

Integrating a broader notion of food security and gender empowerment into the African Green Revolution

Joel Negin · Roseline Remans · Susan Karuti ·
Jessica C. Fanzo

Received: 13 April 2009 / Accepted: 11 June 2009

© Springer Science + Business Media B.V. & International Society for Plant Pathology 2009

Abstract A Green Revolution for Africa is emerging after decades of neglect of Africa's agricultural systems. To counter these years of neglect, the then United Nations Secretary-General Kofi Annan called for "a uniquely African Green Revolution". Since then, a number of initiatives have emerged or are emerging to realize this important vision. As more money and attention galvanizes much-needed action on the African Green Revolution, a vigorous debate is required to ensure that the mission of improving food security on the world's poorest continent is achieved in the most effective, comprehensive and inclusive manner possible. The African Green Revolution cannot be limited to increasing yields of staple crops but must be designed as a driver of sustainable development, which includes gender empowerment and nutrition elements. This paper first reviews the Asian Green Revolution's successes and shortcomings from a nutrition and gender perspective and then outlines what the global community can do to ensure that some of the limitations of the Asian Green Revolution, specifically with regard to nutrition and gender, are not repeated.

Keywords Nutrition · Agriculture · Green revolution · Gender · Food security

Introduction

A Green Revolution for Africa is emerging after decades of neglect of Africa's agricultural systems. While Asia and Latin America dramatically increased their agricultural productivity over the past 40 years, Africa's agricultural growth stagnated due to high transport costs, poor infrastructure, low levels of fertilizer use and the dismantling of public agricultural institutions for research, extension, credit and marketing (Denning et al. 2009; UN Millennium Project 2005). To counter these years of neglect, the then United Nations Secretary-General Kofi Annan called for "a uniquely African Green Revolution" (2004). Since then, a number of initiatives have emerged or are emerging to realize this important vision. Such initiatives include the Alliance for an African Green Revolution and a proposed Global Fund for Smallholder Agriculture (Sanchez et al. 2009; Ideas Foundation 2009).

As more money and attention galvanizes much-needed action on the African Green Revolution, a vigorous debate is required to ensure that the mission of improving food security on the world's poorest continent is achieved in the most effective, comprehensive and inclusive manner possible. Early activities suggest that the efforts being developed to put the African Green Revolution into action are focusing predominantly on increasing staple food productivity and access to markets. This focus is in response to chronic food shortages and extreme poverty in rural areas. However, as in the Asian Green Revolution, critically important components of agricultural systems—specifically gender and nutrition—should be integrated to ensure the

J. Negin (✉)

School of Public Health, University of Sydney,
Edward Ford Building (A27),
NSW 2006 Sydney, Australia
e-mail: jnegin@health.usyd.edu.au

J. Negin · R. Remans · J. C. Fanzo
The Earth Institute at Columbia University,
New York, NY, USA

S. Karuti
The MDG Centre, East and Southern Africa,
Earth Institute at Columbia University,
Nairobi, Kenya

long-term success of the endeavor. The African Green Revolution cannot be limited to increasing yields but must be designed as a driver of sustainable development. As the systems to support the African Green Revolution are being developed, gender and nutrition elements should be integrated from the beginning to ensure that the “Revolution” achieves what Kofi Annan called for: “the rural and agricultural transformation of our beloved continent.” (2004)

The paper first provides a definition of food security that serves as a guiding framework. Then, because the Asian Green Revolution is the most obvious guiding model for the African Green Revolution, the paper reviews the successes of the Asian model as well as its complex shortcomings with regard to nutrition and gender. The next section introduces the African Green Revolution concept and outlines initial activities to support its implementation. The final sections outline what the world community can do to ensure that some of the limitations of the Asian Green Revolution are not repeated and that the new Green Revolution can truly achieve its desired goals in Africa.

Defining food security

According to the definition agreed at the 1996 World Food Summit, food security exists when all people at all times have both physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life (USAID 1992; FAO 1996). This definition focuses on three distinct but interrelated elements that are essential to achieving food security: *food availability* (sufficient quantities available for consumption); *food access* (adequate resources to obtain appropriate foods for a nutritious diet); and *food utilization* (proper biological use of food, a diet providing sufficient energy and essential nutrients, potable water and adequate sanitation, as well as knowledge of food preparation, basic principles of nutrition, proper child care and illness management) (USAID 1992; Fig. 1). Quisumbing noted the central role of nutrition in a comprehensive conception of food security asserting that it “adds the aspects of caring practices and health services and healthy environments to this definition and concept. This aims at what is more precisely called ‘Nutrition Security’, which can be defined as adequate nutritional status in terms of protein, energy, vitamins, and minerals for all household members at all times” (1995). In further defining and understanding food security, Pinstrip-Andersen wrote that “food security is a valuable concept if used with a clear understanding of what it means, its limitations, and how it interacts with behavior and non-food factors. Estimates of household food security, combined with individual anthropometric estimates for children and a thorough understanding of household behavior provide a powerful input into the design and

implementation of policies and programs to improve nutrition” (2009). Without considering the various influencing factors of food security, including social elements, the achievement of the World Food Summit’s definition of food security will be limited.

