

Financing Rural Infrastructure to End Hunger

Table of Contents

Introduction	4
Objectives and Approach	5
A note on methodological challenges.....	7
Return on investment and beyond.....	8
Intermediate Infrastructure: The Missing Middle	10
A focus on financing.....	11
Donor Aid.....	11
Public Spending.....	11
Mobilizing private capital.....	12
Investment Priority #1: Storage and Cold Storage Infrastructure.....	14
Pathways	14
Integrated Storage Infrastructure	15
Integration across the distribution chain.....	16
Integration with supporting infrastructure.....	18
Intermediate Infrastructure – Logistics Providers	19
Financing Approaches	19
Public-Private Partnerships.....	19
Government incentives.....	20
Necessary Conditions.....	22
Investment Priority # 2: Decentralized Renewable Energy (DRE) Infrastructure	24
Pathways	24
Intermediate Infrastructure: Training, awareness raising, and community organization.....	27
Commercial and policy challenges.....	27
Financing Approaches	27
Investment incentives.....	27
Policy support	29
Necessary Conditions.....	31
Investment Priority # 3: Feeder Roads	32
Pathways	32
Quality and Maintenance of Feeder Roads.....	33
Need for Alternative Revenue Sources.....	34
Intermediate Infrastructure – Transport Services	35
Financing Approaches	36
Alternative financing solutions	36
Funding the alternative schemes.....	38
Other incentives and solutions	39
Investment Priority #4: Irrigation infrastructure	41
Pathways	41
Where in the water distribution network to focus?.....	42
Intermediate Infrastructure – Irrigation Management Services	45
Financing Approaches	45
Pricing & Public Subsidies for Irrigation	46
Separating capital expenditure and O&M	47
Identifying and targeting food security beneficiaries.....	47

Public Private Partnerships	48
Conclusion	49

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Introduction

The momentum surrounding the historic goal to end global hunger is palpable. The second of the seventeen Sustainable Development Goals (SDGs), adopted by UN member states in 2016, is none other than to “*End hunger, achieve food security and improved nutrition, and promote sustainable agriculture*” – with specific targets to achieve this by 2030.¹ To repeat: the goal is not to halve, reduce, slow the extent, but to end it, and this has acted as a rallying cry for development organizations and governments alike to become a part of this story. Importantly, the harsh reality behind this optimistic story remains that close **to 800 million people** still face hunger, and about a quarter of all children are affected by stunting due to malnutrition, mostly in Sub-Saharan Africa and South Asia.

Investment in rural infrastructure is indispensable for achieving the goal to end hunger; indeed, it has been a focus of economists, development professionals and scientists for centuries, and remains a critical theme today. Most of the world’s hungry live in rural areas, engaged in agricultural activity, and many lack basic services such as energy and irrigation provision due to a lack of infrastructure. There is global consensus that a productive and sustainable agricultural sector will be key to achieving food security and improved nutrition for all²; this requires a robust infrastructure base for farmers and rural communities to overcome the many constraints on productivity growth in agriculture, agribusiness and other formal and informal sectors in rural economies.

In light of a global infrastructure deficit estimated to reach **USD 90 trillion by 2030**,³ policy makers and governments have tended to use these alarming figures to bolster investment in their urban sectors, addressing the acute challenges posed by increasing urbanization, while the rural infrastructure needs have been less in the spotlight. But not only will direct investment in rural infrastructure address *rural* poverty and hunger – it will slow the urbanization trend to a more sustainable pace. According to the International Monetary Fund (IMF), neglecting *rural* (both social and physical) infrastructure, has been one of the major contributors to both rural and urban poverty.⁴

Rural infrastructure can lower the transactions costs of market exchange for farming households, both by improving physical connections and also by reducing information asymmetries. Better physical market connections increase the availability of inputs (improved seeds, fertilizers) and agricultural extension services – in addition to improving market access – all of which are likely to increase agricultural productivity and, consequently, welfare⁵. In addition, infrastructure improves the spread of knowledge, reducing information asymmetries. This can positively affect farmers’ confidence in negotiating prices, and also inform production decisions regarding inputs and techniques. In these ways, and others, rural infrastructure can

¹ <https://sustainabledevelopment.un.org/?page=view&nr=164&type=230&menu=2059>

² http://www.g20-insights.org/policy_briefs/key-policy-actions-sustainable-land-water-use-serve-people/

³ <http://2015.newclimateeconomy.report/wp-content/uploads/2015/10/Ensuring-infrastructure-is-climate-smart.pdf>

⁴ <http://www.imf.org/external/pubs/ft/issues/issues26/>

⁵ ODI 2013

facilitate the integration of farming households into markets – both in agricultural and non-agricultural.

Box X: Infrastructure to End Hunger – Global Policy Agenda Milestones

2005: Trade-related infrastructure is highlighted as one of the four Aid for Trade categories of support, as defined by the Organization for Economic Co-operation and Development (OECD) and the World Trade Organization (WTO) – along with technical assistance for trade policy and regulations, productive capacity building (including trade development) and trade-related adjustment.

*“Aid for Trade should aim to help developing countries, particularly LDCs, to build the supply-side capacity and **trade-related infrastructure** that they need to assist them to implement and benefit from WTO Agreements and more broadly to expand their trade.”⁶*

2009: L’Aquila Joint Statement on Global Food Security at the G8 Summit

*“We support public-private partnerships, with adequate emphasis on the **development of infrastructure**, aimed at increasing resources for agriculture and improving investment effectiveness.”⁷*

2016: Adoption of 2030 Agenda for Sustainable Development

*Goal #2, Target 2.a: “Increase investment, including through enhanced international cooperation, in **rural infrastructure**, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries”⁸*

Objectives and Approach

Two central research questions guide the thinking behind this report:

1. What rural infrastructure investments can have the most direct positive impact towards ending global hunger?
2. How can these infrastructure assets be sustainably financed?

In addressing both of these questions, an extensive literature review was undertaken, including a review of all of the major recent reports by international organizations - such as the OECD, FAO, IFAD and others - on food security and infrastructure, as well as from donor reports from government development assistance programs⁹. This ‘meta-analysis’ of existing research was

⁶ https://www.wto.org/english/thewto_e/minist_e/min05_e/final_text_e.htm (emphasis added)

⁷ [http://www.g8italia2009.it/static/G8_Allegato/LAquila_Joint_Statement_on_Global_Food_Security\[1\].0.pdf](http://www.g8italia2009.it/static/G8_Allegato/LAquila_Joint_Statement_on_Global_Food_Security[1].0.pdf) (emphasis added)

