniessen 2000). In 2001, the Golden Rice materials were finally transferred to IRRI, and the less glamorous task of back-crossing these materials into local *Indica* varieties began (IRRI et al. 2001).

These two early rice biofortification projects, IRRI-coordinated iron rice research and the Golden Rice project, have influenced the more recent, globalised programmes in markedly different ways. Both projects began with modest expectations of success and were open and exploratory in nature. In the case of iron rice research, plant breeders have often acknowledged the 'serendipitous' nature of the discovery, in the course of a rice breeding programme for marginal environments, of materials that seemed to fit the bill for the new biofortification project (Gregorio et al. 2000). Similarly, for the Golden Rice team their first breakthrough clearly same as a surprise (Potrykus 2001). Secondly, both projects have been credited with providing 'proof of concept' for the broader biofortification enterprise in some way. While a well-publicised 'feeding trial' in the Philippines provided 'proof of concept' that biofortified rice could produce a 'biologically significant effect'[7] on bodily iron stores in humans (Haas et al. 2005), the Golden Rice transformation proved it was possible to genetically engineer a beta-carotene biosynthetic pathway into rice endosperm (Beyer et al. 2002).

In 2003 the CGIAR launched a HarvestPlus (HarvestPlus 2004a), an ambitious global programme of biofortification research, and one of four pilot 'Challenge Programmes' under an institutional reform process taking place within the CGIAR at that time (Science Council 2006). Attention was again drawn to the 'new paradigm' that biofortification research represented. By this time, however, the food systems frame had been largely abandoned in favour of a more reductionist vision. HarvestPlus was to be a highly centralised operation which would set targets for generic, scalable, 'gold standard'[8]

[7] Interview, University of the Philippines, 21st June 2006.
[8] Interview, Harvest Plus, 17th January 2006.

technologies (CIAT and IFPRI 2002). While emphasising interdisciplinary collaboration, particularly with nutritionists, this was, first and foremost, a crop improvement programme which in which plant breeders retained their position at the apex of an evolving interdisciplinary hierarchy[9]. Later that year the Bill and Melinda Gates Foundation (BMGF), the largest donor of HarvestPlus, issued their own biofortification 'Grand Challenge', providing grants to four transgenic biofortification research projects. These included the ProVitaMinRice Consortium (PVMRC), an ambitious programme which would build on the Golden Rice project outputs and institutional framework to develop rice fortified with multiple nutrients[10] (Gates Foundation 2005).

Brokers or gatekeepers? Emerging hierarchies in research partnerships

The structure of programmes such as HarvestPlus and the PVMRC reflect the complexity of the problems they set out to address and the need, therefore, to engage in partnerships with institutions representing complementary areas of expertise. In this case, CGIAR centres were to exchange their traditional 'centre of excellence' status (Chataway et al. 2007) for a new role of 'broker' within complex, heterogeneous research networks (Rijsberman 2002). As discussed in the opening section, the Challenge Program model was designed with the needs of future 'strategic partnerships' with the transnational private sector in mind. In particular, 'longstanding principles of decentralisation and centre autonomy' within the CGIAR presented a barrier to more intense engagement with the private sector (IFPRI 2005:6). The underlying argument seems to have been that these new arrangements would provide a framework within which the CGIAR could sustain its identity as a source of public goods research, while actively pursuing public-private partnerships of various kinds.

Institutional innovations within the Golden Rice project have been highly influential in this respect. In the polarised debates surrounding Golden Rice these have been couched in terms of corporate control and manipulation (Nash 2001; BIOTHAI (Thailand) et al. 2001); an oversimplified interpretation that has clearly exasperated the central actors (Potrykus 2001). In between these entrenched positions, however, significant, if more subtle restrictive practices are being allowed to emerge and redefine 'business as usual'

[9] Interviews, nutritionists, 21st January, 2nd February and 28th March, 2006.
[10] http://www.grandchallenges.org/ImproveNutrition/Challenges/NutrientRichPlants/Pages/default.aspx (21st May 2009), www.goldenrice.org/Content2-How/how10_PVMRC.html (9th June 2007).

in international biofortification research. It is worthwhile at this point, therefore, to retrace some of the events taking place at the time these institutions were in formation.