The Asian Green Revolution

Increasing food security and production—economic and technological growth

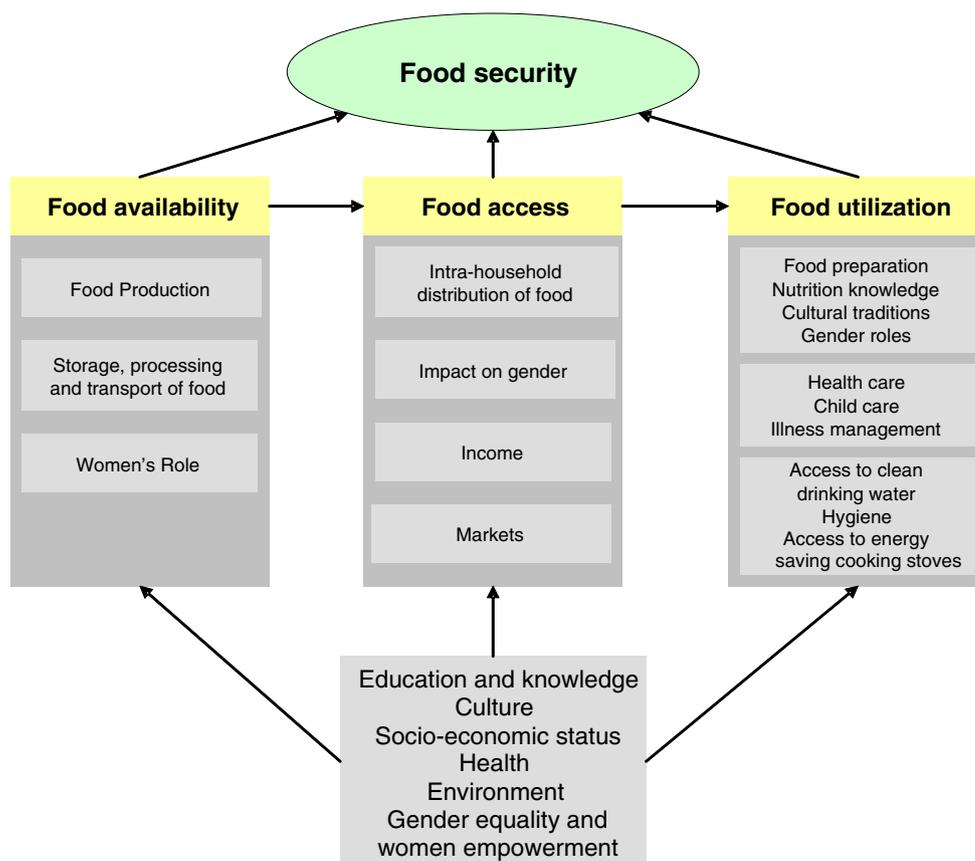
The 1960s was a decade of despair with regard to the world’s ability to cope with the food—population balance, particularly in developing countries. Most of the lands suitable for agriculture in Asian countries had been cultivated while population growth rates accelerated, owing to the rapidly declining mortality rates that resulted from advances in modern medicine and health care. Massive starvation was predicted and international organizations and concerned professionals raised awareness of the ensuing food crisis and mobilized global resources to tackle the problem (Paddock and Paddock 1967; Khush 2001a).

Fortunately, large-scale famines and social and economic upheavals were averted, thanks largely to the marked increase in cereal grain yields in many Asian developing countries that began in the late 1960s (Evenson and Gollin 2003; Swaminathan 2006). This phenomenon—coined the ‘Green Revolution’—was due largely to the development and widespread adoption of genetically improved high-yielding varieties of cereal crops that were responsive to the application of advanced agronomic practices, including most importantly, fertilizers and improved irrigation (Khush 2001a; Swaminathan 2006).

The Green Revolution had a tremendous impact on food production and socio-economic conditions. Between 1966 and 2005, food production in South Asia increased by 240% (FAOSTAT 2009). Applying advanced technology to high-yielding varieties of cereals caused the marked achievements in world food production. The gradual replacement of traditional varieties of rice, maize and wheat—crops which account for almost 50% of calories in most diets—by improved varieties, and the associated improvement in farm management practices, had a great effect on the growth of rice, wheat and maize output, particularly in Asia. For example, since the first high yielding variety of rice was released in 1966, the rice area harvested in South Asia increased by only 25%, whereas the average rice yield increased by 240% from 1966 to 2007. During the same period, daily caloric intake per capita improved on average by approximately 25% in South Asia (FAOSTAT 2009).

The increase in per capita availability of cereals and a proportional decline in the cost of production contributed to

Fig. 1 Food security and its determinants



a decline in the real price of rice, wheat and maize in international and domestic markets. This, when adjusted for inflation, was 40% lower in 2000 than in the mid-1960s (World Bank 2000; Khush 2001b). The decline in food prices benefited both the urban poor and the rural landless (Khush 2001b; Evenson and Gollin 2003; Swaminathan 2006).

In this way, the Green Revolution was able to address *food availability* challenges. The widespread adoption of high-yielding varieties has helped most Asian countries to meet their growing food needs from productive lands and has reduced the pressure to open up more fragile lands. Had 1961 yields still prevailed today, three times more land in China and twice as much land in India would have been needed to equal 1992 cereal production and this would have had disastrous consequences for forests, woodlands and other wildlife habitats (Swaminathan 2006).

The case of nutrition in the Asian Green Revolution

Despite its achievements, the Asian Green Revolution did not solve all food and nutrition security issues partly because the efforts emphasized the *food availability* component of food security over the *food access* and *food utilization* components, resulting in the neglect of core nutrition elements. Although massive efforts were taken to

decrease hunger in India, 50% of children across South Asia continue to suffer from undernutrition (UNICEF 2009; Von Braun et al. 2008). In India, child malnutrition is responsible for 22% of the country's burden of disease with the prevalence of underweight among children in India being amongst the highest in the world—nearly double that of sub-Saharan Africa (UNICEF 2009) (Fig. 2).

