INDEPENDENT SCIENCE & PARTNERSHIP COUNCIL
CGIAR

CGIAR System-Level Outcomes (SLOs), their impact pathways and inter-linkages

ISPC White Paper

June, 2013

ISPC White Paper on CGIAR System-Level Outcomes (SLOs), their impact pathways and inter-linkages

SUMMARY

This paper responds to a request to the ISPC from the CGIAR Fund Council and Consortium to identify the major routes through which agricultural research can address the four high-level goals, called System-Level Outcomes (SLOs), of the CGIAR and the potential linkages between research and impact pathways. The four SLOs are: reducing rural poverty (SLO1), increasing food security (SLO2), improving human nutrition and health (SLO3) and sustainable management of natural resources (SLO4).

SLO1: The conditions under which agricultural research is on balance pro-poor within target regions can be quite specific to local socio-economic conditions (e.g. the distribution and ownership of land, small farm access to markets and inputs, and the empowerment of women farmers) and to national food policies (e.g. agricultural pricing and trade policies and input subsidies). This specificity needs to be addressed at the design stage within individual CGIAR Research Programs (CRPs) and may require complementing technology research with social analysis and policy research, and formation of partnerships with development agencies who can help work within, or change, the socio-economic context. Identification of typologies of target farmers is suggested as a means to assist research planning and focus. Interventions should be underpinned by a detailed theory of change and impact pathway relevant to the local context of the target regions.

SLO2: Given the challenge of feeding both rural and rapidly growing urban populations, and the reach of most national food security policies, agricultural research that focuses only on small farms will not be sufficient to solve the food security challenge. In many countries it will be imperative that medium-sized farms and even large farms have access to productivity enhancing technologies. This may lead to a bifurcated research agenda, and allocating resources appropriately across farm size classes within a target domain. There is potential overlap with the poverty alleviation agenda and substantial scope for policy research to assist farmers and countries to put in place specific policies for enhancing food security. All research on enhancing productivity must be linked to, or consistent with, research on protecting the environment - to ensure sustainable intensification and avoid the trap of making short term productivity gains at the expense of the natural resource base on which agriculture depends.

SLO3: While the primary routes to improved nutrition are suggested to be through availability of nutritious food at affordable prices and increased income to purchase food. However, there are substantial evidence gaps on achieving positive nutritional outcomes from agricultural research. In contrast, there is evidence that other factors, not directly influenced by agriculture, such as health, are essential for achieving nutritional outcomes. This paper identifies seven potential routes to achieving better nutrition. Three of these pathways are close to the food security and poverty alleviation impact pathways for research and four relate to household and women's health/assets and decision making. The paper argues for a distinct research agenda that combines several key elements and a focus on defining the mechanisms to translate food availability and nutritional quality into successful nutritional outcomes for

target populations. For agriculture-related health outcomes, impact pathways are more direct in a limited number of research areas, such as food safety.

SLO4: The paper suggests that basic theories of change for sustainable management of natural resources involve farmers and community use and considers cycling and replenishment of environmental and other sorts of natural capital as essential components of sustainable intensification. The CGIAR has comparative advantage to conduct research on natural resource management with direct links to improvement of agricultural systems that include crop, livestock, fish, and forestry enterprises while preventing negative environmental outcomes due to agricultural practices. For practical purposes the CGIAR will only focus on a small subset of the drivers of change in SLO 4. These drivers will be those that can be influenced by agricultural research and that yield benefits towards the other SLOs 1 – 3. Thus, the primary target of research for NRM will be technologies and policies that maintain or build natural capitals of land, water, soil nutrients, organic matter, and biodiversity for the benefit of more productive agricultural systems, reduced rural poverty, and improved nutrition.

Because of the contextualized nature of the research for development pathways and their many levels of interaction (between drivers as well as research pathways) it is not possible to derive a single prioritization framework. Hence, the following discussion draws attention to the effects of economic growth and choice of target spatial scales at which poverty, farm productivity, and agro-ecologies are considered in priority setting.

Attention is drawn to the fact that most R&D outcomes will occur and be measured in distinct geographies and places, usually under national policy regulation. However, in the case of NRM, some characteristics (natural biodiversity or greenhouse gas emissions reductions) may yield few tangible benefits to smallholder farmers. So while the nation, state or region within a country might be an appropriate scale for defining some of the IDOs, many NRM attributes must be considered at other scales (e.g. river basins or ecoregions).

The description of IDOs as the ‘missing middle' between the high-level SLOs at one end and CGIAR research activities at the other, and specifying the impact pathways that connect them, encourages forward planning of the Strategy and Results Framework (SRF) and the CRPs in ways that allow flexibility and program evolution. Such flexibility is needed for continuous adjustment of the CGIAR’s portfolio over time to accommodate emerging challenges in agricultural development and the CGIAR’s evolving comparative advantage. CRP and System-level IDOs also allow the CGIAR to make its goals transparent and to assess if the right balance of research and investment effort is being applied. This is the first step in prioritization.

1. BACKGROUND

Prioritization at System and CRP levels

This paper responds to a request to the ISPC by the CGIAR Fund Council and Consortium to identify the major routes through which agricultural research can address the four high-level goals of the CGIAR, the System-Level Outcomes (SLOs), and the potential linkages between research and impact pathways.

In 2011, the CGIAR's Strategy and Results Framework was endorsed by the Funders Forum with the proviso that an Action Plan be developed for revisiting the SRF[1]. The SRF was found to lack connection between the CGIAR Research Programs (CRPs) and the high level objectives of the system encompassed in SLOs. Further, the strategy was seen as requiring more flexibility to scan and potentially encompass new areas of priority. In 2012 the ISPC published a White Paper 'Strengthening the Strategy and Results Framework through Prioritization'[2] which was considered as a 'companion paper' to the SRF Action Plan prepared by the Consortium Office and endorsed by the 2nd Funders Forum in 2012. In that first White Paper, the ISPC noted the difficulty in tracing pathways of research to the SLO level and recommended that Intermediate Development Outcomes (IDOs) be developed at an appropriate level between research outputs and the SLOs. At the System-level there should be agreement on a prioritized set of IDOs that are logically linked to the SLOs. The ISPC also emphasized the need for CRPs to go through rigorous prioritization to define CRP-level IDOs that are specific to the CRP thrusts, consistent with the System-level IDOs (SL-IDOs), and supported by carefully constructed impact pathways. The White Paper urged development of a theory or theories of change, which should be elaborated to describe the assumptions underlying the impact pathways. Implementation of this recommendation would provide a framework within which revisions to CRP proposals could be developed. A coherent link between CRP activities and their means of addressing the higher development goals of the CGIAR would be established. IDOs would offer the desired flexibility and become the main mechanism for adjusting the CGIAR's overall portfolio over time.

Objectives of this White Paper on SLO impact pathways and inter-linkages

The ISPC was subsequently asked by the Fund Council and Consortium to develop another White Paper on 'SLO linkages and impact pathways'. This White Paper aims to further extend the recommendations in the first White Paper by proposing a framework for System-level IDOs, which underpin the SLOs. It explores the multiple impact pathways through which agricultural research can contribute to impact at the SLO level, drawing on published evidence regarding the linkages from agricultural research to the SLOs. It discusses direct and indirect linkages, including trade-offs, between the multiple outcomes, as these linkages will influence the strategies for effectively addressing the SLOs and hence potentially for focusing research investment. The paper also contributes to development of meaningful IDOs that will link the CRPs with the SRF and can be used to assess progress towards each of the SLOs. It highlights some principles to guide prioritization at the System-level.

An analysis of the SLO impact pathways and inter-linkages can be used to assess the CGIAR's strategies for directly or indirectly addressing the SLOs and how the trade-offs are dealt with both at CRP and System-level. Further, it can help identify the areas where CRP research should accumulate more evidence of causality, before those planned outcomes become a high priority. It can also be used for assessing the areas where the combined power of the CGIAR CRPs *should* be focused to deliver maximum impact on the SLO targets, given the CGIAR's current comparative advantage and how it is likely to evolve.

Figure 1 below, taken from the first ISPC White Paper, presents the conceptual framework for linking research to the SLOs in the SRF through the IDOs that represent the prioritized results framework for the CRPs and the System.