When the Golden Rice inventors, Ingo Potrykus and Peter Beyer announced their breakthrough, they discovered a number of unforeseen private intellectual and technical property restrictions that threatened to block further progress. While a 'freedom to operate' review (Kryder et al. 2000) conducted by ISAAA for the project's donor, the Rockefeller Foundation, identified a range of options, retrospective accounts of developments taking place at the time highlight only one – a 'humanitarian use' option (Potrykus 2001). Under these arrangements, the Golden Rice technologies would be handed over to a private company, Zeneca (now Syngenta), which would license it back to the inventors under the terms of a 'humanitarian license'. This would allow public research institutions in developing countries to have access to and – crucially for IRRI and its NARS partners – conduct adaptive research and make Golden Rice available to farmers with an annual income below $10,000[11].

Two complementary institutional bodies were established: A 'Humanitarian Board', initially composed of the 'fathers of Golden Rice', Potrykus, Beyer, Adrian Dubock of Syngenta and Gary Toenniessen of the Rockefeller Foundation (now extended to twelve members including donors, scientists and the director of HarvestPlus[12]) would oversee the interpretation and implementation of the humanitarian license. A Golden Rice Network (GRN) would act as 'technology holder' and distribute the technologies and materials to applicants once such transfers had been approved by the Humanitarian Board[13]. While established as an independent structure, the GRN nevertheless included several of IRRI's traditional NARS partners. However IRRI's prescribed role as network 'hub' highlights more restrictive, top-down *modus operandi* than in the past in which vertical rather than lateral relations are emphasised:

> …whatever materials are available at IRRI are accessed for adaptive research by the different countries, and there is still no cross country relationship … it's a hub, and each spoke independently relating to IRRI. Vietnam will relate to IRRI, India will relate to IRRI, Philippines will relate to IRRI, Bangladesh will relate to IRRI. But there is no relationship between Vietnam and India, Philippines and India.[14]

[11] Interview, IRRI, 24th May 2006.
[12] For current membership of the Humanitarian Board see: http://www.goldenrice.org/Content1-Who/who1_humbo.html (24th May 2009).
[13] http://www.goldenrice.org/index.html (24th May 2009).
[14] Interview, IRRI, 5th December 2006.

The impact of these shifting relations has been far reaching, in the context of the increasingly porous boundaries between the Golden Rice, PVMRC and HarvestPlus programmes. Now described as 'an external advisory board'[15] the Humanitarian Board, originally formed for a specific purpose, to oversee the transfer and 'humanitarian use' of proprietary knowledge and materials has, over time, grown in size and broadened its mandate, first over the Golden Rice project, and now the PVMRC. Meanwhile, the structure and timing of meetings, which now link HarvestPlus with Golden Rice and the PVMRC, are indicative of continued mission creep. In practice, the networks supporting these projects are interwoven, with back-to-back meetings an inevitable logistical outcome, scheduled according to emerging hierarchies and overseen by an increasingly omnipresent Humanitarian Board, as the following account illustrates:

> Both HarvestPlus and the [PVMR] Consortium are governed by the Humanitarian Board in terms of research directions. During Consortium meetings and HarvestPlus meetings the Humanitarian Board is there as an R&D board. [These meetings are conducted] back-to-back: the HarvestPlus main meeting, then the Humanitarian Board meeting, then the Humanitarian Board meets each [Consortium member] at a time… We were advised what to present to them…then we were asked to leave…so they can discuss.[16]

Official HarvestPlus discourse highlights collaboration between complementary institutions and disciplines, with CGIAR centres uniquely placed to act as knowedge brokers. This account, however, emphasises that it is vertical, rather than lateral relations that characterise 'business as usual' within these research 'partnerships'. Furthermore, as the next section illustrates, interdisciplinary relations in practice are dominated by established knowledge hierarchies favouring plant genetics and neo-classical economics. In this case, the nodal position of IRRI in linking upstream and with downstream actors; and 'new' disciplines such as human nutrition with the 'classic cluster' of crop sciences (Anderson et al. 1991), allows the role of broker to be transformed into that of gatekeeper. Meanwhile, national scientists find themselves increasingly marginalised, despite the new influx of funds. As one observer noted:

> 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 … CG mentality is "*we are the centres of excellence*"[17]

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[15] www.goldenrice.org/Content2-How/how10_PVMRC.html (9th June 2007).
[16] Interview, NARS Scientist, 16th January 2007.
[17] Interview, nutritionist, 28th March 2006 (original emphasis).