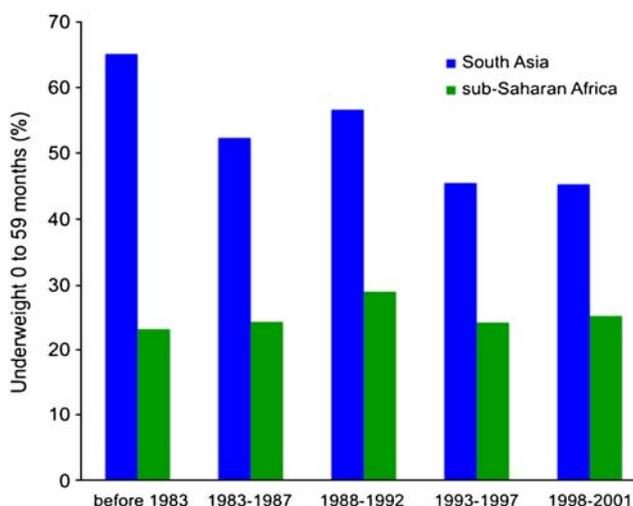


Fig. 2 Percent underweight of children 0 to 59 months in South Asia and Sub-Saharan Africa (adapted from Mason et al. 2005)

There are several hypotheses about how the Green Revolution may not have addressed food and nutrition security for some people. Some economists have argued that because market-purchased inputs are required, only resource rich farmers were able to take full advantage of high-yielding cultivars (Swaminathan 2006). Likewise, a number of environmentalists emphasized that excessive use of fertilizers and pesticides, as well as the monoculture of a few crop cultivars, created serious environmental problems, including the breakdown of resistance and the degradation of soil fertility (Swaminathan 2006). Another hypothesis involves the shift in the use of cropland from subsistence cropland towards production of grain for income and/or animal feed. For example, the Green Revolution replaced much of the land used for pulses that fed Indian peasants, with wheat. With a significant increase in production of cereal grains in the Asian Green Revolution came a narrowing of the food base, in which only three crops—maize, wheat and rice—supply the bulk of the protein and energy needs for the region—thus contributing to poor diet diversity (Frison et al. 2006; Graham et al. 2007). Many of the secondary food grains such as pulses, which are major sources of protein in vegetarian Indian diets, as well as millets such as sorghum, pearl millet, and finger millet, which serve as staples in dryland areas and are rich in micronutrients, were underemphasized, leading to elevated incidence of micronutrient deficiencies and malnutrition (Bamji 2007). Simplified, grain-based diets can also cause overnutrition, leading in part to the prevalence of diabetes in Indian urban areas being about 6% (Shetty 2002; Popkin 2008).

While one widely-held assumption is that lack of food is the primary or even sole cause of malnutrition, even though India achieved sufficiency in cereals at the national level, household and individual nutrition security remained elusive (Bamji 2007). Other *food access* and *food utilization* factors such as healthcare, childcare and food quality directly impact food and nutrition security. In India, child malnutrition is mostly the result of high levels of exposure to infection and inappropriate infant feeding and caring practices and has its origins almost entirely during the first 2 to 3 years of the child's life.

The case of gender equality in the Asian Green Revolution

Traditional agriculture has been dominated by women and it is women who hold much of the traditional agricultural knowledge in many parts of the world, particularly in South Asia. With the introduction of the Asian Green Revolution emphasizing high yielding seeds, chemical fertilizers and mechanization, female-dominated traditional agriculture and knowledge was underemphasized and some women were displaced from their traditional roles (IFPRI 2002).

IFPRI noted that small farmers, the majority of whom are women, lagged behind large farmers in adopting Green Revolution technologies (2002) and were often excluded from technology-based agriculture, leading to their marginalization. This resulted in the removal of land, water and forests from women's control and management (Sobha 2007). While traditional agricultural technologies, though ecologically sound, were unable to meet the food needs of high population growth, some have claimed that the Green Revolution was responsible for the 'feminisation' of poverty in Indian communities (Shiva 1992).

Despite increases in crop production, the malnutrition rates among women and children did not improve substantially, partly due to a failure to address cultural practices relevant to *food access*, such as a lack of women's empowerment and distribution of income within households that favored men (Von Braun and Kennedy 1986; Von Braun et al. 1989). Filmer and colleagues noted that gender disparity in South Asia is apparent and variable, but not correlated with levels of income or poverty (1998). In South Asia, by tradition, women tend to eat last and eat least (IFPRI 2002). Often men and boys consume as much as twice as many calories—even though women and girls do much of the heavy work (Chen et al. 1981). This gender disparity does not only relate to nutrition choices at the household level but also agricultural choices. In one Indian study male-children dominated households were found to have increased purchases of inputs, usage of labor and land size as compared to households dominated by female children (Bhagowalia et al. 2007).

Poor female nutrition early in life reduces learning potential, increases reproductive and maternal health risks and lowers productivity. This situation contributes to women's diminished ability to gain access to other assets later in life and undermines attempts to eliminate gender inequalities. In South Asia, child mortality is 30–50% higher in females than males indicating that gender disparity in health and education is also an issue early in life (Filmer et al. 1998). In essence, women with poor nutrition are caught in a vicious circle of poverty and undernutrition (Oniang'o and Mukudi 2002). While the Asian Green Revolution has had positive impacts in education (Kajisa 2008; Quisumbing et al. 2004) and access to micro-finance, the potential effect of the interventions may have been muted by persistent gender inequalities.

The new African Green Revolution

Despite the public investment-led model that led to Asia's significant agricultural accomplishments, donors to Africa throughout the 1970s and 80s asserted that the continent's

agricultural transformation would be driven solely by market forces. During this time, overseas development assistance targeted to agriculture declined from 17% in 1980 to 3% in 2005 and there was a similar drop in agricultural research investment (FAO 2008). The emphasis on the market and the dismantling of public institutions led to a neglect of smallholder production. This agenda led to a significant policy and development failure whereby most African countries saw agricultural yields stagnate (Fig. 3).