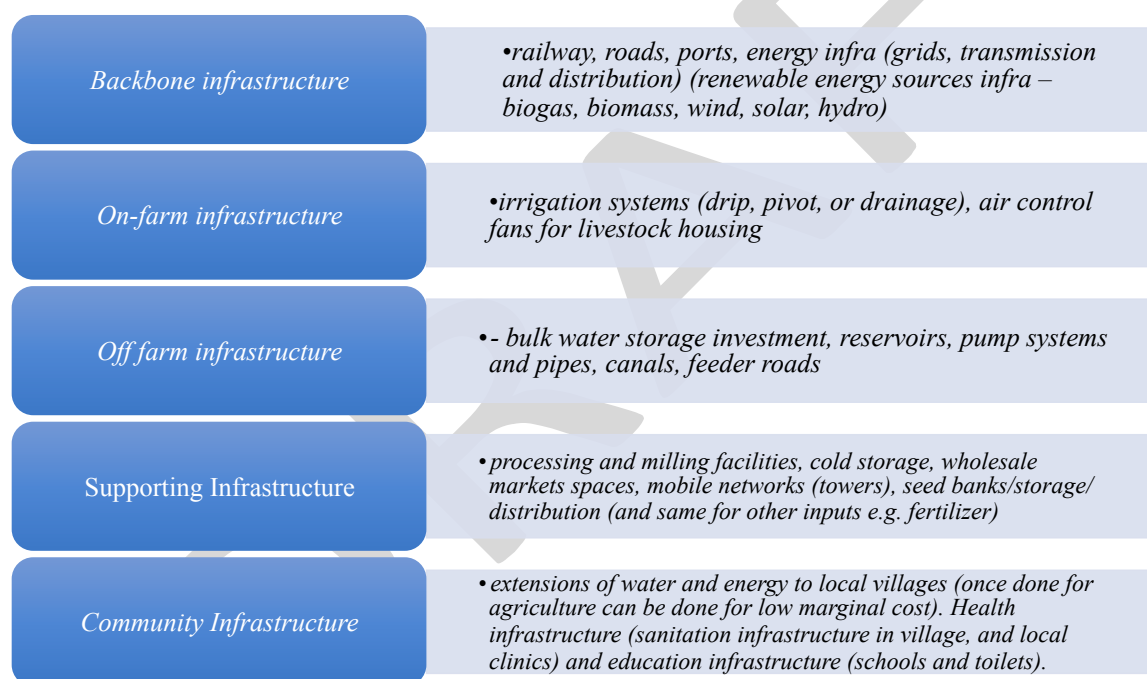
⁸ <https://sustainabledevelopment.un.org/post2015/transformingourworld> (emphasis added)

⁹ A list of these reports can be found in Annex 1

complemented by phone call interviews with experts from agricultural development, agribusiness, infrastructure finance and sector-specific authorities¹⁰.

Beginning with a “long list” of infrastructure assets that affect rural development, poverty, and food security (Figure 1 below), the goal of the literature review and expert interviews were, in part, to pare this list down to a manageable list of **four asset categories** that demonstrate the most robust and empirically verified pathways to food security, and also ones for which financing poses a distinct and persistent challenge. Our focus was to capture the two principle mechanisms through which people experiencing, or at risk of experiencing, hunger can consume more food (and where possible, more nutritious food): 1) by growing more food for own-consumption (i.e. subsistence agriculture) or 2) by generating more income with which to buy more food. Both pathways are legitimate and vital approaches to ending hunger, given equal importance throughout this report.

Figure 1: Long list of rural infrastructure assets that affect hunger



From this long list, a short list of four assets were chosen for an analysis on their pathways to food security and how to overcome the associated financing challenges. These assets are: storage/cold storage, feeder roads, decentralized renewable energy and irrigation infrastructure. This short list selection was informed by the literature review and the expert interviews, and broadly speaking, based on the following criteria: the persistence of success stories over decades of research (empirical and anecdotal), the strength in the established correlations between the infrastructure and the desired development outcome (i.e. ending hunger), and limited by the availability of existing published information.

¹⁰ A complete list of interviewees can be found in Annex 2

It is our hope that this analysis will serve to assist those donors and investors who are dedicated to ending hunger to target their financial resources to high-impact infrastructure categories, and to help them understand why.

A note on methodological challenges

There is much descriptive literature on the positive impact of infrastructure investment on diverse rural development outcomes, such as poverty alleviation, agricultural productivity, and food security. However, a persistent challenge faced by researchers in the field is in confirming the precise causal links between the intervention (e.g. new road) and the impact (e.g. enhanced food security). This can largely be attributed to the extensive multiplier effects of infrastructure investment, the benefits of which can be difficult to capture in a simple model (ODI, 2013). Some studies even challenge the “direction” of this causal chain, referred to as *reverse causality*, suggesting that infrastructure is in response to, not cause of, economic growth, or recognized growth potential.¹¹ Furthermore, some studies have highlighted the limitations of our ability to observe the costs and benefits farmers (and rural communities) face through external analyses¹².

Nevertheless, methodologies have been developed and employed to make these correlations more robust. In the literature reviewed for this report, the following variables are the most frequently used (in order) to measure the impact of infrastructure interventions:

- Market access¹³
- Agricultural trade
- Agricultural performance/ productivity¹⁴
- Poverty incidence/ Household income
- FDI¹⁵
- Food security¹⁶
- Per capita consumption (not done to our knowledge)

Various econometric approaches confirming causality between rural infrastructure and agricultural productivity and poverty reduction were captured in a 2006 World Bank study¹⁷, including simultaneous equation models (SEMs), and quintile regression models; all of those studies covered resulted in a positive and significant correlation. Another methodology used for dealing with reverse causality is the gravity model approach, to measure and predict the relative importance of different variables on a particular outcome.

¹¹ <http://r4d.dfid.gov.uk/PDF/Outputs/IIG/Dercon-wbro1.pdf>

¹² Takeshima et al. 2010

¹³ E.g. USAID 2011

¹⁴ E.g. <http://www.fao.org/docrep/016/ap108e/ap108e.pdf>

¹⁵ E.g. IADB study

¹⁶ OECD's 2011 *Systematic Overview of Food Security Interventions*

¹⁷ Anderson and Shimowaka, 2006

http://siteresources.worldbank.org/INTDECABCTOK2006/Resources/Per_Pinstrup_Andersen_Rural_Infrastructure.pdf

The most rigorous studies reviewed for this report present a counterfactual – that is, also monitor the change in food security indicators or proxies in populations that did *not* receive the infrastructure intervention – for the sake of controlling variables and comparison. For instance, the OECD’s 2011 *Systematic Overview of Food Security Interventions* selected studies and articles that evaluate and assess the impact of agricultural interventions (including but not limited to infrastructure interventions) on household-level food security, and then screened them based on whether or not they presented a counterfactual. From the 300-plus studies found after the first search, only 38 studies qualified for the review¹⁸. This shortlist of 38 studies was helpful in informing this report.

While a full description of these methodologies is beyond the scope of this paper, the report proceeds on the assumption, captured in many studies from the literature review, confirming causal chains – or pathways – between the 4 types of infrastructure covered and food security or its proxies. To the extent possible, our research draws from studies that focus on food security outcomes specifically, but studies and surveys assessing poverty alleviation, market access, and agricultural productivity are also considered relevant as proxies for ending hunger. The beginning of each infrastructure section begins with a mapping of these various impact pathways, inferring the many possible causal linkages between the intervention and the outcome. This choice is neither prescriptive nor normative, but reflects the pathways suggested in the literature and from expert interviews.