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[1] Summary of *ad hoc* Funders Forum 2011

[2] http://www.sciencecouncil.cgiar.org/fileadmin/templates/ispc/Expert_advice/Advice_to_the_CGIAR/Strengthening_Strategy_and_Results_Framework_through_prioritization.pdf

Figure 1. Contribution to SLOs through intermediate development outcomes at System and CRP level

Four System Level Outcomes	SLO1. Reduction in rural poverty SLO2. Increase in food security SLO3. Improving nutrition and health SLO4. Sustainable management of natural resources
Intermediate development outcomes (System level) *Represent accumulation of CRP results with the scale corresponding to the CGIAR's target domains* *Generated as a result of multiple activities by diverse actors outside the CGIAR* *Documented through System level studies*	**Examples:** SLO1: Increased income for poor producers; Increased empowerment for women SLO2: Increased productivity; Price stability SLO3: Increased consumption of nutritious food; Decreased harm from agricultural processes SLO4: Decrease in resource degradation; Payment schemes for environmental services
Intermediate development outcomes (CRP level) Targets at Program level that represent CRP-specific thrusts and target domains. Scales reflect target domain and estimated volume of benefit Generated *as a result of multiple activities including by diverse actors outside the CGIAR* *Documented through CRP level studies*	**Examples:** SLO1: Increased market opportunities for poor from specific value chain; Participation of women in decision-making in a target domain SLO2: Increased productivity of maize production systems; Functioning seed markets SLO3: Increased consumption of biofortified foods; Reduced aflatoxins in specified food chain SLO4: Reduced deforestation; Increased carbon sequestration
Research outcomes Represent adoption and further use of research outputs by immediate users targeted by the CRP, such as NARS researchers and national policy makers *Generated as a result of research, capacity building and advocacy activities* *Documented in internal CRP monitoring*	**Examples**: SLO1: National policies support pro-poor value chain development; National guidelines for credit schemes for women SLO2: CGIAR developed maize breeding materials used by NARS breeders and varieties released; CGIAR research informed policies and regulatory frameworks incentivise private seed market development SLO3: National release of biofortified varieties; technologies for aflatoxin control adopted SLO4: Policies controlling illegal logging adopted; CGIAR developed soil management practices adapted to local conditions and promoted

Section 2 contains analysis and discussion of each SLO and their inter-linkages. In Section 3 we present some general characteristics of IDOs across the four SLOs. In Section 4 we discuss the implications of the SLO analysis and IDO development for System-level decision making on CGIAR strategies and design of the System-level research portfolio. Section 5 contains a brief discussion on the implications of the results framework for monitoring and impact assessment. This paper draws heavily on the background papers prepared for an ISPC sponsored workshop on "SLO linkages and impact pathways", (FAO, Rome, March 11-12, 2013) and the ensuing workshop discussions.

2. SLO IMPACT PATHWAYS AND LINKAGES

Robust and evidence-based theories of change for many of the pathways linking international agricultural R&D to the four SLOs of the CGIAR System do not yet exist. There is ample scientific evidence showing that achievement of the development goals is often characterized by fundamental complexity and that in many cases pathways to impact are specific to the development context. As a result, the following discussion draws extensively on specific examples. Important knowledge gaps remain, including the possibility of further critical linkages that need to be illuminated through additional research.

SLO1 Reduction in Rural poverty

The links between agricultural R&D and poverty outcomes are particularly complex and serve as a good illustration of the challenges faced in developing System-level IDOs.

There are a number of pathways through which improved technologies could potentially benefit the poor (Hazell and Haddad, 2001). Within adopting regions, research can help poor farmers directly through increased own-farm production, providing more food and nutrients for their own consumption and increasing the output of marketed products for greater farm income. Small farm and landless laborer households could gain additional agricultural employment opportunities and higher wages within adopting regions. Research can also help to empower the poor by increasing their access to decision-making processes, enhancing their capacity for collective action and reducing their vulnerability to economic shocks via asset accumulation.

Poor people outside adopting regions might also gain indirectly from agricultural research. Growth in adopting regions could create employment opportunities for migrant workers from other less dynamic regions (e.g. over a million seasonal migrants gained employment in Punjab and Haryana during the early stages of the green revolution). It could also stimulate growth in the rural and urban nonfarm economy, for instance through value chains, with benefits for a wide range of rural and urban poor people. Agricultural research can lead to lower food prices (and hence greater purchasing power) which could provide an immense benefit for all types of poor people.

But agricultural research can also work against the poor. Some technologies are more suited to larger farms, or require inputs that may only be affordable or accessible to large farms. Some technologies (e.g. mechanization and herbicides) could displace labor, leading to lower earnings for agricultural workers. By having greater impact in some regions than others, technology could harm non-adopting regions by lowering their product prices but without the offsetting cost reductions associated with the technology.

Given that many of the rural poor are simultaneously farmers, paid agricultural workers, net buyers of food, and earn nonfarm sources of income, the impacts of technological change on their poverty status can be difficult to predict, with households experiencing gains in some dimensions and losses in others. For example, the same household might gain from reduced food prices and from higher nonfarm wage earnings, but lose from lower farm gate prices and agricultural wages. Measuring net benefits to the poor requires a full household income analysis of direct and indirect impacts, as well as consideration of the impacts on poor households that are not engaged in agriculture and/or who live outside adopting regions, including the urban poor. Much of the controversy in the current literature about how agricultural R&D impacts the poor arises because too many studies have only taken a partial view of the problem.

Attention also needs to be paid to how success is to be measured. There can be winners and losers, both at household and regional levels, and between rural and urban dwellers. The existence and magnitude of such potential tradeoffs vary depending on spatial scale of the analysis. At issue, then, is the geographical space at which success be measured. Is it to be measured within adopting regions or for a country as a whole? Is it to be assessed separately for rural or urban dwellers? And does it matter if there are losers as long as aggregate measures of poverty go down?

The conditions under which agricultural research is on balance pro-poor within adopting regions can be quite specific to local socio-economic conditions (e.g. the distribution and ownership of land, small farm access to markets and inputs, and the empowerment of women farmers) and to national food policies (e.g. agricultural pricing and trade policies, input subsidies). This specificity needs to be addressed at the design stage within individual CRPs and may require research on technologies to be complemented with policy research and the formation of partnerships with development agencies who can help change the socio-economic context. These interventions need to be underpinned by a detailed theory of change and impact pathway that accounts for local contexts.

At aggregate levels there are not many 'necessary' outcomes that can be used to define IDOs for poverty reduction. The best one might hope for is to find necessary outcomes for clusters of pathways targeted to specific socioeconomic groups. To this end small farm typology framework might be useful to identify the primary target groups of the CGIAR.

There are two key dimensions to consider in a small farm typology. One is the regional context and the other is the market orientation of the farmers. The literature contains several variants of a typology based on these two dimensions, and which can be simplified for present purposes into the 2×2 typology in Table 1. Here two types of regional context are defined: Favored regions that have good agricultural production potential and/or good market access (A and C), and less-favored regions with poor agricultural production potential and/or poor market access (B and D). Favored regions provide many more business opportunities for small farms, particularly in today's world of rapid urbanization and globalization of agricultural value chains. Indeed, opportunities for shifting into higher value agriculture for urban and export markets can be particularly attractive as, for example, in some of the rural regions around large cities in India, China, and Mexico, or the opportunities for producing fresh horticultural products for export in Kenya and Central America. In less-favored regions, market opportunities for most small farms are much more constrained, input levels are typically low, and productivity is generally less than in favored regions. Less-favored regions tend to be much less competitive, more risky, and oriented to production of staple foods, largely for local consumption. Recent GIS mapping work (Sebastian, 2007) shows that for the developing world as a whole, 30-47% of the agricultural area and 8-23% of the population can be classified as being in less-favored areas, depending on whether one draws the line on market access at low or medium levels[3].

Table 1: A simple typology of small farms

	Market oriented small farms	Subsistence and transition oriented small farms
Favored regions with good agricultural production potential and/or market access	A	C
Less-favored regions with poor agricultural production potential and/or market access	B	D

Table 1 also differentiates small farms into two groups. Market-oriented small farms are those already successfully linked to value chains, or which could link if given a little help. Market-oriented small farms are typically net sellers and may be full- or part-time farmers. The second group consists of small farms that are primarily subsistence-oriented. This group includes small farm households that are heavily diversified into off-farm sources of income and who are at various stages of transition out of farming. A high proportion of small farms fall into this category throughout the developing world today. This group also includes households that are marginalized for a variety of reasons that are hard to change, such as ethnic discrimination, affliction with HIV/AIDS, or being located in remote areas with limited agricultural potential. Many of the same factors also prevent them from becoming transition farmers. Subsistence-oriented farms frequently sell small amounts of produce at harvest to obtain cash income, but they are typically net buyers of food over the entire year.

The relative importance of these two small farm groups varies widely from region to region. In a less-favored region a within a country with slow economic growth – a "worst case scenario", and a situation all too prevalent in Africa – the number of market-oriented farms is very low. There are a lot of subsistence-oriented small farms trying to get out while lack of off-farm opportunities often prevents them from doing so, leaving many trapped in low productivity farming. At the other extreme, in a dynamic region in a dynamic country – such as some of the coastal areas in China – there are a great number of market-oriented small farms producing large volumes of high value products for the cities. There are also a lot of other small farmers being pulled out of agriculture into much better-paid opportunities in the industrial areas; and only a very small group of subsistence farmers – often the elderly or the infirm. There are lots of other regions, of course, that fall somewhere between these poles.

Returning to the challenge of identifying pathways for reducing poverty, these need to be differentiated for each of the cells in Table 1. In cells A and B, the focus should be on pathways involving commercial farming opportunities, including high value agriculture, which may be the only viable way of lifting many of these small farmers out of poverty.

[3] Sebastian, Kate. 2007. GIS/Spatial Analysis Contribution to 2008 WDR: Technical Notes on Data and Methodologies. Background paper for WDR 2008. World Bank, Washington DC. Cited in Hazell, Peter, Ruerd Ruben, Arie Kyvenhoven and Hans Jansen. Development strategies for less-favoured areas. In *Development Economics between Markets and Institutions*, Erwin Bulte and Ruerd Ruben (eds.). Mansholt Publucation Series – Volume 4, Wageningen Academic Publishers. 2007.

Increases in farm cash income might be a necessary outcome towards poverty alleviation for this group, and hence a useful IDO.

In cells C and D it may be more relevant to focus on raising the productivity of existing food staples and developing off-farm opportunities. Here the best IDOs might relate to on-farm production of food staples, and levels of nonfarm cash income. The challenges in D will be greater because of limited availability of farm and nonfarm opportunities.