Since 2004, there has been a fundamental shift in support of an active and collaborative initiative, which is science-based, to increase the scale of agricultural productivity in Africa—the African Green Revolution. That year, in a meeting of African Heads of State, the then UN Secretary-General Kofi Annan called on the global community: “Let us all do our part to help Africa’s farmers and their families take the first steps out of chronic poverty and to help societies to make a decisive move towards balanced and sustainable development. Let us generate a uniquely African Green Revolution—a revolution that is long overdue. And let us never again allow needless hunger to ravage lives and the future of the Continent” (2004). Annan explicitly confronted the complexity of hunger in Africa, acknowledging “the interconnected challenges of agriculture, health, nutrition, unfair market conditions, weak infrastructure and environmental degradation” and recognized the importance of integrating gender stating that “a green revolution in Africa will happen only if it is also a gender revolution.” (2004)

The African Green Revolution that emerged from Annan’s speech calls for supporting African smallholder farmers with vital agricultural inputs including fertilizer, high-yielding seed, water management and training (UN Millennium Project 2005; Sanchez and Swaminathan 2005; Sanchez et al. 2009). The drive to improve African agriculture has secured high level support from around the world. The World Bank, despite its decades-long neglect of

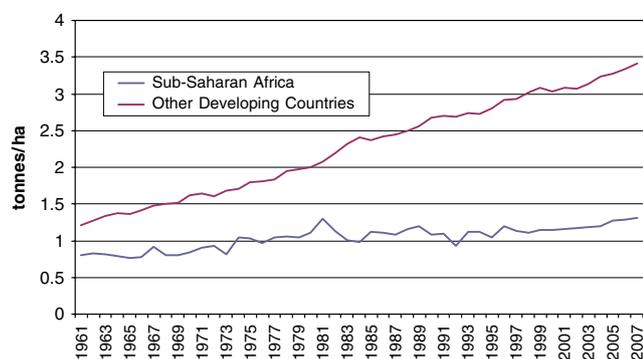


Fig. 3 Increase in cereal yields in tonnes per hectare in Sub-Saharan Africa compared with the rest of the world’s developing countries (including Asia, South-America and North Africa), 1961 to 2007 (FAOSTAT 2009)

African agriculture, advocated greater investment in smallholder farming in its 2008 World Development Report and has set aside substantially increased funding (World Bank 2007). At the urging of governments in food-insecure countries, donors have also discussed a special fund for smallholder agriculture culminating in a call for a Global Fund for the African Green Revolution (Oslo 2007; Bellagio Working Group 2009). Additionally, the spike in food prices in 2008 encouraged a greater sense of urgency in developing effective programs and mobilizing resources to improve agricultural productivity. More recently, the Obama administration announced a doubling of support for agricultural development in developing countries (White House 2009).

An important step in the push for increased agricultural productivity was the establishment in 2006 of the Alliance for an African Green Revolution (AGRA) with funding from the Rockefeller Foundation and the Bill and Melinda Gates Foundation, which was chaired by Kofi Annan. With investments of \$500 million over 5 years, AGRA is aiming to revitalize smallholder agriculture by focusing on improved seeds, soil health, agricultural education, access to water for irrigation and strengthened markets (AGRA 2009a).

AGRA is commendably focused on some of the greatest challenges facing African agriculture acknowledging that the obstacles “start in the field and extend across the entire agricultural value chain.” (AGRA 2009b) AGRA is also committed to local solutions and to fairness declaring that “this agricultural revolution must rely on uniquely African solutions to uniquely African problems... It must be pro-poor and pro-environment” (AGRA 2009b).

The challenges facing the African Green Revolution

With such positive momentum and substantial funding commitments, the African Green Revolution is following in the footsteps of the Asian Green Revolution. There is an opportunity to learn from the lessons that emerged from the Asian model in order to ensure an African version that acknowledges and integrates Kofi Annan’s interconnected challenges and has a significant pro-poor and wide-ranging impact on African development. This will require the development of an African Green Revolution that integrates a broader conception of food security.

The majority of Africa’s farmers are women and it is they who drive agricultural production. Women are responsible for 70% of staple food production in Africa (Saito and Weidemann 1990) and women contribute 60–80% of the labor used to produce household and cash crops (FAO 1995). Despite the central role of women in agricultural production and despite Kofi Annan declaring that “women

are on the frontlines,” (2004) gender is not an explicit focus of AGRA’s activities nor is it included among the eight priority areas. AGRA’s website does note that “individual farmers, women’s associations and farmer unions are key partners” (2009a) but a greater direct focus on women’s access to agricultural inputs will be needed to ensure success.

An emphasis on markets, inputs and investment, while critical to increasing agricultural productivity, runs the risk, as it did in Asia, of limiting the impact of the revolution on women. To realize equitable impact, women need to be explicitly included in efforts to increase agricultural productivity as it is they who perform the majority of agricultural labor, and it is they who are most impacted by food and cash shortages due to imbalances in intra-household distributions (Dey Abbas 1997). Quisumbing noted that when women obtain the same levels of education, experience and farm inputs that currently benefit the average male farmer, women increase their yields for maize, beans and cowpeas by 22% (1996).

Empowering women through agriculture has the potential to have cascading effects through households and communities due to women’s role as managers of daily life including health, education and market activity. Increasing assets in the hands of women tends to lead to greater spending on education and child welfare (Quisumbing and Maluccio 2000; Oniang’o and Mukudi 2002). Smith and Haddad (2000) have shown that by providing women with education and improving *food availability* as well as *food access*, there is a direct reduction in malnutrition and overall health improvement of children under five. The authors note that in sub-Saharan Africa, the deterioration of women’s relative status and per capita national income, as well as stagnations in women’s education and food availability, are all partly responsible for the lack of improvement in child malnutrition.

As with the Asian Green Revolution, some of the calls for an adapted African version neglect nutrition leading to the risk of sustained high levels of undernutrition amidst increased yields. The recent Windhoek High-Level Declaration on African Agriculture firmly threw its support behind an African Green Revolution with a call for a diverse, multi-sectoral push for sustainable development but did not mention nutrition (Windhoek 2009). Likewise, the focus areas of the US government’s proposed doubling of resources for agricultural development do not include nutrition or gender (White House 2009). AGRA’s 2009 plan calls for investments in improving crop storage, finance systems, market information and transport systems. These important scientific investments would benefit from an emphasis on diversification and household nutrition. While investments in water, soils and seeds will increase productivity, greater emphasis on ensuring that diverse and nutritious foods are produced and that poor households

are able to access such foods would be very beneficial and could have synergistic positive impacts into economic growth, health and education.