Return on investment and beyond

In as far as possible, this report seeks to assess the efficacy of infrastructure investment on its ability to end hunger; that is to end chronic dietary energy deficits (which can be anywhere from 100 to 400 kilocalories/day)¹⁹ that thwart human development and potential, most prevalent in Sub Saharan Africa, as well as in parts of Asia and the Pacific.

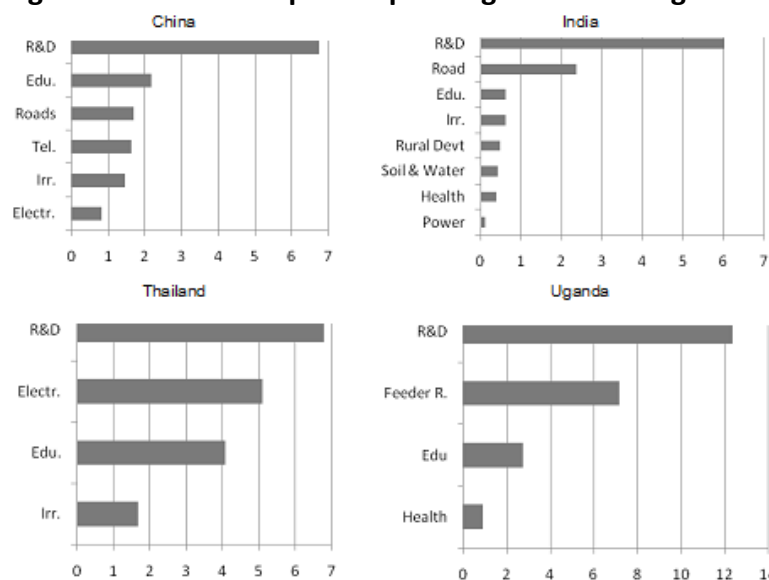
Return on investment is one way to capture and compare different types of agricultural investments, where “return” can be defined in terms of agricultural performance, poverty reduction, or other proxies. A 2012 study by the *International Food and Policy Research Institute* (IFPRI)²⁰ illustrates how different forms of agricultural investments (research, extension, irrigation, fertilizer subsidies, and so on) perform comparatively, using return on investment in terms of agricultural performance and poverty reduction (Figure 1 and 2 below).

¹⁸ <https://www.oecd.org/derec/49558328.pdf>

¹⁹ <http://www.fao.org/docrep/x8200e/x8200e03.htm>

²⁰ <http://www.fao.org/docrep/016/ap108e/ap108e.pdf>

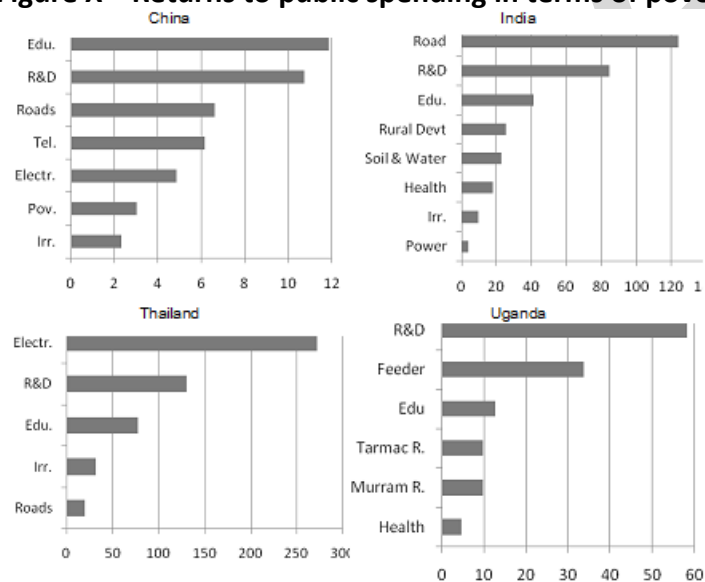
Figure X—Returns to public spending in terms of agricultural performance (IFPRI, 2012)



Source: IFPRI, 2012 (p.g. 28)

Notes: Edu. = Education; Tel. = Telecommunication; Irr. = Irrigation; Rural Devt = Rural Development; Soil & Water = Soil and Water Conservation; Electr. = Electricity; Feeder R. = Feeder Roads. The magnitudes are returns to one monetary unit of different types of public spending in terms of (the same) monetary unit of the value of agricultural production or productivity. The agricultural performance variable is measured slightly differently in each country: agricultural GDP in China, agricultural total factor productivity in India, and agricultural labor productivity in Thailand and Uganda.

Figure X—Returns to public spending in terms of poverty reduction (IFPRI, 2012)



Source: IFPRI, 2012 (pg. 29)

Note: The magnitudes are the reductions in the population size of the poor per monetary unit spent in each area of spending. The respective monetary units are as follows: 1 million baht in Thailand (that is, number of poor population reduced per 1 million bahts spent in different sectors); 1 million rupees in India; 10,000 yuan in China; and 1 million Ugandan shillings in Uganda.

The IFPRI findings show that after investment into agricultural R&D (i.e. seed improvements, new technologies) – which has the single largest effect on long-term agricultural performance –

that investment into infrastructure such as roads, electricity, irrigation and telecommunications all have significant, positive impact on poverty reduction and agricultural performance. Feeder roads in particular showed the highest returns to public spending in terms of agricultural performance in India, Uganda, and China, and strong correlation with poverty reduction. Investment into education had the largest single impact on poverty reduction in China, and ranks in the top three interventions across all four countries covered in the study.

What return on investment might fail to capture in terms of infrastructure, however, is that because infrastructure is integrative by nature, the full extent of benefits is not likely captured. Consider the following:

- Infrastructure is an enabling/foundational investment that has far reaching benefits *over time* on food security and nutrition.
- Infrastructure investment can help prevent diminishing returns to R&D over time: which many agricultural investments in R&D experience. Although such diminishing returns may be in play, the effect of complementarities in public investments could stall this decline. For example, if the effect of agricultural research on farmers' incomes is enhanced by better road infrastructure, thus lowering the transaction costs of accessing inputs and marketing outputs, then continued and simultaneous investments in both R&D and infrastructure may mean that the returns to expenditures in the former would not see diminishing returns over time in one sector; this, in turn, would hold investments in the other sector constant. (IFPRI 2012)
- Infrastructure plays a role in the redistribution of wealth in the economy, and can result in higher long term returns in transforming the economy – not limited to the agricultural sector.

Finally, measuring infrastructure investment must also, critically, capture maintenance investment. Preventing infrastructure collapse and disrepair is generally cheaper than its complete replacement or the introduction of new infrastructure, thus also favourably impacting this return on investment calculation for infrastructure.