For policy research, there are broader opportunities for reducing poverty. Not only can this help change the socioeconomic context in all cells in Table 1, perhaps even moving some small farms into more desirable cells (e.g. in cells B and D, through promoting investments in roads), but it can also help amplify the spillover benefits from technology research. For example, research that leads to more efficient food markets nationally may contribute to even lower food prices and help make them more stable.

Policy research can also target complementary policies for assisting small farms. For market-oriented small farms, policy research can help promote development of value chains so that small farms have better access to modern inputs, financial services and insurance, market outlets, and secure access to land and water. It can also help promote development of the nonfarm economy to create more off-farm opportunities for subsistence-oriented farms. For those unable to make the transition out of subsistence farming, policy research can help develop forms of social protection that are complementary to agricultural research investments that aim to raise on-farm food production.

In Table 2, and in subsequent tables for each SLO, we discuss characteristics of potential IDOs in terms of their position along the impact pathway, the time to achieve the outcome and the scale for targeting and monitoring. These examples result from discussions at the Rome workshop and are intended to highlight some issues for consideration in agreeing on a set of System-level IDOs.[4]

Table 2. Some examples for potential IDOs for poverty and their properties

IDO	Stage along impact pathway	Time to achieve outcome	Relevant scales
Yield or productivity of small farms	Early to intermediate	Medium	Adopting regions; commodity
Greater resilience in farm production	Intermediate	Long	Adopting regions
Marketed surpluses from small farms	Intermediate	Medium	Adopting regions; commodity; country
Agricultural employment and wages	Intermediate	Medium	Adopting regions
Rural nonfarm employment and wages	Intermediate to advanced	Medium	Adopting regions
Total income of small farm & ag labor households	Advanced	Medium	Adopting regions

[4] In a parallel process to this White Paper, the CRPs have been designing a set of IDOs that at the aggregate could represent the System-level IDOs. Ultimately, the System-level IDOs will comprise those that represent work done in many CRPs as well as some CRP-specific IDOs that represent development outcomes in specific domains targeted by an individual CRP.

Child malnutrition	Advanced (indicator for SLO3)	Medium to long	Adopting regions
Improved national policies for poverty reduction	Intermediate	Short to medium	Country
Prices of food staples	Intermediate to advanced	Short to medium	Country
Stability of food prices	Advanced	Medium to long	Country
Food consumption patterns	Advanced	Medium	Adopting regions; country

SLO2 Increased Food Security

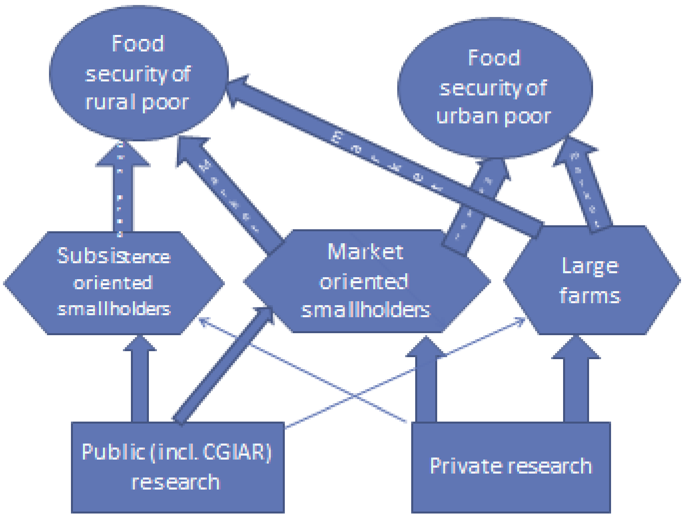
Food security and poverty are tightly linked because food security is in large measure a purchasing power or income problem. However, this is not always true. For example, small farms that expand into high value cash crops for the market may end up producing less food for themselves and hence become more dependent on the vagaries of local markets for their own food security. It is also important to differentiate between the pathways available for ensuring the food security of rural people versus those for urban populations.

In Figure 2, a distinction is again made between subsistence-oriented smallholders who are either self-sufficient or net buyers of food, and market-oriented smallholders who produce surpluses for sale. About half the malnourished people in the developing world live on small subsistence-oriented farms, so research that increases their on-farm productivity can have a big impact on their food security. However, the urban poor account for increasing shares of the total food insecure, and these households have little or no access to land. Their food security depends on access to affordable market supplies, so agricultural R&D can only assist them if it leads to increases in the productivity of market oriented smallholders and large farms that supply the market. The kinds of technologies needed by these two groups of farms are typically different (e.g. subsistence-oriented farms are less likely to be able to afford modern inputs than farms supplying markets and thus generating income) so there is need for a bifurcated research agenda.

Full self-sufficiency in food is often not the best economic strategy for households or countries. Depending on comparative advantage, it may be better in economic terms for a country to import some foods while exporting other agricultural products, and the same may hold true of farm households. So improved technologies for food staples may be only part of the answer to the food security problem, and policy research is needed to help farmers and countries develop their best economic strategies for achieving food security. Other kinds of national food policies also have far-reaching impacts on food security. These include national policies for stabilizing food prices (e.g. buffer stock and trade policies), and safety net programs, including cash transfers and food aid. Policy research that leads to improvements in these policies can generate large impacts on poverty, as well as generate positive synergies with technology research that increases national food supplies. In order to capture these synergies, the design of policy and technology research within the CRPs needs to be complementary and the potential benefits of policy research need to be captured in the IDOs.

Given the challenge of feeding both rural and growing urban populations, and the national reach of most food security policies, agricultural research that focuses only on small farms will not be sufficient to solve the food security challenge. In many countries it will be imperative that medium-sized farms and even large farms have access to productivity enhancing technologies. The private sector plays an increasingly important role in meeting this need, but there are still many important types of research (e.g. on natural resources management, NRM) where the private sector lacks sufficient incentive, and the public R&D systems including the CGIAR have complementary roles to play.

Figure 2. Pathways to food security through production of food staples



Because poverty and food security are strongly linked, many IDOs suitable for assessing poverty outcomes will also be relevant for food security, as can be seen by comparing Table 3 below with Table 2.

Table 3. Some examples for potential IDOs for food security and their properties

IDO	Stage along impact pathway	Time to achieve outcome	Relevant scales
Production of food staples.	Early to intermediate	Medium term	Adopting regions; commodity; country
Length of the hungry season	Intermediate to advanced	Medium	Adopting regions
Stability of farm production	Intermediate	Long	Adopting regions
Marketed surpluses of food staples	Intermediate	Medium	Adopting regions; commodity; country
Post-harvest losses	Intermediate	Medium	Adopting regions; commodity; country
Storage	Early to intermediate	Short to intermediate	Adopting regions; commodity; country

Improved national policies for food security	Early to advanced	Short to medium	Country
Prices of food staples	Advanced	Medium	Country
Food consumption patterns	Advanced	Medium	Adopting region; country
Malnutrition indicators for children	Advanced (indicator for SLO3)	Medium to long	Adopting regions; country

SLO3 Improving Nutrition and Health

Agriculture produces food, and food is integral to human nutrition and health. The basic pathways to improving nutrition had been assumed to be though increased availability (better production) of foods, allied to the food security pathway, or through the development of income to purchase food, allied to the food security and poverty alleviation pathways. However, the simple availability of food does not necessarily ensure food security or better nutrition (Herforth et al., 2012). Supplying sufficient calories from the production of staples does not alone meet nutritional requirements, particularly for essential micronutrients, either at the household or individual level. Intra-household distribution of income and dietary assets complicates simple equations of cause and effect based on the income pathway. Importantly also, existing nutritional status and underlying levels of health, nutrient balance and bioavailability, food safety, presence of toxins and disease all make apparently simple pathways for agriculture to contribute to human health less clear and hence a priority for research. Table 4 summarizes the seven main pathways through which agriculture impacts human nutrition as identified by Headey et al. 2011, Gillespie et al. 2012, and USAID 2013.

Table 4. Main pathways through which agriculture is thought to influence nutrition