The meeting of the Bellagio Working Group for the African Green Revolution fund, held in February of 2008, asserted that “higher agricultural productivity is only a part of the solution to any of these challenges. The fight against hunger depends not only on increased food supplies and higher rural incomes but also on gender equity, micronutrient sufficiency, de-worming, community awareness and capacity building... and targeted programs aimed at pregnant mothers, young children and school-aged children.” If nutrition is to be taken seriously as an integral part of the Revolution, robust and sustainable funding of nutrition programs needs to be put into place at the same time as the agricultural sector is financed.

Two other factors make the achievement of an African Green Revolution more difficult than that of Asia and therefore need to be considered and integrated into early planning. One factor, the HIV epidemic, is having a significant impact on Africa’s agricultural systems by “undermining rural household production, contributing to declining agricultural output and affecting the very integrity of families and their sustainability as viable units” (Baylies 2002). HIV illness limits agricultural labor both for those affected and for carers (Fox et al. 2004; Negin 2005; Hawkes and Ruel 2006). HIV also changes household spending and investment decisions with Rwandan and Kenyan studies demonstrating reduced investment in farm products and the sale of agricultural assets to pay for health care (Donovan et al. 2003). HIV has been shown to lead to a shift away from high-intensity products such as cash crops and vegetables to more easily cultivated crops such as cassava and yams (Yamano and Jayne 2004). This shift has a dramatic effect on nutrition with a move away from protein-rich foods and varied diets to starchy, carbohydrate-rich foods. Overall, HIV has caused reduced agricultural output, leading de Waal and Whiteside to associate the HIV epidemic with the southern African famine of the 1990s (2003).

Gender and nutrition sit at the center of this complex reality. Women are most impacted by the epidemic in Africa as well as by the changes to household spending and agricultural decision-making. The HIV epidemic has increased the responsibilities of women in rural areas for productive and care work. People living with HIV have greater nutrition needs thus highlighting the importance not only of agriculture and food but of nutrition specifically (Kotler 2000). The multi-faceted health and development challenges brought on by Africa’s HIV epidemic threaten the goals of the African Green Revolution.

The other distinct challenge facing the African Green Revolution is climate change. Climate change also has the potential to dramatically exacerbate food security chal-

allenges, particularly in Africa's difficult and mostly rainfed agro-ecological conditions. Changes in rainfall and temperature will profoundly affect agricultural systems in Africa highlighting the need to build adaptation strategies into Green Revolution initiatives. The impacts of climate change will vary across the continent with increased desertification in the Sahel, increased rainfall in some areas, and longer drought periods in others—all negatively impacting crop yields with some predictions of 15% cereal yield losses (Battisti and Naylor 2009; Christensen et al. 2007; Ngaira 2007; Fischer et al. 2005; Funk et al. 2008). Additionally, temperature increases are likely to lead to an increased incidence of pest attacks and will also reduce soil fertility (Stockholm Environment Institute 2008). Overall, climate change will weaken food security and will exacerbate poverty across the continent.

Integrating a broader notion of food security and gender empowerment into the African Green Revolution

The African Green Revolution is a critical initiative that must succeed. In order to truly build a platform for sustainable rural development, a holistic approach—which integrates *food availability, access and utilization* and explicitly includes gender and nutrition determinants—needs to be integrated into its early initiatives and throughout national agriculture policies. While acknowledging that strengthened agricultural markets, greater access to fertilizer and improved seed varieties are all critical, such a focus can lead to persistent gender and nutritional inequalities that may perpetuate the poverty trap for the poorest. The Green Revolution, as expressed in some documents, rightly emphasizes a cross-sectoral approach, including environmental considerations, land management, trade and technology transfer but the scope of the endeavor must be widened to include nutrition and gender (Denning et al. 2009). Collaboration among sectors at the community, science and policy level, particularly ministries and governments on the continent, as well as donors, is necessary to enhance synergies and tackle tradeoffs between agriculture, nutrition and gender.

With sustainable funding of food-based nutrition programs, specific nutrition interventions could be rolled out with agricultural-focused Green Revolution projects. Though raising smallholder agricultural productivity increases incomes and allows families to purchase more food, farmer-focused initiatives focusing on the production side can also improve diet diversity and the associated micronutrients lacking in the diet of sub-Saharan populations (Fanzo and Haddad 2009). Such initiatives include promotion of homestead gardens to increase dietary diversity

of non-cereal food sources, which are micronutrient-rich, in conjunction with small animal rearing. These have an even greater impact on the household consumption of animal and higher quality plant products because of the direct availability of those products in the household and their potential to provide additional income (Helen Keller International 2004).

The introduction of food legumes to farming systems—as AGRA has started doing—improves soil health through nitrogen fixation and increases protein and micronutrient intake in the diet. Food legumes may also provide an additional source of cash income for smallholders. Biofortification technology and introduction of nutrient rich foods such as orange-fleshed sweet potato increased Vitamin A intake and serum retinol concentrations in young children in rural Mozambique (Low et al. 2007). Biofortification of seeds—the breeding of crops with high amounts of minerals and vitamins in their seeds—is another high impact nutrition intervention (Welch and Graham 2002). Under certain soil conditions, the use of micronutrient fertilizers, in balanced combination with macronutrient fertilizers, has shown promising potential to increase production, disease resistance, stress tolerance, and nutritional quality of crops (Graham et al. 2007; Graham 2008). The increase in yield from use of micronutrients deficient in the crops, notably zinc and boron, should compensate their cost and can also make the use of macronutrient fertilizers more cost effective as a package of balanced nutrients (Graham 2008).