Intermediate Infrastructure: The Missing Middle

Hard infrastructure investments are not, alone, sufficient to transform food availability and rural incomes. The success of physical infrastructure interventions to improve food security, as described in the report, are deeply dependent on the complementary services and human capacities, or “soft infrastructure,” to manage it. Between this hard and soft infrastructure is the so-called “intermediate infrastructure” linking them together, including transport services, logistics services, extension services, standards-related services as well as the policies and regulations supporting them.

This point was established at least as early as 1994, with the The World Bank's *World Development Report on Infrastructure for Development*, which highlighted that focusing solely on increasing the quantity of installations was not adequate: more should be done on the

quality and efficiency of related services. Since then, analyses of rural economic infrastructure have increasingly been referencing the systemic inefficiencies that arise without proper intermediate, services infrastructure.²¹

This perspective only serves to highlight the interlinkages of each of the infrastructure assets covered in this report: storage facilities require roads *and* transport services to get crops to collection points as well as reliable energy services to keep perishables cold; irrigation and storage require energy infrastructure and services where pumps or cold storage are involved. Furthermore, the quality – not just existence – of infrastructure and services along supply chain have profound impacts on the quality of the final product, and therefore market value (e.g. potholed roads = bruised produce, longer travel time = reduced shelf life).

In this vein, each of the following four sections contains a box highlighting the intermediate infrastructure considerations specific to the asset category. We present options – though not in any exhaustive way – for promoting and financing robust intermediate infrastructure for each of the four asset categories.

A focus on financing

For each of the four infrastructure assets presented in the remainder of the report, our focus will be on not only identifying their potential for food security improvement amongst users, but also very specifically on how to finance these assets sustainably in the long term. We can distinguish between the three major sources of financing for infrastructure: donor aid, public spending and private capital.

Donor Aid

Donor aid has played an important role in the financing of infrastructure projects in developing countries, especially in rural areas. However, ensuring that the funds are allocated and used in a manner that delivers the most long-term impact has always been a challenge. Aid dependence can weaken accountability and risk management²² and result in aid recipient countries over-prioritizing new infrastructure development as opposed to spending on maintenance and retrofits of brownfield projects. Aid is a limited resource and countries should use it in a smart and efficient way. Instead of funding infrastructure projects outright, grants need to be used to mobilize additional sources of funding. Many of the instruments discussed later in the paper, rely on some form of grant-based solution.

Public Spending

Generally, rural infrastructure is financed by governments, often with the assistance of development finance institutions. As addressing the infrastructure deficit is beyond the budget

²¹ <https://pdfs.semanticscholar.org/043e/62efb6f053374d3f9e0fa772848ecfde7a76.pdf>

²² <http://documents.worldbank.org/curated/en/680631468249703830/pdf/360310Pacific01ture0Report01PUBLIC1.pdf>

of most governments, innovative solutions of how to leverage these resources need to be considered. As will be discussed in detail in the following sections, public spending can be applied at various stages of infrastructure development in the form of project preparation funding, risk capital, availability payments, as well as at the policy level through various fiscal incentives to encourage investment in infrastructure. Before committing public funds to finance projects outright, a *Value for Money Assessment* should be used to evaluate whether this setup delivers the most value for taxpayers.

Mobilizing private capital

A general theme across the four assets is that private capital plays an important role where public resources are not, on their own, sufficient to bridge the infrastructure gap. However, private investors are more hesitant to commit capital in regions where the perceived risks are higher due to remote locations, lower population densities, limited transparency, and higher uncertainties from weather-sensitive economies. At the same time, the return potential of rural projects are often not high enough due to the difficulty of securing a stable revenue stream using more traditional financing structures.

Innovative financing solutions can address these barriers and mobilize more private financing into rural infrastructure projects. However, governments and development finance institutions (DFIs) still need to play an important role to de-risk these transactions. Through blended finance (a mix of public and private capital) the limited public resources can be better leveraged. Underlying project risks need to be assessed carefully and allocated to the party, which is the best positioned to manage it.

The government's responsibilities also include the creation of an enabling regulatory environment, encouraging competition, providing support for accurate demand forecasting, establishing project pipelines, smart use of subsidies, allowing realistic tariff setting (cost-recovering tariffs) and ensuring that the project meets environmental and social requirements.

In general, projects reaching a large number of users, who are willing to pay for their services are easier to be financed by private capital. There is an important distinction between the users' *ability* and *willingness* to pay, which can materially affect the financial viability of the project, as will be discussed later in the paper. As per the World Bank, "the potential for private sector interest in providing infrastructure increases as the activity shifts from public to private. A shift from smaller to more extensive coverage also tends to transcend community-based solutions."²³

When governments are considering to engage private investors in rural infrastructure projects, the following areas need to be assessed and financing solutions applied accordingly:²⁴

²³ World Bank Rural Development Strategy: Reaching the Rural Poor, Annex 5, Physical and Social Infrastructure, 2006

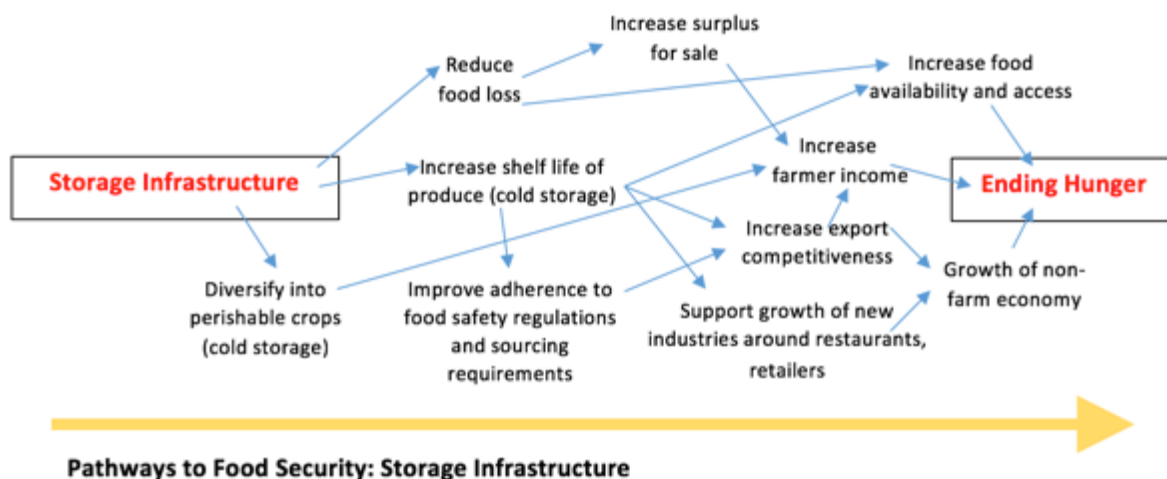
²⁴ <http://www.fao.org/3/a-i0465e.pdf>

- *Source of revenue* (user fees, subsidies, purchase agreements, availability payments, etc.) that is stable and sufficient to cover investment costs and generate a profit
- *Commercial scale* that warrants the high sunk costs involved in project development, including competitive bidding and other fixed legal, regulatory and transaction costs. In addition, the asset size needs to be large enough that is suitable for institutional investors such as pension funds, insurance companies and other private infrastructure funds.
- *Growth potential* for the private party e.g. project is located in a rapidly developing agricultural area, or offers potential for design innovations, operational changes or expansion to raise revenues over time

While similarities exist in innovative structures across the different asset types discussed in the following sections, the solutions are bespoke enough to be covered separately for each asset type. Moreover, financing solutions need to be further customized depending on whether the asset is a public or private good, depending on the scale of the asset (e.g. across different communities and municipalities) and on the sophistication of local capital markets. However, providing bespoke solutions for each specific scenario falls outside the scope of this paper.