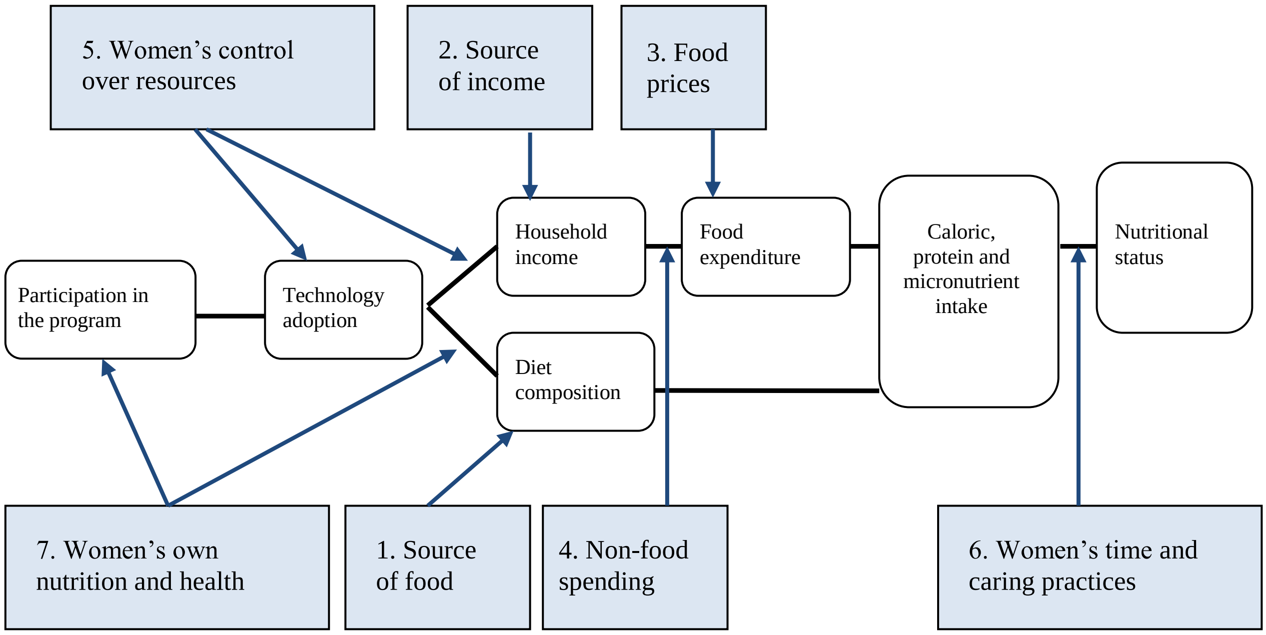
1. Agriculture as *source of food* (production to consumption)
2. Agriculture as *source of income* (wages earned or marketed sales)
3. Agricultural policy and *prices* (price setting, price volatility)
4. Agricultural income (non-food expenditure on nutrition/health)
5. Women’s *status/control of resources* (re: food, health, and care)
6. Women’s *time, knowledge* (ability to care, feed, promote health)
7. Women’s *nutrition* (energy expenditure, health, longevity)

Considering these seven likely pathways from agriculture to improved nutrition, the first three factors determine the nutritional diversity of the foods available to households, while the remaining four factors impact on whether households[5] are enabled to care for the health and nutrition of their families and thereby to influence the choice of foods they consume. These two outcomes largely determine whether households will consume better diets.

Figure 3 proposes a logical framework that allows visualization of the entry points for research on these several pathways. Webb (2013) also highlights that several factors along the impact pathway, such as poor health – for instance resulting from poor sanitation – have significant influence on the nutritional outcomes.

[5] Analysis by Okali (2011) proposes considering a less static view of gender relations than commonly presented and emphasizes that men, too, have a role in caring and in family health and nutrition.

Figure 3. Logical framework for assessing impact of agricultural interventions on nutrition (Webb, op cit, following Masset et al. 2011).



Although, investment in agriculture is commonly seen as critically important for reducing malnutrition (Herforth et al., 2012), evidence is lacking on the impact pathways. According to FAO, there is insufficient understanding on how best to achieve this potential (Thompson and Amoroso, 2010). Because of confounding elements and, in large part, because prior agricultural research may have not have been adequately designed to encompass nutritional aspects, evidence is sparse from published literature on specific nutritional improvements that can be traced to contributions from agricultural research programs. The FAO (2012) has noted that "Agriculture interventions do not always contribute to positive nutritional outcomes" and the most comprehensive recent review of literature has stated that there is "No evidence of impact on prevalence rates of stunting, wasting and underweight among children under five" (Masset et al., 2011).

Indeed, there have been 10 significant evidence reviews since 2001 that incorporate published and unpublished literature going back to the 1980s (reviewed in Webb, 2013) that have tried to answer fundamental questions framed along the lines of 'do agricultural interventions improve nutrition?' The general findings from these reviews are that:

i) Empirical evidence of positive net impacts on nutrition is scarce.
ii) Where positive impacts have been documented, mechanisms are poorly articulated.
iii) Positive impacts are more likely where integration of multiple sectors of activity has been strong, yet understanding of the relative contribution of different elements remains weak.
iv) Impacts are possible via multiple pathways but analysis of the roles of different pathways is often lacking.
v) Women's combined roles in agriculture, dietary choices and healthcare are crucial, but few agricultural interventions target all three domains.
vi) Nutrition impact of price/trade policies as mediated by agriculture and food choices at household level have been assumed rather than fully explored and measured

vii) Lack of empirical evidence of agricultural impacts on nutrition outcomes may say more about poor study design and methods used than it does about the interventions considered. That is, a lack of evidence to date does not negate the possibility that evidence of positive impacts may still be found.

The gaps in evidence are substantial but these can be grouped into three main categories: there has been (i) a lack of specificity regarding causal mechanisms and types of impact (different nutrition outcomes) along the various potential pathways; (ii) an incomplete elaboration of links or pathways, and; (iii) lack of understanding of the relative contribution of various elements of food-based strategies to empirically documented human impacts, costs, and feasibility at scale. A set of possible research questions for the agriculture/nutrition nexus is shown in Annex 1.[6]

First the quality and volume of research on this topic *has* to be improved. Second, we need elaboration of, (a) specific mechanisms not broad pathways, (b) contextual counterfactuals, and (c) appropriate metrics to allow for measurement of net, often non-linear, effects. Third, the CGIAR is well-positioned to undertake significant parts of such an enhanced nutrition-sensitive research agenda as the demand is very high for empirical evidence of how to leverage agriculture's potential to promote enhanced nutrition and health. Such work can be useful for the CGIAR and others in agricultural health and nutrition sectors.

How nutrition and health impact pathways link to other SLO pathways

It is clear that addressing SLO 3 is intimately connected to the other targets for the CGIAR, particularly SLOs 1 and 2. All the literature reviews mentioned above looked broadly at agricultural projects (including home gardens, small ruminants, aquaculture, irrigation, biofortification, as well as credit and cash transfers etc.) relating to efforts to improve food and income security or the management of natural resources. The negative findings of these reviews do not mean that there are not important linkages between research towards food security, poverty alleviation and environmental goals and better human nutrition.

Nutritional outcomes are not likely to be derived as add-ons to existing CGIAR research but will require a new undertaking of tailored research and the formation of new research and development partnerships with other sectors.

The dearth of good evidence reinforces the idea that nutritional outcomes are not the automatic result of agricultural productivity research (for instance) and that specific research programs, accomplished with greater statistical power as well as attention to human health and socio-economic dimensions than previously, will be required to demonstrate improved human nutritional and health outcomes from agricultural research. Issues of seasonal supply and availability of nutrients and the appropriateness of interventions for target populations (women and children under 2 years), for instance, are of particular importance for SLO3. Relationships with poverty alleviation research are nuanced e.g. the relationship of early nutrition to the development of obesity (non-communicable diseases) is associated with windows of nutrition in both developed and poor developing country populations. Economic growth is reported to be associated with positive increases in vitamin A and B12 intake, but the same relationship is not necessarily noted for other micronutrients (Iannotti et al. 2012).

[6] The ISPC sponsored Science Forum 2013 titled "Nutrition and health outcomes: targets for agricultural research" will explore the current understanding and gaps in the nexus of agriculture, nutrition and health.

There is an urgent need to understand how agricultural policies, projects and investments can be designed and implemented to achieve nutrition goals (Herforth 2012) which is a cross cutting issue.

The most direct impact pathways to health outcomes may result from research on pesticide reduction in agriculture, the improved management of water or potentially hazardous farming inputs and practices that might lower the likelihood of zoonotic and agriculture-related diseases and toxins affecting human health

IDOs might be based on the seven factors listed above, though some of these are likely to be context-specific and hence more relevant to individual CRPs. IDOs for SLO3, particularly for nutrition, require programs move beyond agricultural production for the IDOs to be proxies of nutritional and health changes. For instance, production of nutritious crops is not sufficient (although it may result in SLO1 outcomes), but changes in availability of crops that support diverse diets and changed consumption patterns would need to be targeted and demonstrated. Moreover, greater diversity of foods grown would only be a positive indicator if it were also associated with improved nutritional status of farm families and perhaps higher incomes. At the SLO level, demonstration may involve anthropomorphic and metabolic indicators and measurement of effects. Impact pathways to some health benefits can be more direct, for instance, pesticide or aflatoxin reduction.

Table 5. Some examples of potential IDOs for nutrition and health and their properties

IDO	Stage along impact pathway	Time to achieve outcome	Relevant scales
On-farm diversity of foods grown	Early to intermediate	Short to medium term	Adopting regions
The nutritional diversity of the diets available to households	Intermediate	Medium	Adopting regions; country
Women’s empowerment to care	Intermediate	Medium to long	Adopting regions
The incidence of agriculture related diseases including pesticide poisoning.	Intermediate	Short to medium	Adopting regions; country

SLO4 More Sustainable Management of Natural Resources

SLOs 1, 2 and 3 focus on the issues of increasing food security and nutrition and reducing poverty in the short-to medium term. The outcomes that result are felt by the targeted users of the new knowledge and technologies. Sustaining such results through agricultural production in the longer-term, as population and demand for different types of food increase, depends on the sustainability or even renewal of the natural resource base and the ecosystem services that underpin agricultural production. Pressures of population, urbanization and land and resource degradation in some areas mean that enhancing future productivity will depend to a great degree on the ecological intensification of agriculture (Cassman, 1999). The CGIAR’s major research effort in this area is likely to be management of the natural resources (e.g. soils, water, land) that underpin agricultural production and on resource systems (e.g. forests, fisheries, pastures) that the poor rely upon for food and other benefits. Agriculture and food production are activities that exploit the natural resource base and use non-renewable resources such as fossil energy, phosphate and in many instances, fossil groundwater. NRM research is often one of optimization and managing trade-offs between system components. Agriculture has been associated with several types of negative effects on the natural resources (see Annex 2). A new factor which needs to be considered in this respect is climate change. Climate change has emerged as a major challenge of the 21st century, and in relation to agriculture, there is a need both to manage the contribution of agricultural systems to greenhouse gas emissions and also to ensure that adaptation to climate change enables increased production without damaging the natural resource base. Thus, making agricultural production more environmentally sustainable, and making agriculture part of the solution to environmental problems is vital to continuing progress in delivering on SLOs 1 to 3.