Women are the bedrock of Africa's agricultural future and progress towards a more sustainable and equitable future for Africa will be determined significantly by the attention given to women farmers. AGRA grants and other mechanisms should ensure that women gain access to inputs, training and opportunities and are not displaced from their leading agricultural role. Land rights remain a substantial barrier to women's agricultural progress in Africa. Guaranteeing equal access to control over land will allow greater long-term investment in farms with the knowledge that investments are secure (Gray and Kevane 1999; Doss and Morris 2001). Women should be encouraged to participate in agricultural income management programs and microfinance opportunities. These actions will not only involve more women but will have substantial benefits for the social and economic development of African communities, thus accelerating the African Green Revolution's ultimate goal of a rural transformation (Oniang'o and Mukudi 2002). The Gender & Diversity Program of the Consultative Group on International Agricultural Research is a positive example of an initiative working towards these goals.

Addressing HIV is critical to improving agricultural systems in Africa. Getting HIV-positive individuals on treatment has been shown to at least double the number of days per month that HIV positive farmers can work in their

fields (Larson et al. 2008). Assisting women with securing land ownership in the face of male head of household death and assisting women with skills needed to farm cash crops can also mitigate the impact of HIV and AIDS. Agriculture can also play a positive role in integrating HIV-positive people back into their communities (Siika et al. 2005).

In order to mitigate the worst impacts of climate change, ensuring that drought-resistant crops are integrated into African Green Revolution initiatives is essential. Building in weather-related crop and livestock insurance can protect farmers from the increasing likelihood of adverse weather effects (Negin and Denning 2008). Focusing on agroforestry and tree crops can also help to mitigate the effects of climate change through carbon sequestration. Current communication and information systems, including mobile phones and the internet, offer great opportunities for improving farmers' access to updated information on climate conditions. Women play a major role in the management of natural resources in rural communities and should be included in these environmental responses (Sobha 2007). Unless such actions are integrated into African Green Revolution efforts now, Africa's agricultural vulnerabilities and especially those of female farmers will be exposed in the coming years.

The momentum generated by the African Green Revolution to date is remarkable and much needed. As the push for these critical changes gains strength, the opportunity to design mechanisms that can truly strengthen African families, communities and countries cannot be missed.

Acknowledgments The authors are grateful for the comments on the manuscript by and support of Glenn Denning.

The authors declare that they have no conflict of interest.

References

- AGRA (2009a) AGRA at Work. <http://www.agra-alliance.org/section/work>. Accessed February 10, 2009
- AGRA (2009b) About the Alliance for a Green Revolution in Africa. <http://www.agra-alliance.org/section/about>. Accessed February 10, 2009
- Annan K (2004) Africa's green revolution: a call to action. Proceedings of the July 5th, 2004 high-level seminar, Addis Ababa, Ethiopia, convened by the Government of Ethiopia and the UN Millennium Project. MDG Centre, Nairobi
- Bamji MS (2007) Nutrition-secure India—How do we get there? Nutrition conclave discusses the way forward. *Curr Sci* 93 (11):1473–1475
- Battisti DS, Naylor RL (2009) Historical warnings of future food insecurity with unprecedented seasonal heat. *Science* 323 (5911):240–244
- Baylies C (2002) The impact of AIDS on rural households in Africa: a shock like any other? *Dev Change* 33(4):612
- Bellagio Working Group for the African Green Revolution (2009) Fund for the African Green Revolution. The Earth Institute at Columbia University, New York, February 22, 2009
- Bhagowalia P, Chen S, Shively G (2007) Input choices in agriculture: is there a gender bias? Working Paper #07–09, Department of Agricultural Economics, Purdue University
- Chen LC, Huq E, D'Souza S (1981) Sex bias in the family allocation of food and health care in rural Bangladesh. *Popul Dev Rev* 7(1):55–70
- Christensen J, Hewitson BC, Busuioac A, Chen A, Gao X, Jones R, Kwon WT, Laprise R, Magana V, Mearns L, Menendez C, Raisanen J, Rinke A, Kolli RK, Sarr A (2007) Regional Climate Projections, in IPCC Fourth Assessment Report "Climate Change 2007: The Scientific Basis", Cambridge University Press.
- de Waal A, Whiteside A (2003) New variant famine: AIDS and food crisis in Southern Africa. *Lancet* 362:123
- Denning G, Kabambe P, Sanchez P, Malik A, Flor R, Harawa R, Nkhoma P, Zamba C, Banda C, Magombo C, Keating M, Wangila J, Sachs JD (2009) Input subsidies to improve smallholder maize productivity in Malawi: toward an African Green Revolution. *PLOS Biology* 7(1):e23
- Dey Abbas J (1997) "Gender asymmetries in intrahousehold resource allocation in Sub-Saharan Africa: some policy implications for land and labor productivity," ch. 15 in Haddad, Hoddinott, and Alderman, eds., *Intrahousehold Resource Allocation in Developing Countries: Models, Methods, and Policy*, Johns Hopkins
- Donovan C, Bailey L, Mpyisi E, Weber M (2003) Prime-age adult morbidity and mortality in rural Rwanda: effects on household income, agricultural production, and food security strategies. Research report for ministry of agriculture, livestock, and forestry, March 2003
- Doss CR, Morris ML (2001) How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana. *Agric Econ* 25(1):27–39
- Evenson RE, Gollin D (2003) Assessing the impact of the Green Revolution, 1960 to 2000. *Science* 300:758–762
- Fanzo JC, Haddad L (2009) Smallholder food production and poverty reduction: principles for a financial coordination mechanism to support smallholder farmers. Ad Hoc advisory group to the Madrid conference on food security chaired by Prof. Jeffrey Sachs. Fundacion ideas foundation. Box 10:34–36
- FAOSTAT (2009) <http://faostat.fao.org/site/291/default.aspx>. Accessed March 23, 2009
- Filmer D, King E, Pritchett L (1998) Gender Disparity in South Asia: Comparisons between and within Countries. (<http://www.uoit.ca/sas/Demography/genderdisparity.pdf>)
- Fischer G, Shah M, Tubiello F, van Velhuizen H (2005) Socio-economic and climate change impacts on agriculture: An integrated assessment, 1990–2080. *Philos Trans R Soc B* 360:2067–83
- Food and Agriculture Organization (1995) A synthesis report of the Africa region—women, agriculture and rural development. FAO, Rome
- Food and Agriculture Organization (1996) Declaration on world food security. World Food Summit. FAO, Rome
- Food and Agriculture Organization (2008) The world only needs 30 billion dollars a year to eradicate the scourge of hunger: Time for talk over—Action needed. 3 June 2008, Rome
- Fox MP, Rosen S, MacLeod WB, Wasunna M, Bii M, Foglia G, Simon JL (2004) The impact of HIV/AIDS on labour productivity in Kenya. *Trop Med Int Health* 9:318–324
- Frison E, Smith IF, Johns T, Cherfas J, Eyzaguirre PB (2006) Agricultural biodiversity, nutrition, and health: making a difference to hunger and nutrition in the developing world. *Food Nutr Bull* 25:143–155
- Funk C, Dettinger MD, Brown ME, Michaelsen JC, Verdin JP, Barlow M, Hoell A (2008) Warming of the Indian Ocean threatens eastern and southern Africa, but could be mitigated by agricultural development. *Proc Natl Acad Sci* 105:11081–11086
- Graham RD (2008) Micronutrient deficiencies in crops and their global significance. In: Alloway BJ (ed) *Micronutrient deficiencies in global crop production*. Springer, Heidelberg