Also, it cannot be emphasized enough that applying the right financial solution does not make a project attractive to private capital in itself as often there is a lack of capacities at the procurement level, which would be essential for a well-structured, bankable deal. Therefore, costs of technical assistance and project preparation need to be sufficiently budgeted and funded during project planning.

Investment Priority #1: Storage and Cold Storage Infrastructure



Pathways

Modern storage facilities such as cold storage, grain silos and warehouses, have a critical role to play in ensuring food security and ending hunger. The Food and Agriculture Organization of the United Nations (FAO) estimates that about 1/3 of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year.²⁵ Lack of sufficient storage is one of the main causes behind food losses in developing countries.

Effective storage infrastructure will prevent moisture condensation from ruining a crop post-harvest, while also keeping out pests such as rodents, insects and birds. It can enable a family or community to better preserve crops on-site for their own consumption, increasing food availability and access, or means that a farmer can raise his or her income by a) having *more* unspoiled surplus to sell and b) waiting until off-season to sell, when prices might be higher. The many pathways to improved food security are outlined in Figure X above.

In particular, cold storage infrastructure is an important piece of the food security puzzle. Many foods are actually more perishable than we think: it is known that dairy and meat products need to be refrigerated immediately and maintained at a cool temperature on their journey to market, but roots and tubers, such as yams and potatoes, also benefit enormously from post-harvest cold storage. Access to cold storage encourages farmers to produce, or diversify into, more perishable crops that can fetch a higher market price than non-perishables. Longer shelf life translates into greater export competitiveness. In addition, foods deteriorate and lose their nutritional content faster at higher temperatures, so there are nutritional benefits that can accrue also if farmers incorporate more perishable products into their own diets.

²⁵ <http://www.fao.org/docrep/014/mb060e/mb060e.pdf>

ADB Storage Project in Afghanistan

In Afghanistan, the Asian Development Bank project built 1,100 cold storage rooms across three different districts – increasing farmers’ annual sales of potatoes anywhere from 35% to 60%²⁶. Whereas potatoes would previously go to waste during the winter, farmers now sell and trade potatoes throughout the year.

It should be noted that there are discrepancies in the ways that terms such as ‘food loss’ and ‘food waste’ are used (some studies include pre-harvest losses, and some do not) and methodologies for measuring do differ (some based on physical quantities and some on the loss of value in the production chain). From a value chain perspective, however, food is lost at *each* stage, and strategies must therefore be taken that consider the whole journey from ‘farm to fork’.

Figure x: Food Losses along the value chain



Source: <http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/130211/filename/130422.pdf>

Integrated Storage Infrastructure

Storage infrastructure investment must be approached in an *integrated* manner, supporting value chain strategies. Stand-alone cold storage or processing units will not be effective for addressing the problem of food waste unless they are part of an integrated (ideally cold) value chain^{27 28}.

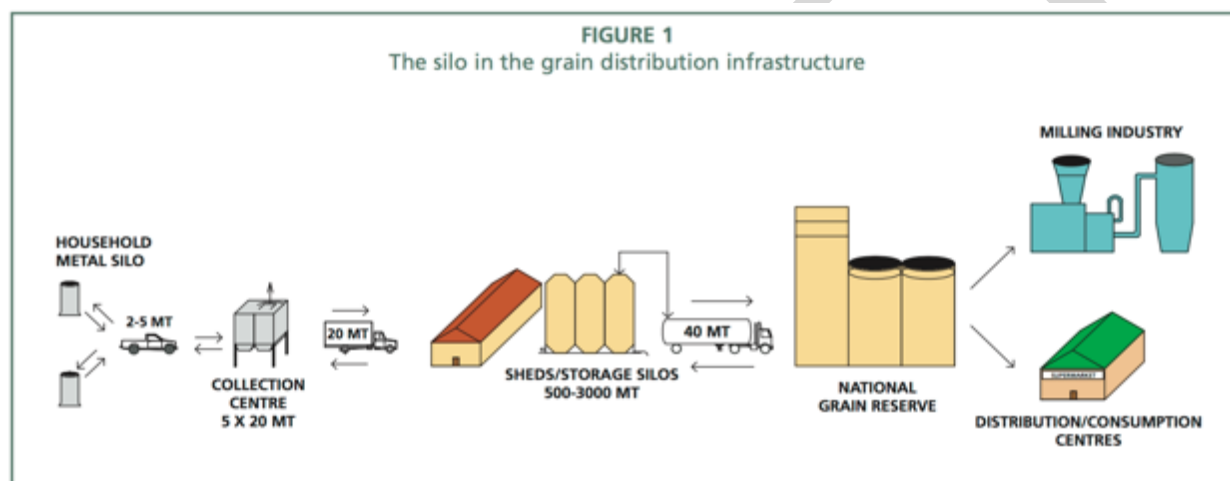
²⁶ <https://www.adb.org/results/agriculture-afghanistan-cold-storage-increases-food-security>

²⁷ <http://postharvest.org/Use%20of%20cold%20chains%20PEF%20white%20paper%2013-03%20final.pdf>

There are two important elements to integration in this context: 1) integration across various levels of storage infrastructure (from the household level to national reserves), as well as 2) integration with other supporting infrastructures.

Integration across the distribution chain

In terms of the former, figure X is a theoretical depiction of the infrastructure required for grain distribution from the household level, through intermediary storage shed or silos, to national distribution centres. Importantly, this distribution network enables the flow of food in both directions (in case of drought or famine, for example). Understanding a particular storage investment in the context of this broader distribution infrastructures important for identifying gaps, prioritizing projects, and making meaningful progress towards food security.



Source: A.Mejía, 2008

Source: http://www.fao.org/fileadmin/user_upload/ags/publications/silos_E_light.pdf

i. Household Level

While many farmers have some form of storage capacity on site, the *quality* of these storage containers is as important as capacity and must not be overlooked. Elevated baskets, or pits in the ground, may serve to store a harvest – but will not protect the crop from condensation, storms, rodents and other troubles. To this end, the FAO has found metal silos to be a key infrastructure for supporting household food security.²⁹ In terms of capacity, these silos can hold between 100 and 3000 kilos of grain; 1000 kilos are enough for a family of five for one year. In terms of quality, it is airtight, keeps rodents out, avoids the need for insecticides, and maintains the quality of the product. A study on the installation of these silos in four Latin

²⁸ The flower industry is one area that is well- established and follows best international practices for exporting. Kenya is a large exporter of fresh cut flowers and accounts for 38 percent of flower imports into the European Union.