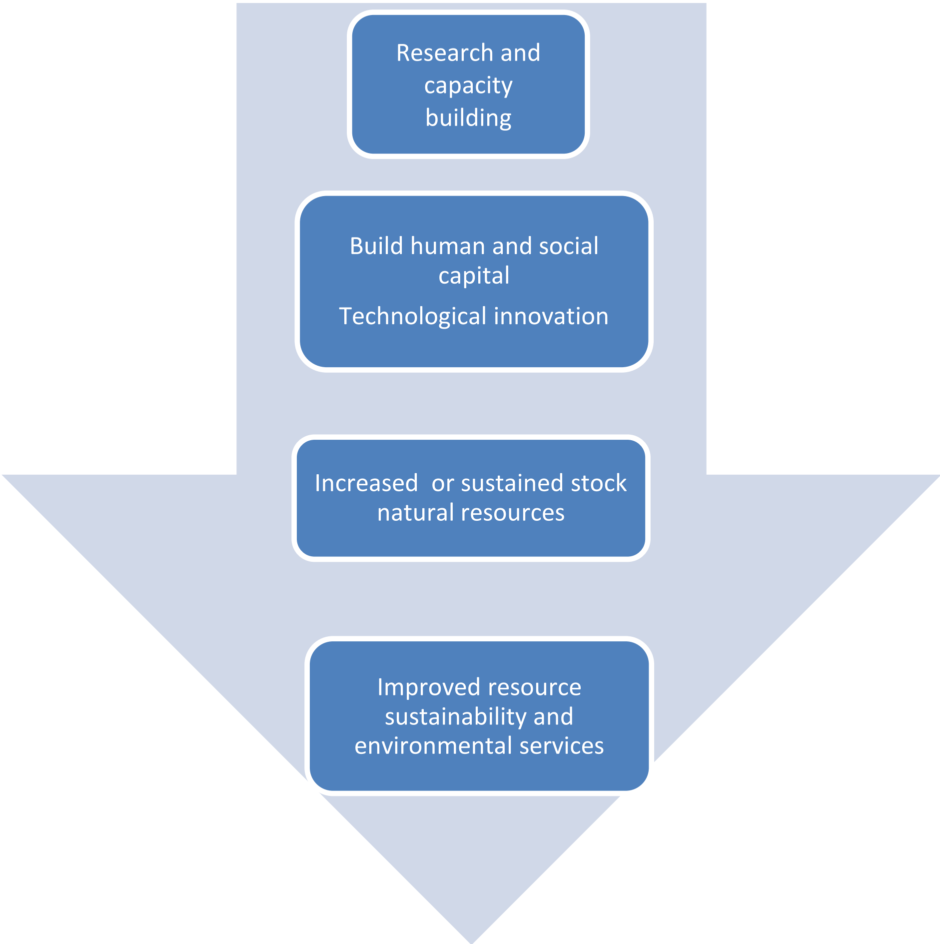
A basic theory of change for the sustainable management of natural resources is shown in Figure 4[7]. Farmers and communities need to use human, financial and social capital to improve the condition (or stock) of their natural resources (soil, water, nutrients, forest, pastures, biodiversity, etc.). This will lead to improved flows of environmental services, such as productivity of soils (in terms of their nutrient, organic matter and moisture content), stabilized soils that do not erode, clean water, greater biodiversity, more trees, multi-functional landscapes etc. CRP research needs to take these issues into account in designing new technologies to improve agricultural production. Improved understanding of the policy and institutional changes is needed to ensure that farming enterprises can afford to adopt such technologies and gain access to the new knowledge. Seeking ways to stimulate the community, public and private investments also are needed to build up stocks of natural capital. Manager and community learning and empowerment will be part of the solutions but are difficult to measure. Many benefits of improved environmental services will be captured on-farm, but some will arise in the form of external public goods, such as less polluted waterways or greater sequestration of carbon, that can benefit much larger regions and populations. This has implications for judging the scales at which impact of NRM research outputs are measured and monitored.

Costs and benefits of changes in natural resource endowments vary substantially across temporal and spatial scales. A short-term local gain may entrain a longer term regional or global scale loss. Relevant spatial scales of analysis for capturing outcomes at farm and community levels are often more easily defined than the scale required for capturing benefits that reach broader communities. For instance increases in biodiversity or decreased greenhouse gas emissions may yield few benefits to a smallholder farmer/ whereas improved watershed protection may benefit people and businesses located downstream, and with large river basins this could have cross-border impacts. Hence, the nation state might be an appropriate scale for defining some of the IDOs needed for capturing impacts of improved NRM although for many NRM attributes other scales will need to be considered.

Whilst Figure 4 represents a simple linear view of the components of an NRM impact pathway, in reality, impact pathways from agricultural research to better sustainability of natural resources are highly protracted and characterized by context specificity. Farmer

[7] The more realistic non-linear theories of change for natural resources and environmental outcomes that involve iterative changes and feed-back loops are described in the ISPC white paper *Strategic overview of CGIAR Research Programs, Part 1. Theories of change and impact pathways* (December, 2012). The highly simplified schematic of Figure 4 seeks only to highlight the two aspects of the pathway - building capacity for innovation and that most NRM pathways involve changes in the extent of natural capital - that can become targets for IDOs and discrete measurement.

Figure 4. Impact pathway for improved NRM



adoption of resource management recommendations and technologies is highly contextualized. It is also influenced by the fact that changes in ecosystem functions and environmental services may take years to become apparent while returns on investments to improve farming practices are immediate. While some changes in natural resources happen locally and over the short or medium-term, many changes occur over longer time periods that are beyond the economically relevant time of interest for small-farmers (Stern et al. 2012). Generic assumptions on technology applicability can rarely be made and cases of broad-scale technology adoption resulting in large scale impacts have been very limited.

As appropriate to the CGIAR's comparative advantage, CRPs will focus on a small subset of drivers of change in SLO 4. These drivers will be those that can be influenced by agricultural research and that give complementary benefits under SLOs 1 – 3. The primary target of IDOs for NRM will be technologies and policies that maintain or build the natural capital of land, water, soil nutrients, carbon balance and biodiversity. Research must aim to improve the efficiency of use of these capitals – essentially producing more crops while maintaining or with less depletion of these resources. The recent NRM review of the CGIAR argued that the evidence of the potential gains from improved resource efficiency is becoming apparent[8].

The potential list of IDOs across the range of NRM research is very large, and thus they will need to be chosen with care. Only a few illustrative examples are provided in Table 6.

Table 6. Some examples of potential IDOs for sustainable management of natural resources and their properties

IDO	Stage along impact pathway	Time to achieve outcome	Relevant scales
Adoption of improved NRM practices at farm and landscape scales	Early	Short to medium term	Plots to farms and agro-ecological systems
Ecosystem health – capital stocks	Intermediate	Long	Adopting regions
Soil organic or carbon content	Intermediate to advanced	Medium to long	Adopting regions
Soil nutrient balances (e.g. measured as phosphate or nitrogen-use efficiency)	Early to intermediate	Short to medium	Adopting regions
Fuelwood and construction timber availability	Intermediate	Medium	Adopting regions
Water quality and flows	Advanced	Medium to long	Adopting regions; river basin
Status of fisheries	Advanced	Medium to long	Adopting regions; river basins, country

Regarding the potential targets, adoption of farming practices which improve NRM is a necessary step towards impact and important for CRPs to monitor, but too early along the impact pathway to serve as a proxy for SLO4. Water quality and flows, or the status of fisheries, are examples of steps at the advanced end of the impact pathway. They are medium-to long-term targets that are often affected by a number of economic sectors other than agriculture. Hence impact is beyond the control of agricultural research institutions and impacts difficult to attribute to agricultural research efforts. Models that link outcomes at the farmer's field level to larger spatial scales are essential tools. Suitable medium-term outcomes could include targets on carbon sequestration, forest cover and soil erosion recovery. Changes in resource use efficiency (water, nitrogen) to be achieved through genetic enhancement, if properly assessed, may also be suitable intermediate outcomes and proxies for the SLO.

The indirect effects of poverty and food security on the natural resource base have been the subject of considerable research. Acute land degradation has been shown to be associated with high levels of poverty but there are no explanations for the cause and effect. Degradation

8 The PNAS special issue hosting a set of research articles from the 2011 Science Forum presents recent research which indicates the potential gains from improved resource use efficiency. http://www.sciencecouncil.cgiar.org/fileadmin/templates/ispc/documents/Mobilizing_science/Science_Forum/SF11_Summary_Final_15Dec.pdf

could be the cause of poverty. It has been postulated (Environmental Kuznets Curve) that environmental quality deteriorates at the early stages of economic growth but improves at later stages of development (Stern, 2004). The relationship between poverty and the state of natural resources is governed by complex socio-economic, cultural and biophysical factors and likely to be highly indirect. Fereres et al. (2013) have synthesized a number of cases, invariably context-specific, that illustrate the effects of selected drivers of SLOs 1-3, such as income, urbanization, energy requirements and diet changes on environmental impacts.