- Graham RD, Welch RM, Saunders DA, Iortiz-Monasterio I, Bouis HE, Bonierbale M, de Haan S, Burgos G, Thiele G, Liria R, Meisner CA, Beebe SE, Potts MJ, Kadian M, Hobbs PR, Gupta RK, Twomlow S (2007) Nutritious subsistence food systems. *Adv Agron* 92:1–72
- Gray L, Kevane M (1999) Diminished access, diverted exclusion: women and land tenure in Sub-Saharan Africa. *Afr Stud Rev* 42(2):15–39
- Hawkes C, Ruel M (2006) The links between agriculture and health: an intersectoral opportunity to improve the health and livelihoods of the poor. *Bull WHO* 84:985–991
- Helen Keller International (2004) Homestead food production increases household food and nutrition security. Homestead food production bulletin No. 2.
- Ideas Foundation (2009) Smallholder food production and poverty reduction: principles for a financial coordination mechanism to support smallholder farmers. Report of Ad Hoc Advisory group to the Madrid conference on food security, January 26, 2009
- International Food Policy Research Institute (IFPRI) (2002) “Green Revolution: Curse or Blessing?” Washington, DC, USA
- Kajisa K (2008) The revolution keeps rolling. *Rice Today* 7(2):46
- Khush GS (2001a) Green revolution: the way forward. *Nat Rev Genet* 2(10):815–22
- Khush GS (2001b) Challenges for meeting the global food and nutrient needs in the new millennium. *Proc Nut Soc* 60:15–26
- Kotler DP (2000) Nutritional alterations associated with HIV infection. *JAIDS* 25(suppl 1):S81–S87
- Larson BA, Fox MP, Rosen S, Bii M, Sigei C, Shaffer D, Sawe F, Wasunna M, Simon JL (2008) Early effects of antiretroviral therapy on work performance: preliminary results from a cohort study of Kenyan agricultural workers. *AIDS* 22:e421–425
- Low J, Arimond M, Osman N, Cunguara B, Zano F, Tschirley D (2007) A food-based approach introducing orange-fleshed sweet potatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique. *J Nutr* 137:1320–1327
- Mason J, Rivers J, Helwig C (2005) Recent trends in malnutrition in developing regions: vitamin A deficiency, anemia, iodine deficiency, and child underweight. *Food Nutr Bull* 26(1):57–108
- Negin J (2005) Assessing the impact of HIV/AIDS on economic growth and rural agriculture in Africa. *J Int Aff* 58(2):267–281
- Negin J, Denning G (2008) Shared challenges and solutions: Australia’s unique contribution to the future of African development. Lowy institute for international policy. Policy Brief, December 2008
- Ngaira JKW (2007) Impact of climate change on agriculture in Africa by 2030. *Sci Res Essays* 2(7):238–243
- Oniang’o R, Mukudi E (2002) “Nutrition and gender: a foundation for development”. Brief 7 of 12: World Bank/Curt Carnemark, Geneva
- Oslo Declaration on the African Green Revolution (2007) African Green Revolution Conference 2007. Considerations of the Ministerial and High Level Roundtable. Oslo, Norway, August 29–September 1, 2007
- Paddock W, Paddock P (1967) *Famine 1975!*. Little, Brown & Co., Boston, Massachusetts
- Pinstrup-Andersen P (2009) Food security: definition and measurement. *Food Security* 1:5–7
- Popkin B (2008) The world is fat: the fads, trends, policies, and products that are fattening the human race. Penguin
- Quisumbing AR (1996) Male-Female differences in agricultural productivity. *World Dev* 24:1579–1595
- Quisumbing AR, Maluccio J (2000) Intrahousehold allocation and gender relations: new empirical evidence from four developing countries, FCND Discussion Paper 84, IFPRI, Washington, D.C., 2000
- Quisumbing AR, Haddad L, Peña C (1995) Gender and poverty: new evidence from 10 developing countries. FCND Discussion paper 9. Washington, D.C. International Food Policy Research Institute (IFPRI)
- Quisumbing AR, Estudillo JP, Otsuka K (2004) Land and schooling transferring wealth across generations. Johns Hopkins University Press, Baltimore
- Saito KA, Weidemann CJ (1990) Agricultural extension for women farmers in Africa. Policy Research Working Paper Series 398, The World Bank, 1990
- Sanchez PA, Swaminathan MS (2005) Cutting world hunger in half. *Science* 307:357–359
- Sanchez PA, Denning GL, Nziguheba G (2009) The African green revolution moves forward. *Food Security* 1:37–44
- Shetty PS (2002) Nutrition transition in India. *Public Health Nutr* 5:175–182
- Shiva V (1992) The violence of Green Revolution: third world agriculture, ecology and politics. Publisher: Zed Books
- Siika AM, Lewis S, Chesire L, Komen F, Kimaiyo SN, Nyandiko WM, Sidle JE, Wools-Kaloustian K, Einterz RM, Mamlin JJ (2005) AMPATH’S HAART “n” Harvest Initiative: addressing the nutritional needs of HIV-infected patients on antiretroviral therapy. Presented at the “International Conference on HIV/AIDS and Food and Nutrition Security: From Evidence to Action”, Durban South Africa, 14–16 April 2005
- Smith LC, Haddad L (2000) Explaining child malnutrition in developing countries: a cross-country analysis. IFPRI Research Report No.111, International Food Policy Research Institute (IFPRI). Washington, DC
- Sobha I (2007) Green revolution: impact on gender. *J Hum Ecol* 22(2):107–113
- Stockholm Environment Institute (2008) Climate change and adaptation in African agriculture, March 2008
- Swaminathan MS (2006) An evergreen revolution. *Crop Sci* 46:2293–2303
- UN Millennium Project (2005) Halving hunger: it can be done. UN millennium project task force on Hunger. Earthscan, London
- UNICEF (2009) State of the children. New York
- U.S. Agency for International Development’s (USAID) (1992) Policy Determination of 1992 for definition of food security [<http://www.usaid.gov/policy/ads/200/pd19.pdf>]
- Von Braun J, Kennedy E (1986) Commercialization of subsistence agriculture: income and nutritional effects in developing countries. International Food Policy Research Institute, Washington, D.C
- Von Braun J, Puetz D, Webb P (1989) Irrigation technology and commercialization of rice in the Gambia: effects on income and nutrition. International Food Policy Research Institute, Washington, D.C
- Von Braun J, Ruel M, Gulati A (2008) Accelerating Progress Towards Reducing Malnutrition in India. International Food Policy Research Institute
- Welch R, Graham R (2002) Breeding crops for enhanced micronutrient content. *Plant Soil* 245:205–214
- White House (2009) Doubling Financial Resources for Agricultural Development. White House Fact Sheet, April 2, 2009. http://www.whitehouse.gov/assets/remarks/G20_fact_sheet_1_Doubling_Financial_Resources_or_Agricultural_Development.pdf. Accessed April 5, 2009
- Windhoek High-Level Ministerial Declaration on African Agriculture in the 21st Century (2009) Meeting the challenges, making a sustainable Green Revolution. Windhoek, Namibia, February 9–10, 2009
- World Bank (2000) World bank quarterly review of commodity markets. Oxford University Press, New York
- World Bank (2007) World Development Report 2008. Agriculture for Development. Washington, DC, 2007
- Yamano T, Jayne TS (2004) Measuring the impacts of working-age adult mortality on small-scale farm households in Kenya. *World Dev* 32(1):91–119