²⁹ http://www.fao.org/fileadmin/user_upload/ags/publications/silos_E_light.pdf

American countries find that from 2005 to 2009 the households that adopted silos experienced a significantly higher improvement in their food security and well-being compared to non-adopters (Bokusheva et al. 2012).

1000 kilos of grain are enough for a family of five for one year³⁰.

Even though household storage units like metal silos are relatively low-cost, farms operating with low profit margins typically cannot finance them on their own. Hence there is a reliance on governments or international donors to finance such projects with grants or loans. Strategies for repayment can include revolving credit funds and repayment in grain. Furthermore, as there is a growing track record of household storage units contributing to the fight against hunger, this is helping to de-risk this investment.³¹

ii. Community / District Level

Farmers who market and sell their crops through cooperatives might have some form of shared storage shed or silo. These units could either be owned or rented by the cooperative, with co-financing from members, or perhaps with the support of an NGO or another donor. Where they exist, cooperative storage may be used for storing crops, or for the storage of seed and fertilizer for its members.

Not all cooperatives offer storage, however, and where they do not, finance is often the main barrier. In Ethiopia, for instance, IFPRI conducted a study in 2012 asking cooperatives without storage facilities why that was so, and 90% said that they had a need for them, but not the funds³².

Other intermediary storage facilities are those built by international commodity and agriculture companies, in the countries and regions they operate. However, in interviews conducted for this report³³, it was found that these facilities are usually for the exclusive use of the company commissioning them. In some cases, storage places might be shared with other international conglomerates also operating in the region, but usually not with farmers and local businesses who are not directly associated with them.

iii. National Level

³⁰ http://www.fao.org/fileadmin/user_upload/ags/publications/silos_E_light.pdf

³¹ The FAO has introduced household metal silos in Afghanistan Bolivia, Burkina Faso, Cambodia, Chad, Ecuador, Guinea, Iraq, Madagascar, Mali, Malawi, Mozambique, Namibia, Panama, Senegal, East Timor

³² <https://www.ifpri.org/publication/role-agricultural-cooperatives-and-storage-rural-ethiopia-results-two-surveys>

³³ with a representative of the Louis Dreyfus Company

At the national level, governments generally procure storage infrastructure for one of two reasons:

- 1) To stabilize global prices and protect the poor from high market prices; and/or
- 2) For emergency relief stock

One way to assess whether government investment in storage is justified, is to calculate the value of food loss without sufficient facilities to store them. For example, the IFC estimates that there were 42 million metric tons of storage available in covered warehouses in India in 2010, while there was a need for 61 million tons for wheat and rice. As rice has a priority in India, wheat is largely stored in makeshift facilities, which are susceptible to rotting and losses. Considering that 25.4 million tons of wheat is produced in India (2010) even a 2 percent loss costs the government about USD 110 million per year³⁴. This example illustrates well that the commissioning of storage infrastructure can certainly pay for itself and can generate value for money for the government and for taxpayers.

Since the global financial crisis, and subsequent spikes in food prices, many governments are concerned about food security, and are striving towards some degree of national self-sufficiency. As a result, some national governments have increased their grain stock holdings, as strategic reserves³⁵. National food access is mostly expressed as tons of food in the country, which is the total of food imports, domestic food production, international food aid and food stocks. One must be careful, however, not to conflate food stocks at the national level with food availability at the household level, as households may not have the purchasing power to avail of this food.

Integration with supporting infrastructure

Storage infrastructure also requires supporting infrastructure to be in place to effective, and financially viable. Without reliable access to electricity, for example, the operation of cold storage facilities cannot be ensured. Especially in developing countries, farmers often rely on diesel generators to provide the necessary electricity, increasing significantly the operating cost of the asset. Also, lack of roads and other transportation infrastructure make any investment in storage unattractive by limiting farmers' access to major domestic and international markets and therefore reducing their ability to pay for storage (note the transport required between each level of distribution in Figure X).

³⁴ [https://library.pppknowledgelab.org/World%20Bank%20Group%20\(WBG\)/documents/1948/download](https://library.pppknowledgelab.org/World%20Bank%20Group%20(WBG)/documents/1948/download)

³⁵ <https://pppknowledgelab.org/sectors/grain-storage>

Intermediate Infrastructure – Logistics Providers

A considerable share of food loss along the supply chain is due to non-optimal cold chain processes and management.³⁶ Indeed, the challenges associated with linking farmers and their crops to the global market are many and diverse, and relate to communications, logistics, transport, storage and other variables. ‘Shelf life’ is a common term that relates to the number of days that a food product has left to be of ‘acceptable quality’ and safe to consume. The shelf life of a product depends on optimal temperature and air flow in transport and storage conditions.³⁷

To address these challenges, there is a need for a competitive market of third party logistics providers (“3PLs”) that are able to, for example, harness the power of the growing cell phone market to schedule pickups and deliveries from small farms dispersed around the country, and connect them to regional or international markets.

Governments can help create a supportive environment for 3PLs by taking a holistic approach to storage investment, one in which “hard infrastructure” investments are complemented by:

- Building the local capacity, and investing in technologies, to monitor environmental parameters like temperature, humidity, and CO₂ and O₂ concentrations in storage units and food containers.
- Building local capacity in food handling and transportation best practices.
- Building local capacity and expertise on food safety and quality standards.
- Identifying opportunities to build competitive advantage in the provision of logistics, distribution and storage services.

Without a market for 3PLs, the alternative is that investors build their own vertically integrated supply chains, setting up all of the storage and distribution logistics they require for their specific needs and individual business only. A notable example of this vertical coordination is the cut-flower industry in Kenya. While this approach is not negative per se, in terms of food security it misses an important opportunity to bring value added activity to the agricultural sector while also supporting the growth of, and transition to, knowledge-based and industrial economies.

Financing Approaches

Public-Private Partnerships

Large scale storage infrastructure, usually commissioned at the national level, can also be structured as a Public-Private Partnership (PPP). The private partner can be responsible for designing, financing, operating and maintaining the asset. Well-prepared PPPs can offer a wide range of benefits to governments:

³⁶ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4006167/>

³⁷ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4006167/>

- Significant efficiency gains can be realized during the operation of the asset as the private partner has a financial interest in minimizing costs and maximizing revenues. This also means that often the latest and most suitable technology is used to increase efficiency.
- The government does not need to use its own limited resources to finance the asset.
- Technical capacities and know-how are transferred from the private to the public sector.
- The government can decide (at the time of structuring) whether to keep the asset at the end of the commission period. For example, if the need for storage decreases due to a change of market conditions, the government does not need to be stuck with an asset that it does not need or cannot operate profitably.
- Project risks are allocated to the party who is best suited to manage and mitigate them.