The CGIAR portfolio covers a vast area of research targeting SLOs other than SLO4 but with potential for impact on SLO4. For enhancing mutual advancement of several SLOs and particularly for dealing with trade-offs, the relationships between SLO4–specific activities and underpinning the sustainability of outcomes in other SLOs needs to be explored at the planning stages of the CRPs.

Measuring change in the natural resource base also needs to be assessed. Sometimes desired IDOs will be difficult to measure on the ground within realistic time frames because they represent complex systems or processes subject to unpredictable shocks (e.g. weather). Targets may be the *prevention* of depletion, degradation, or loss over time, which may be more challenging to assess than an increase in natural capital or flows. Recent uncertainties over likely trajectories for fossil fuel availability and prices, and over the nature of future climate changes, demonstrate the very high level of uncertainty associated with dealing with long term sustainable natural resource use issues.

The Challenge of Linkages Among the Four SLOs

The CGIAR has identified four SLOs as its ultimate goals. Most impact pathways will lead towards more than one SLO and the outcomes may inevitably involve linkages between SLOs. Some linkages may be synergistic and positive (win-win) but sometimes they will be negative and involve trade-offs between different impact pathways or research efforts.

The nature of many of these linkages is still not fully understood largely because they are context-specific, but also because they are influenced by other important drivers. One of these drivers is population growth. Another, and one which has often been neglected in recent donor and CGIAR deliberations, is the key role of economic growth. Growth in per capita incomes is the major determinant that can leverage other interventions to reduce poverty and food insecurity and enhance the natural resource base. Indeed, it can be difficult to achieve significant and sustained reductions in poverty and food insecurity without adequate growth in per capita incomes. Nutrition and some environmental values will also be more easily improved in a context of economic growth. Ignoring growth also brings other dangers. For example, some approaches to poverty alleviation and environmental sustainability could lead to outcomes where sustainable farming systems or carbon capture are achieved at low levels of productivity. This may look good from a short term environmental perspective and score well against some IDOs, but it may not last when confronted by increasing population pressure and rising livelihood aspirations. These examples highlight the need for IDOs that address the performance of the entire natural resource system within which poverty alleviation and food security are to be achieved (such as watershed and multifunctional landscapes).

Some of the most important linkages between the four SLOs that have been identified in past agricultural research are as follows:

- New technologies that raise productivity are not always pro-poor within adopting regions. This depends very much on the prevailing socioeconomic conditions, such as the distribution of land, small farm access to modern inputs and markets, gender empowerment, and whether new technologies are scale neutral or not (Hazell and Haddad, 2001). On the other hand, many technologies for food staples can sometimes make important indirect contributions to poverty reduction and food security through food and labor markets. During the green revolution, for example, these indirect impacts often far outweighed the benefits observed within adopting regions (Hazell and Haddad, 2001).
- Despite co-benefits obtained through food and labor markets, R&D investments that help some regions grow faster, and achieve favorable SLO outcomes, can sometimes make other non-adopting regions worse off. This can happen, for example, if the successful region drives down the market prices of its main outputs, making it difficult for farmers in other regions to compete when they have not benefited from the same productivity enhancing technologies.
- On their own, reductions in poverty and food insecurity are insufficient for ensuring improvements in nutrition and health. The green revolution, for example, made dramatic changes in the availability of cereals at reduced prices which helped slash poverty and food insecurity. But by making cereals more profitable relative to other crops, it sometimes inadvertently led to reductions in the production of other nutritionally rich foods and to higher prices, and this contributed to more calorie intense but nutritionally sparse diets (Hazell, 2008).
- Some types of resource degradation (e.g. deforestation, soil erosion, soil nutrient mining) are often linked to poverty, hence it is expected that research interventions that help reduce poverty will also lead to reduced resource degradation. There are cases where this has been shown to be true, and a lot of CRP research is premised on this positive linkage. However, this is highly context-specific and there are few generalizable solutions. Poverty has to be alleviated in ways that do not deplete natural resources and natural resources have to be maintained or enhanced in ways that contribute to poverty alleviation – research has to operate at the level of the system that delivers on both.
- Many technologies that have contributed to productivity growth, food security and poverty have also had adverse impacts on the environment. Critics of modern farming methods have highlighted the environmental and human health problems that have arisen from the intensive and often poorly managed use of water, fertilizers, pesticides and mono-cropping (see Annex 2). Many of these adverse impacts have occurred at scales larger than the farm.
- Tradeoffs or negative linkages have been noted, such as the environmental costs associated with agricultural intensification, or the poor nutritional outcomes associated with too narrow a focus on food staples. On the positive side, it is hoped that improved NRM and poverty alleviation are strongly linked, but even here the evidence is mixed. Poverty may be reduced by improved NRM, but simply alleviating poverty may not improve NRM.

These observations are not exhaustive, but they were chosen to indicate some of the potentially unexpected consequences of focusing the design of agricultural research too closely on one objective such as increased productivity. One focus of CGIAR research could be to explore more of these inter-linkages and to prioritize key knowledge gaps. These observations should also help to raise attention as the CGIAR moves from an IPG knowledge and technology generator to an organization that focuses much more explicitly in trying to ensure development impacts, that possible countervailing or corollary outcomes can result from program actions and that monitoring nets should be thrown as wide as is feasible to track the possible negative trends and outcomes.

3. GENERAL CHARACTERISTICS OF SYSTEM-LEVEL IDOs

Aiming at System-level IDOs

The earlier ISPC white paper (ISPC, June 2012) noted that IDOs represent potential changes that occur in the medium term that are intended to affect positively the welfare of the targeted population or environment, and which can be influenced by research carried out by the CGIAR and its partners. The IDOs can be influenced by research attributable to CRP-level activities and these IDOs are necessary precursors and logically linked to the SLOs. Intermediate development outcomes at the System level (or SL-IDOs) need (a) to be sufficiently discrete to take account of trade-offs between achieving the different SLOs, and, (b) to have the potential to be influenced by the collective of CRP research at a scale corresponding to the CGIAR's target domains. The earlier paper envisioned these as reflecting changes in productivity, the state of natural resources, and enhanced equity and empowerment of human populations in specific production systems, agroecologies and regions. These IDOs at both CRP- and System-level are the result of multiple activities, including by diverse actors outside the CGIAR. The SL-IDOs are documented through System-level impact studies

At the System-level, defining a set of IDOs responds to the requirement to connect the CRP research activities to the high-level SLOs – i.e. to fill in 'the missing middle'. They could provide a framework within which to highlight the different pathways from CRPs to impact at the SLO level and hence to inform the design of CRPs and collaborative activities to enhance likelihood of impact. They could also help to identify 'gaps' in the portfolio of CRPs and thereby steer the CGIAR's research priorities. Filling these 'gaps' would enhance the overall impact of CGIAR research on the four SLOs.

Ideally, the SRF should lead the development of the CRPs. The specification of CRPs, however, occurred before the SRF was finalized, and so far provided CRPs have provided variable detail on how former and new research target and address the SLOs. Given this situation, through an iterative process of developing IDOs at both the System and CRP levels, it should now be possible to improve alignment of CRPs with SLOs. The IDOs described at the System level can confirm and refine the CRP IDOs being developed and contribute to the strategic alignment of activities and goals across CRPs. As a whole, the System-level IDOs should provide a vision of the potential impact of the CGIAR in the medium-term; some deriving from a large volume of research across many geographies, commodities and agricultural systems, and others deriving from smaller investments in specific issues or small domains. Ideally they reflect the CGIAR's current comparative advantage and competences of the CGIAR and its partners.

Desirable Properties of System-level IDOs

System-level IDOs lie somewhere along impact pathways between research outcomes and SLOs, which are the ultimate measures of impact. The ISPC's White Paper on prioritization discusses the SL-IDOs as representing multiple, similar IDOs developed through different impact pathways specific to the CRPs (for instance productivity increases through several commodity specific impact pathways). Thus, while the scale of the outcome is different between a CRP IDO and the SL-IDOs, the distance along the impact pathway could be similar. The examples of SL-IDOs given earlier in this paper represent differences in interpretation regarding the level at which they should be set and the examples vary in terms of their distance to the SLOs along the impact pathway. For instance 'child malnutrition' is acknowledged to be an advanced level indicator for SLO1 and an impact indicator for SLO3. However, in deciding on the level of the SL-IDOs along the impact pathway, it is important to consider that the further away from research activities the IDOs are set and the closer they are to the SLOs, the more difficult it becomes to design and monitor the precise impact pathway to the IDOs and to attribute changes in the IDOs to research.