Joel Negin is Lecturer in International Public Health at the School of Public Health at the University of Sydney and a Research Fellow at the Menzies Centre for Health Policy. He maintains an ongoing appointment at the Earth Institute at Columbia University where he previously worked on the Millennium Villages Project. Negin's research focuses on multi-sectoral development models and health systems strengthening in sub-Saharan Africa and the

Pacific. He is particularly interested in the agriculture-nutrition-health nexus. Negin has worked in a number of countries including Kenya, Côte d'Ivoire, Liberia, Zimbabwe, Botswana and South Africa on various health and development projects for UN agencies, government departments and academic institutions.



Susan Karuti joined the MDG Centre—East and Southern Africa in 2006. Susan holds a M.A in Sociology from the University of Nairobi, a Post-Graduate Diploma in Education from Kenyatta University, and a Bachelor's Degree in Social Sciences from the University of Nairobi. Karuti is the Gender Coordinator for the MDG Centre and the Millennium Villages Project. Her key role is to strengthen the organization's capacity to advance the understanding and application of gender

issues and initiatives in rural development. Prior to joining the MDG Centre, Karuti worked with the Christian Children's Fund (CCF)—Kenya as the National Education Coordinator. There, she coordinated the girl-child program and was the Eastern Africa region representative for the education and learning task force group.



Roseline Remans is a Marie Curie Research Fellow in the Tropical Agriculture Program at the Earth Institute at Columbia University. She is also an honorary fellow of the Belgian-American Education Foundation (BAEF). Her research focuses on synergies and tradeoffs between agriculture and nutrition in African villages and is embedded in the Millennium Villages Project (www.millenniumvillages.org). Remans received her PhD from the Catholic University of Leuven in Bioscience Engineering, studying

ecology of legume-based tropical agriculture systems. During her PhD, she was a scholar of the Flemish Interuniversity Council (VLIR) and performed research at the National Soil Institute in La Havana, Cuba and at the International Centre for Tropical Agriculture (CIAT) in Cali, Colombia. Prior to her PhD, Remans worked as a project scientist in the Centre for Research on Nitrogen Fixation at the Universidad Nacional Autónoma de México in Cuernavaca, Mexico.



Jessica Fanzo is the Nutrition Coordinator for the Millennium Villages Project (MVP) of the Earth Institute of Columbia University and serves as a Nutrition Specialist for the MDG Centre for East and Southern Africa in Nairobi Kenya. The MVP project offers a bold, innovative model for helping rural African communities lift themselves out of extreme poverty and achieve the Millennium Development Goals. She is also a Scientist for the Center for Global Health and

Development. Fanzo received her PhD from the University of Arizona in Nutrition and became a Stephen I. Morse Fellow in immunology at Columbia University. Prior to joining the Earth Institute, Fanzo was a Program Officer for the Medical Research Program at the Doris Duke Charitable Foundation focusing on HIV/AIDS initiatives in sub-Saharan Africa as well as clinical research programs in the United States.