As a notable example, Government of Punjab together with the IFC of the World Bank structured highly a successful grain storage PPP in India in 2010. IFC's role was to demonstrate the business case of using modern storage facilities and how private capital can be used to realize projects essential for the food security of the country. LT Foods, the private partner, won a 30-year concession to build and operate temperature-controlled steel grain silos with a capacity of 50,000 metric tons.³⁸ The outcomes of the project (operational since March 2012) were the following:

- Grain losses were reduced significantly (weather, rot and pests), mitigating purchasing and storage costs.
- The transaction mobilized USD 7 million of private investment.
- Savings were estimated to be USD 6 million during the concession period.³⁹

Due to the success of this project, the Indian government plans to extend its PPP program to create an additional 2.5 million metric tons of storage capacity in the country.

Government incentives

Public-Private Partnerships would not be a feasible solution for small scale projects, which is needed in some rural communities, as the associated transaction costs would be too high and project sizes would be below the investment threshold of institutional investors active in PPPs. For addressing the financing needs of small scale storage projects, solutions need to focus on how to encourage financing by the farmers themselves and / or by their farming cooperatives. These solutions could be in the form of various government incentives, infrastructure schemes, enabling policy environment and access to affordable financing.

i. Dedicated Funds

³⁸ https://www.ifc.org/wps/wcm/connect/33e1a87d-f2dd-49cb-9d82-4e316e98d970/PPPStories_India_PunjabSilos.pdf?MOD=AJPERES

³⁹ https://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/ifc+ppp

A dedicated infrastructure fund can be setup with the specific mandate to provide financing for storage infrastructure projects. The fund should also be required to allocate a certain percentage of the loans to projects below a certain size and both private and public entities should be eligible beneficiaries. The storage infrastructure fund can be part of a larger infrastructure scheme, but in order to be an effective policy tool and achieve the expected outcomes, it should exclusively finance storage projects.

For example, as part of the Warehousing Scheme of the National Bank for Agriculture and Rural Development (NABARD) in India, a Warehouse Infrastructure Fund was setup in 2013. The purpose of the fund is to provide loans to public and private sector players for the construction of warehouses, silos, cold storages and other cold chain infrastructure for agricultural commodities. When selecting projects to finance, states with food grain deficit (Eastern and North Eastern states in India) enjoy a priority. Eligible entities include government agencies, cooperatives, farmers' organizations, farmers' collectives, private companies and individuals⁴⁰.

ii. Preferential Loans

Loans with preferential terms can be provided to farmers and / or cooperatives for investment in agricultural storage. The improved conditions can include lower interest rates, longer tenor and grace period. The loans can be provided through a dedicated infrastructure scheme (for example as the one discussed above) or through a partner bank, in which case the government would top up the difference between the market and preferential interest rates.

For example, the U.S. Department of Agriculture's Farm Service Agency provides low-interest loans for farmers to build storage units, upgrade and expand existing storage, or purchase mobile storage facilities. Tenors are between 7 – 12 years for a maximum amount of USD 500,000 with a rate in line with US government bonds (so below the commercial interest rates charged)⁴¹.

iii. Grants

Grants can be a particularly effective tool to encourage infrastructure development. However, their role is not to finance projects outright, but instead to mobilize other sources of financing. Lenders are often hesitant to finance projects in the agricultural sector due to the high perceived risks. This often results in insufficient access to finance in rural areas and / or prohibitively high risk premiums charged. For economically and socially important projects, such as storage in grain deficit areas, grants can be used to provide the necessary risk capital to make banks and investors more comfortable to provide financing. Grants can use domestic funds channeled through a scheme or fund structure, such as a Viability Gap Fund discussed in the earlier sections. Alternatively, grants can be sourced internationally (especially in the case

⁴⁰ https://www.nabard.org/english/NABARD_WAREHOUSING_SCHEME_NWS_2013_14.aspx

⁴¹ <http://sustainableagriculture.net/publications/grassrootsguide/credit-crop-insurance/farm-storage-facility-loans/>

of developing countries), however, these funds might have less flexibility in how they can be deployed and have limited long term availability.

As a recent example, the government of India commissioned a study on the “*Assessment of Quantitative Harvest and Post-Harvest Losses of Major Crops and Commodities in India*”, which concluded that the annual value of harvest and post-harvest losses of major agricultural products at the national level is about USD 13.6 billion. This prompted the government to introduce a series of measures to address the shortage in storage infrastructure. One of the initiatives was to make modern storage projects eligible for the viability gap funding scheme of the Ministry of Finance, providing grants to priority infrastructure projects.⁴²

iv. Fiscal instruments

Farmers and cooperatives face a wide range of challenges when financing modern storage facilities, including rising cost of land, difficulties with land acquisition, fluctuating demand for storage, high interest rates and stringent asset based lending requirements. Governments can use various fiscal incentives to encourage investment in these projects. These include tax exemptions throughout the lifecycle of the asset, accelerated depreciation, tax deductibility of certain expenses beyond 100%, preferential import tariffs for technologies and products needed during construction. Incentives can vary for different regions depending on the need for storage facilities and the state of existing assets. Based on prevailing policy objectives, incentives can also be differentiated for greenfield vs. brownfield projects and / or favour particular project sizes.

India has implemented a wide range of fiscal instruments specifically aimed at stimulating investment into storage infrastructure. As per the 2015-2016 budget, the following items are exempted from service tax: services of pre-conditioning, pre-cooling, ripening, waxing, retail packing, labeling of fruits and vegetables as well as the construction of greenfield post-harvest storage projects for agricultural products. The government has also extended project import benefits to cold storage, cold room, industrial projects for preservation, storage as well as processing of agricultural, horticultural, dairy, poultry, aquatic and marine produce and meat.⁴³