In conclusion, in order to serve as useful guides for priority setting, SL-IDOs need to be selected that conform to a number of desirable properties:

- While they need to indicate meaningful steps towards achieving one or more SLOs, they also need to be realistic in terms of what the CRPs or the CGIAR System can reasonably be expected to deliver.
- SL-IDOs need to serve as lead indicators or proxies for SLOs, not become ends in themselves. This is to ensure that the dogged pursuit of individual IDOs does not lead to inadequate or even perverse outcomes, something that arises all too easily in management systems if a box-ticking culture is inadvertently created.
- The SL-IDOs need to be linked to the SLOs through a theory that is supported by the best evidence available and further research may be needed for building the evidence base. Progress towards achievement of SL-IDOs should generate confidence in the stakeholder community that the overall research investment is being appropriately directed.
- SL-IDOs should capture things that are within the comparative advantage of the CGIAR. For practical purposes this might be taken to mean that only pathways involving a key role for international agricultural R&D should be considered by the System and CRPs.
- The SL-IDOs should cover a range of intermediate outcomes that generate value propositions from the range of CRPs and capture their IDOs at scale.
- SL-IDOs need to anticipate linkages amongst SLOs. Many impact pathways will lead to more than one SLO. Multiple-goal outcomes may be win-win, but sometimes trade-offs can arise. To serve as lead indicators, planning for SL-IDOs needs to anticipate the kinds of relationships that exist among (SLO) outcomes.
- CRPs in designing their IDOs need to be cognizant of these SLO linkages. So, for example, a CRP working on the intensification of cereals in poor regions not only needs IDOs to proxy for likely impacts on poverty and food security among adopters, but should also anticipate in its theory of change any positive or negative environmental or nutrition and health impacts that might arise within the adopting region.
- Where potential trade-offs between goals arise, they need to be resolved at the planning stage of a CRP in the first instance. Where concerns persist, means should be established to track trends and policy changes which bear on the trajectory towards development results and wider environmental externalities.
- The set of SL-IDOs also needs to capture possible outcomes that result from linkages between CRPs and that will not be captured at the individual CRP level. It can be imagined that CRP collaboration or additional system linkages will be

required for the proper definition of SL-IDOs of this sort. This collaboration will be especially important for assessing indirect outcomes (both positive and negative) that arise beyond the adopting regions of individual CRPs. By including these at the planning stage (and this will require a portfolio perspective) negative trade-offs might be avoided or managed, and positive synergies exploited (e.g. through the right mix of technical and policy research).

- Following from the above, SL-IDOs should be useful for making attributions to the combined contributions of CRPs and their research and development partners.
- Some types of research may have long lead times before IDOs can be achieved. Relevant time frames will vary by CRP, but the CGIAR System needs a set of SL-IDOs that, at the aggregate level, capture an appropriate mix of short, medium and long term outcomes. Within the framework of time-bound IDOs, a sufficient volume of long-term and potentially risky research is needed for securing the future delivery pipeline.
- CRPs work at different spatial scales, including targeted micro regions, commodities, agroecologies, countries and the global domain. Therefore System-level IDOs need to be identified at meaningful integrative scales.
- SL-IDOs should be measurable and amenable to monitoring. This does not always mean they have to be quantifiable, but qualitative IDOs must be defined and measured in consistent ways that can be compared over CRPs and over time.

4. ISSUES FOR SYSTEM-LEVEL DESIGN OF A RESEARCH PORTFOLIO

The ISPC's intent is to encourage forward planning of the portfolio and the individual CRPs in ways that fill in the pathways, the "missing middle", between the high-level goals of the System and its researof target domains and to the possible collateral effects (and possible synergies) of pursuing research towards any one goal. However, the planning through use of CRP- and SL-IDOs also allows the System to make its goals transparent and to assess if the right balance of research and investment effort is being achieved. This is the first step in defining the portfolio appropriate for the reformed CGIAR. It could be imagined that the CGIAR to date has been involved most convincingly in research towards food security targets, and in the maintenance of natural resources. Research has contributed towards poverty alleviation but work on the nexus between agriculture and human nutrition, apart from the specific program on biofortification, is at an initial stage. In moving on from the development of individual CRPs to a System portfolio aimed at development goals, the ISPC encourages further attention to other dimensions of decision-making as discussed in following sections.

Prioritization at the System-level

Despite largely representing international public goods research, CRP IDOs should be defined for distinct target domains, and outcomes and (largely) human welfare impacts are expected to accrue in individual countries and defined geographic areas. This geographic specificity occurs because uptake (as described earlier) is frequently context-specific. This means that prioritization of contexts is required at the System level for several reasons. First, prioritization needs to be made at the level of beneficiaries (see the discussion of SLO 1). As stated in the 2012 ISPC White Paper, decisions are also needed on broad System-level target domains, including regions, agroecosystems and major commodity-based systems. Such decisions on priority target domains require that the CGIAR leaders, stakeholders and donors agree on the choices involved; for instance that progress towards impact on the poorest people and most deprived countries and regions may involve slower progress and smaller impacts than targeting relatively better off farmers and regions where faster and larger effects on food security (for instance) might be made. Or, conversely, that impact pathways are understood with enough certainty to suggest that focus on more favorable regions with higher productivity is a good bet to ensure food security, poverty alleviation, and improved nutrition in less favorable regions, where farm families are net food consumers, through effects on food availability and commodity prices.

Sub-Saharan Africa has been the highest priority region for CGIAR research for several decades through Center-led strategies. A more explicit agreement on the relative importance of SSA should be reflected across the CRPs in terms of resource allocation and of CRPs determining their target domains more explicitly and transparently in SSA and other regions Similarly, the CGIAR operates in key areas in Asia due to persistent poverty and resource degradation problems. In other locations with high research potential, the collaboration may aim at transferring the results to the primary target countries and locations. The CGIAR also needs to understand how its comparative advantage *vis-a-vis* the private sector and the NARS is evolving and where international public goods research is most needed and where others can best contribute to fulfilling the CGIAR's aspirations.

Additional considerations include agroecologies. Currently three agroecologies have been chosen in the systems programs (series 1 CRPs). The choices echo the historic mandate of the Centers that led to the CRPs. This prioritization of dryland, humid tropic and aquatic agricultural systems could be enforced by design, by increasing co-location and integration of activities of multiple CRPs that operate within the same agroecologies to better capture synergies and enhance impact.

Prioritization could either be focused on need or pragmatically coordinated with major national governments and willing partners, including the private sector. By operating in countries that vary widely in terms of the strength of the national research system and investment levels in agricultural R&D, the CGIAR needs differentiated strategies. The CGIAR has strong and evolving relations with countries that have considerable research capacity and investment levels superior to those of the CGIAR. These countries, for instance India, still have high levels of poverty, but the CGIAR's strategy needs to be different from strategies in countries with institutional weaknesses. Moreover, the CGIAR can leverage capacity and resources in countries with growing economies as global partners for jointly tackling development challenges in the poorer countries and regions.

From the SLO impact pathway analysis it can be concluded there is considerable evidence about the fundamental complexities underpinning the impact pathways from research to development impact in the System's high level objectives. Agricultural research is but one factor contributing to change in the SLOs. Furthermore, System-level discussion on prioritization among potential IDOs may also need to account for value- or moral-based judgments. Strong impact orientation, particularly when impacts are expected in the relatively short term and of a relatively sustainable nature, could lead to the CGIAR picking target domains where the ability to absorb international public goods is high rather than choosing areas, communities or populations that are most threatened by degrading natural resources, climate change, and political instability. The bottom line is that CGIAR research plans must to be transparent with regards to justifications for focus and resource allocation across geographies, agroecologies, and commodities. The path forward is through development of robust theories of change and impact pathways that link research outputs with IDOs at intermediate and system levels. Ambition and feasibility need to be balanced in the selection of research for development targets.

Using the IDO results framework for developing a portfolio

The CRPs' current coverage of regions, locations, commodities and systems is a heritage of the CGIAR's historic mandates and locations. While this is due to the brick and mortar aspects of the Centers and their assets, and competencies and brands linked to specific research areas, the CRPs are by nature more flexible and time-bound. Therefore, at the System-level, there is scope to re-evaluate the 10-15 year priorities within broadly defined parameters, such as region/sub-region, farming systems, commodity-base, and the feasible targets for poverty alleviation through agricultural research. The IDO structure allows the System first to identify its current range of targets (and investments) and to confirm them or shift gradually to assume new responsibilities and bring former areas of emphasis to closure.

Within the set of IDOs (CRP and system-level), a larger volume of effort and resources can be placed on those that represent the most pertinent and widespread development challenges where agricultural research can be effective and the CGIAR with its partners has a high comparative advantage. Other SL-IDOs may have a more restricted scope, target domain and research supply within the CGIAR. For practical reasons, the current CGIAR Center fixed assets, long-term programs, existing locations and established partnerships must had a large influence on the starting point for CRPs and the relative mix of SL-IDOs. There is now opportunity for the SRF to be more visionary and to point towards gradual changes in System-level resource allocation to influence spatial (regions, agroecological, country, etc.) and commodity priorities, particularly where this may lead to greater collaboration and synergies between CRPs.

In the longer term, it is envisaged that the System will take a more assertive role in defining research priorities. Based on foresight and other strategic studies that evaluate and update the CGIAR evolving comparative advantage, the System could use its IDOs to signal priorities for the development of future CRPs to enhance overall impact. The SL-IDOs can become the tool for shifting attention to new challenges to be addressed. From a prioritized set of SL-IDOs, the CGIAR's research priorities can be made evident to stakeholders who should also be involved in negotiating the strategic foci of the CGIAR's activities.

5. HOW WILL IDOs BE MONITORED?

The SL-IDOs can also be used for expressing ambition in terms of expected aggregate results from the CGIAR and for assessing progress and documenting impact from the individual research paths of the CRPs towards the SLOs at an aggregate, intermediate level. The SL-IDOs are also likely to combine many different kinds of interventions from CRPs, each dealing with a specific area of research and target domain. However, while the CGIAR contributions are important, they are only a part of development steps that result in sustainable impact. Choosing SL-IDOs for which the direct effects of CGIAR research can be traced or attributed is essential, and the IDO concept is intended to serve a feasibility purpose both in planning and in assessing impact.