Has the CGIAR come full circle, with its centres returning to their traditional 'centre of excellence' role? If so, this would confirm concerns that centre directors might 'block change by trying to use the CPs to raise new resources while holding onto old mandates and activities' (Eicher and Rukuni 2003:24). In practice, however, these dynamics are part of a more complex story, in which shifting institutional and programme boundaries are allowing more room for manoeuvre for some actors than for others. What is clear, however, is that intensified upstream scientific and institutional complexity and ambiguity is drawing attention further away from downstream realities in all their complexity and diversity. These dynamics are compounded and obscured by the selective use of disciplinary lenses, in ways that are explored in the next section.

The view from upstream: constructing 'use', 'demand' and 'impact'

This recasting of the 'new paradigm' that biofortification represented, from a systemic to a reductive frame, reflected global shifts that had been taking place at that time. As discussed in the opening section, despite its many shortcomings the MDG framework has become entrenched as the single overarching framework for the evaluation and justification of international development initiatives of all kinds (Saith 2006). With reference to this framework, improved nutrition has been singled out as a key input to ensure the achievements of global development targets (Jeffrey Sachs, in SCN 2004b), intensifying trends towards what has been called 'goal-oriented nutrition' (Gillespie et al. 2004). Similarly, the philosophy of the BMGF (and other 'philanthrocapitalists' (Edwards 2008)) emphasises the power of breakthrough science to solve intractable global problems. In this case, an inbuilt predisposition towards reductionism within the CGIAR has been reinforced by broader trends towards reductive, generic, centralised approaches to international nutrition and development. This was reinforced in 2004 when an 'expert panel' of influential economists produced the 'Copenhagen Consensus', which ranked a series of projects according to their cost-effectiveness on a global scale. 'Providing micronutrients' was ranked second only to 'control of HIV/AIDS'.[18]

The disproportionate influence of a group of neo-classical economists on the level of global attention paid to nutrition is telling. Similarly, an economistic vision has shaped a particular approach to impact assessment and 'reaching end users' within biofortification initiatives. However, the sophistication of these economic analyses obscures their

[18] www.copenhagenconsensus.com (18th March 2008).

reliance on simple causal pathways linking induced changes in 'consumer choice' with positive health outcomes and economic impacts (Zimmerman and Qaim 2004; Stein et al. 2005), using the 'standard' epidemiological unit of the disability adjusted life year (Stein et al. 2005:8). Beneficiaries - and their needs - are *constructed* around an imagined future product; as passive 'populations at risk'[19] from malnutrition-related disease, or as aggregates of individual consumers who might be induced to make more 'rational' choices about which crop varieties to plant or consume. In this case, the Challenge Program functions as a 'centre of calculation' (Latour 1987), simplifying and streamlining diverse manifestations of 'use', demand' and 'impact' and crafting them into a rationale for products already in the pipeline. These constructions provide reassurance to upstream actors about the soundness of decisions already made, as well to donors attracted by the impact projections and high absorption capacity of these large research consortia. At the same time, they divert attention away from understanding the diversity of ecological, social and cultural conditions with which biofortified varieties will interact and, ultimately succeed or fail - even though the pitfalls of such an approach were spelt out in the early days of the CGIAR micronutrients project:

> [T]he 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 1995:21).

This effective separation of impact from context has particular implications for biofortification research, which within today's globalised programmes recombines the reductive frames of two hegemonic disciplines - plant genetics and neo-classical economics – marginalising contributions from other social *and* natural sciences. Both disciplinary perspectives incorporate assumptions of scale neutrality which enable them to construct problems, solutions and beneficiaries in a particular way – one that is equally attractive both to science-policy strategists making the case for agricultural research outputs as GPGs and donors in search of simple, 'silver bullet' solutions. The calls for greater attention to site specificity and context responsiveness made both by nutritionists such as Calloway as well as agronomists within the CGIAR and NARS[20] are a poor match for these claims for 'impact at scale' in an era of GPG-oriented research.

[19] The CGIAR Biofortification Challenge Programme: Shared Solutions to Global Problems, World Bank Human Development Network Briefing, 13th March 2003 www.ifpri.org/events/seminars/2003/20030313_briefing.htm (January 2004).

[20] Interviews, IRRI and PhilRice, June 2007.