Tracking and documentation of outcomes and impacts requires CRPs to benchmark baseline data for key performance indicators and then monitor changes in these parameters. Thus, the CRPs will be monitoring their own IDOs by accumulating data from sentinel sites and other sources, and by conducting adoption and impact studies. The accumulated data and impact assessment results will be essential for making conclusions about progress towards IDOs, also at the System-level. However, as discussed earlier, the spatial scales where the combined impacts of multiple CRPs accrue, including their interactions, are different from individual CRP scales. The spatial units that are most meaningful for monitoring the IDOs depend on the immediate target domain of the research, which for different types of research may vary. For food security, nutrition and poverty goals, the country level, or sometimes a well-defined sub-national region, may be optimal. While policies and institutions that affect both adoption and subsequent changes along the impact pathway towards the SLOs are national, the spatial unit for the potential achievable impact may be vary depending on the targeted farming systems, farm typologies, agroecological zones, river basins or community profiles. Thus it is difficult to determine a default scale *a priori*.

It is worth noting that the CRPs collect data and information primarily for their internal decision-making and accountability purposes. Indicators that are informative for the donors regarding desired development outcomes and impacts, for instance on poverty, hunger, total factor productivity or environmental health, each encompass a large number of factors many of which are not related to, or controlled by, agricultural research. These high level development indicators cannot be easily used for teasing out the value of CGIAR research even if that research may have contributed to development change. Furthermore, index values and composite indicators disguise variation among the parameters comprising those composite measures. Likewise, aggregation of data across different data sets, programs and their sub-units disguise individual program and unit values. The purpose and utility of measurement therefore needs to be considered and whether the costs associated with collection of the and supporting information are commensurate with the benefit from their expected use. On-the-ground monitoring costs by CRPs need to be built into funding plans.

A recent assessment of indicators, metrics and monitoring systems (Shepherd et al., 2013; and references therein) concludes that there is little information on how indicators have been used in decision-making and policy. The development of universally agreed, balanced, and comprehensive indicators, indices, or indicator sets is challenged by changing natural and social conditions, and scientific discoveries opening new questions, and changes in public and policy concerns (Rinne et al., 2012). Drawing from findings on sustainable development, it is suggested in the review that indicators need to be designed for a specific audience, purpose and context as there are no sets of indicators that are universally accepted and backed by compelling theory of change and rigorous data collection and analysis.

Collecting data for CGIAR impact assessment purposes at higher scales than is feasible for the CRPs will need to be thought through anew. Availability of credible data at suitable scales is a challenge that the CGIAR will need to address by linking to existing services and initiatives where possible. Yet the CGIAR needs to cautiously explore whether data available from elsewhere collected for other purposes than the CGIAR's can be reliably linked to the CGIAR's interventions. For instance, the CGIAR research agenda for enhancing agricultural development will be influenced by the Rio+20 Conference global agreement to develop a set of Sustainable Development Goals (SDGs), which will build upon the Millennium Development Goals and converge with the post 2015 development agenda. Indicators will be developed that are pertinent to the work of the CGIAR. Researchers argue that in the new

SDGs potential conflicts between different development objectives and sustainability objectives need to be resolved (Griggs et al. 2013); such potential trade-offs need to be addressed also in the CGIAR's strategies. In addition to livelihoods and food security, goals such as water security, clean energy, healthy and productive ecosystems have been suggested. Quantifiable global goals - for instance, for nitrogen release to the atmosphere and phosphorous release to waterways - are proposed to be achieved through increased nutrient-use efficiency.

Limitations of any monitoring approach and associated metrics for use in management and funding allocaton decisions will need to be transparently discussed and developed. SPIA's impact assessments that may span across several CRPs are likely the System's most realistic means for documenting achievement at the level of SL-IDOs. Even in rigorous studies, however, attribution of observed development changes to research interventions is a challenging proposition.

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Annex 1. Possible questions for research at the agriculture/nutrition nexus arising from gap analysis

A mix of macro (policy-level), programmatic (cost-effectiveness of alternatives), and micro (physiological – human and cultivar) research is required which matches the range of economic, social and biophysical research highlighted by the CGIAR Independent Research and Science Council (2012)

Which **metrics** of nutritional well-being are most appropriate (individually or as groups) as markers of success for food-based approaches?

Which fruits and which vegetables matter more in delivery of key nutrients in relation to ***measured*** **micronutrient status** outcomes?

How much food sufficient to meet defined nutrient needs and feasible/probable (**dose-response**)

Which crops most contaminated by **aflatoxins**, and how does that translate to ingestion and impact on nutrition and health of **child stunting/wasting.**

What **anti-nutritional factors** must be prioritized in agricultural research?

What are the most cost-effective ways to address **mycotoxins, food saf**ety.

Determinants of purchased food choices in context volatility and shocks.

Gendered entry barriers to program participation (including opportunity costs of time), **program fidelity** and intensity of uptake of new technology among households containing nutritionally-vulnerable demographics.

Implications for product research of global diet shifts to **processed/packaged foods**.

Subsectors of agriculture (not just home gardening) that are best combined with non-agricultural sectors (health, education, water provision, etc.)

Agriculture as platform for delivery of messaging on nutrition knowledge, not just extension.

How price shocks translate to consumption of '**non-tradables**' (millets and sorghum, etc.)

Pathways research relatively less important than 'mechanisms research'. Much needs to be understood about reasons why, and contexts in which, nutrients in foods *do not* always become building blocks for good nutrition outcomes.

Research on products (enhancing nutritional value of individual crops) still important. But has to be placed in **wider context of human impacts derived from individual choices** that relate to non-farm activity as much as farm-focused investments.

Annex 2. A qualitative list of known or perceived effects of poverty alleviation and of improvements in food security on the sustainability of natural resources

- ***Expansion of agriculture into:***

  a) ***Forests*** *i) soil degradation due to organic matter losses; ii) increased CO_2 emissions; iii) loss of biodiversity; and, iv) losses of ecosystem services from forests.*

  b) ***Fragile lands*** *(ej. rangelands) i) soil and water degradation risks; ii) increased CO_2 emissions iii) loss of biodiversity; and, iv) losses of ecosystem services.*

- ***Increased soil erosion from agricultural soils*** *caused by tillage and other soil management practices.*

- ***Irrigation practices:***

  Diversion of water away from natural aquatic ecosystems (rivers, lakes, oases, and other groundwater-dependent wetlands).

  a. Surface water overuse (impacts on stream flows and on aquatic biodiversity).

  b. Irrigation based on surface water could lead to the development of perched water tables resulting in waterlogging in many areas and in soil salinization.

  c. Fertilizer leaching into underlying aquifers (human health, etc.).

  d. Water quality deterioration (excess nutrients, acidification, metal pollutants, toxic wastes, salinity, increases in total suspended solids, and in eutrophication).

  e. Mobilization of salts and other ions in the soil and subsoil that may result in environmental pollution and health risks (toxicity from arsenic or selenium, or fluorosis in some areas).

  f. Groundwater depletion that is not sustainable.

  g. Falling groundwater tables have resulted in health risks from the dissolution of toxic ions in the vadose zone.

  h. Increased energy consumption due to falling groundwater tables (GHG emissions).

  i. Groundwater overdraft in coastal areas can cause seawater intrusion.

  j. Waste water irrigation: microbiological contamination and health risks when irrigating with untreated water.

  k. GHG emissions from irrigated rice (methane).

  l. Channel erosion and sedimentation from poor irrigation management.

- ***Fertilization practices:***

  a. Nitrogen and Phosphates are lost to air (GHG emissions, N2O), water, and land that cause a cascade of environmental (aquatic ecosystems and marine fisheries, elevated nutrient inputs are known to drive biodiversity losses in tropical areas) and human health problems (N in the environment may also change the prevalence of important infectious diseases, drinking water).

b. Use continues of inorganic fertilization reduce SOM stocks (carbon sequestration, erosion, decline in soil biological activity, biodiversity preservation).
c. Impacts on water quality (human health, aquatic ecosystems and marine fisheries).
d. Inorganic fertilization: high energy requirements (reduction of atmospheric nitrogen and the mining of phosphorus).

- ***Crop protection practices***
  a. Pesticides in water, soils, and air (environmental and human health risks).
  b. Reduction of biodiversity.
  c. Induced resistance to pesticides.

- ***Livestock practices***
  a. Overgrazing (erosion, compaction, land degradation risks).
  b. GHG emissions (methane).
  c. Pharmaceutical pollutants.
  d. Induced antibiotic resistance.
  e. Excess organic matter in water and soil in areas of intensive production.
- ***Aquaculture practices***
  a. Release into water bodies of organic effluents or disease treatment chemicals.
  b. Indirect impacts through its dependence on industrial fisheries to supply feeds.
  c. Source of diseases or genetic contamination for wild species.

- ***Forestry***
  Sustainable forestry management does not normally impact negatively on NR; however, there are many instances where commercial exploitation for biomass extraction exceeds the carrying capacity of forests leading to effects similar to those described in agriculture.

- ***Biofuel production***
  a. Use of new energy crops or perennials reduces biodiversity and negatively affect natural forests nearby.
  b. Use of food crops for biofuels competes with food and feed production.
  c. Consequently, both lead to additional expansion of agricultural lands (see above).
  d. Use of residues decreases soil OM and increases erosion risks.