The visualisation of biofortification as a public health intervention comparable to water fluoridation is a case in point:

> The [required nutrients] will get into the food system much like we put fluoride in the water system. It will be invisible, but it will be there to increase intakes'.[21]

This framing locates biofortification in the 'best shot' category of GPG, 'where the largest contribution solely determines the good's overall level, and lesser action is redundant' (Sandler 2006:152). It is clear, however, that the 'best shots may have much to learn from the 'lesser actions'. However, this would require interdisciplinary engagement in which scale assumptions embedded in particular disciplines are acknowledged and debated in relation to their relevance to the problem at hand. Literature that cites biofortification research within the CGIAR as a GPG is notably silent on this issue (Dalrymple 2008:364). This is not surprising, since public goods frameworks do not take account of the kind of cross-scale dynamics that mediate the impact of global programmes such as biofortification research on people in diverse environments.

Conclusion: science, diversity and the public good

Is international agricultural research a global public good; and can this claim be sustained in an era of public private partnerships? The case of biofortification presented here suggests that perhaps this is the wrong question. This paper has highlighted processes of simplification and convergence inherent in maintaining complex globalised research networks which are expected to generate 'cutting edge research' as well as demonstrate attributable impact within the constraints of a 'time bound' programme. These expectations and pressures undermine the potential of science as a public good as conceptualised by Callon (1994). According to Callon, science is a public good if and when it is a source of diversity, irrespective of the institutional location of the actors involved. Conversely, 'private science' is science that leads to commodification and 'lock in':

> Science is a public good when it can make a new set of entities proliferate and reconfigure the existing states of the world. Private science is the science that firms up these worlds, makes them habitable. That is why public and private science are complementary despite being distinct: each draws on the other. This definition is independent of the identity of the actors involved (Callon 1994:23).

[21] http://www.worldfoodprize.org/assets/symposium/2005/transcripts/Bouis.pdf (9th January 2009).

At present, biofortification research as practiced within global research networks discussed in this paper is not benefitting from such complementarity. Rather, both public and private actors are increasingly locked into a mode of operation whose outputs exemplify what Callon calls 'private science'. But what is the nature of the world that this science 'firms up' and makes 'habitable'? As Fernandez (2007) has highlighted, such questions about the 'capital in agriculture' are rarely posed, even by noted critics of the increasingly narrow disciplinary base of the CGIAR. As discussed in the previous section, a hegemony of disciplines that share largely unexamined assumptions about the scale neutrality and universality of the knowledge and artifacts they generate compounds a lack of accountability towards national institutions and 'partners'. Of particular concern is the lack of engagement with health ministries in target countries[22] regarding what is ultimately 'a health intervention, using food as an intervention to administer extra nutrients'.[23] Instead, the attention of these global actors is focussed upstream; and on maintaining the alliances necessary to secure continued financial and institutional support.

A notable feature of the language used by proponents of biofortification as a global project is the proliferation of 'boundary terms' (Gieryn 1999) such as 'new paradigm', 'gold standard' and 'proof of concept'. The normalisation of such terms within a scientific research context has been rapid and apparently unproblematic, perhaps due the CGIAR's unusual position as a 'mission oriented' research institution (Anderson et al. 1999). The ubiquity of the term 'proof of concept' across a range of peer-reviewed, scientific articles on biofortification is a case in point (for example see Beyer et al. 2002: 510s, Toenniessen 2002: 2946S). Such terms perform an inherently political function: a function obscured by their ostensibly 'technical' character. In particular, their employment serves to downplay the uncertainties and ambiguities that inevitably emerge from the conflicting interests, agendas and disciplinary framing assumptions that lurk behind the 'consensus' presented by globalised research networks.

With 'scaling up biofortification' written into CGIAR plans for the coming years (von Braun et al. 2008); these dynamics can be expected to intensify. Given the inbuilt tendencies and external pressures towards reductionism described in this paper, the

[22] Interview, nutritionist, 26th March 2006.
[23] Interview, WHO, 14th March 2006.

question is how to create and protect spaces for a 'public goods' science which engages with social, cultural and agro-ecological diversity. Recent reflections on the social and political dynamics of the International Assessment of Agricultural Knowledge Science and Technology for Development (IAASTD) may provide lessons in this regard (Feldman et al. 2010, Scoones 2010); in particular, the backdrop provided by the 'antagonistic politics' (Scoones 2010: 568) of competing interests and associated 'epistemic communities' (Haas 1992) that were unlikely to reach a meaningful 'consensus'. Meanwhile, the uncritical acceptance of biofortification as an exemplar of global public goods research as a way forward for the CGIAR suggests that a far more searching examination of the role and responsibility of the system *vis a vis* science for the public good has yet to take place.

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