Necessary Conditions

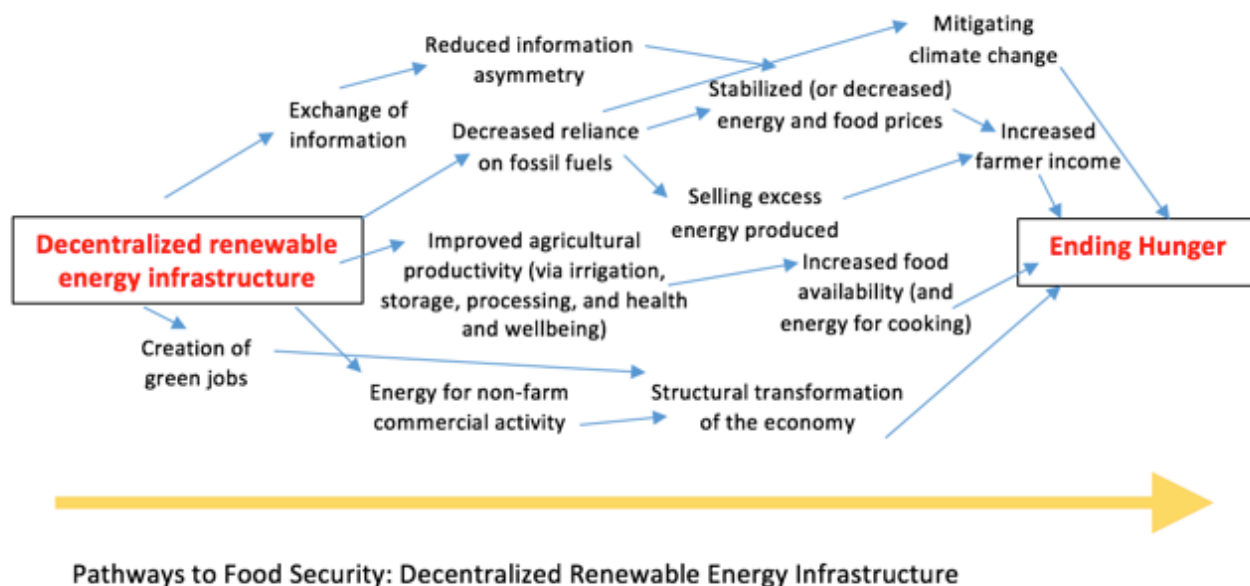
Storage infrastructure has an inherent business case; if the necessary conditions are in place it can be financed solely relying on its own cash flows. In order to achieve this level of bankability however, there is a need for an enabling policy and regulatory environment, supporting infrastructure network (as discussed) and sufficient scale to optimize costs. In rural areas in developing countries, especially at the household and community level, these components might be missing, triggering the need for government support such as policy and / or financial incentives to make projects financially viable in the long term and attractive to private capital.

⁴² <http://pib.nic.in/newsite/PrintRelease.aspx?relid=136922>

⁴³ <http://pib.nic.in/newsite/PrintRelease.aspx?relid=136922>

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Investment Priority # 2: Decentralized Renewable Energy (DRE) Infrastructure



To add to graphic: benefits of refrigeration on nutrition and positive effect of improving working conditions for women which has trickledown effect on food and nutrition

Pathways

Energy is a game-changer in agriculture – needed for diverse activities such as: operating irrigation pumps, powering and lighting facilities such as slaughterhouses, refrigeration, cold storage of produce and vaccines, postharvest processing, sterilizing fruit and vegetables, and for charging portable telephones and other electronics. The price of energy also has a very real impact on food security; an increase in global energy prices, for example, was one of the main drivers behind the sharp rise in food prices in 2008, which reduced households' access to affordable food and worsened food insecurity in the years that followed.⁴⁴

Decentralized renewable energy (DRE) is particularly appropriate for targeting food security improvements, and the major causal pathways are indicated above in Figure X. As much as a **quarter of the world's population** – or 1.3 billion people – lack access to electricity, and almost 85% of these people live in rural, dispersed communities across sub Saharan Africa and South Asia.⁴⁵ Given these characteristics, the extension of national energy grids is often technically difficult, costly and inefficient. There is a growing consensus in the international development

⁴⁴ (IFPRI, 2016 Global Report)

⁴⁵ UN Department of Economic and Social Affairs (2014) Improving Sustainable Energy Access for Rural Areas AND <https://www.rockefellerfoundation.org/blog/new-report-says-off-grid-systems-can/>

community that off-grid renewable energy might be the best way to support inclusive energy access⁴⁶. Some of the advantages are that:

- The infrastructure is more flexible than traditional infrastructure, and can be deployed faster in remote areas than a centralized grid;
- The infrastructure's capacity can be upgraded (easy to use, modular conception) to meet a community's increased energy demands and can interface with the national grid when and if it reaches the area;
- Technologies can be used singular – e.g. only biomass, hydro power, solar and wind – or combined (hybrid).
- If energy storage systems are involved, electricity can be guaranteed 24/7⁴⁷;
- DRE mitigates the efficiency losses in the transmission and distribution of the grid energy; and
- DRE mitigates the use of expensive and carbon-intensive diesel generators during black-outs.

This is not to say that the expansion the national electricity grid is not important – both off-grid and on-grid energy production and distribution systems have a role to play in food security – and of course it depends on the local context. Vietnam, for example, provides an excellent example of the expansion the national grid using investment from revenue in rice production. In the 1980s, the post-war government invested in hydropower infrastructure and high voltage transmission and distribution lines – and the impacts on agriculture and other industries along the transmission routes have been impressive.⁴⁸

Most of the population without access to modern energy sources live in rural areas of developing countries (84%), without connections to electric grids.⁴⁹

Yet developing and maintaining a nationwide grid is often beyond developing country budgets. Existing grids are concentrated in cities, leaving areas with lower population density to seek other solutions. Indeed, the cost of rural grid extension is substantial: for example, in Africa as well as in Asia it can cost up to USD 22,000 / km.⁵⁰ Furthermore, connection charges and tariffs may prohibit the poorest from connecting to the grid.

It is in this context that off-grid renewable energy is an alternative worth exploring. The International Energy Agency (IEA) estimates that 70% of those in rural areas would be more affordably reached by decentralized energy solutions.⁵¹

⁴⁶ <https://www.devex.com/news/rural-energy-access-the-case-for-renewable-energy-mini-grids-82580>

⁴⁷ Alliance for Rural Renewable Energy

⁴⁸ <http://beta.adb.org/sites/default/files/rural-electrification-vie.pdf>

⁴⁹ International Energy Agency (2011) Energy for All: Financing Access for the Poor

⁵⁰ https://static1.squarespace.com/static/532f79fae4b07e365baf1c64/t/57e9f524440243231bbf08f8/1474950436696/FactSheet_MakingEnergyAccessAffordable_Sept_16.pdf

⁵¹ International Energy Agency (2011) Energy for All: Financing Access for the Poor

Table x: Types of DRE infrastructure and how they work

Type of Renewable Energy	DRE Infrastructure Required	How it works
Solar Power	Photovoltaics or “solar cells” Solar water pumps	Solar radiation absorbed by solar panels (mounted on rooftops or on the ground) is converted into electricity. The solar panels are connected to an inverter which converts the direct current ('DC') generated by the panels into alternating current ('AC') electricity. This AC electricity can then be used by the home/business and/or exported to the electricity grid.
Small wind	Wind turbines	The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.
Small hydro	Turbine Hydroelectric generator Intake structure on river/ stream to screen out floating debris and fish Pipeline to turbine	The turbine converts the flow and pressure of the water to mechanical energy; The turbine turns a generator, which is then connected to electrical loads; this might be directly connected to the power system of a single building in very small installations, or may be connected to a community distribution system for several homes or buildings
Biogas ⁵²	Biogas digester – brick/concrete structure with versions using fiberglass-reinforced plastic dome covers for improved efficiency	human and animal wastes are used as feedstock to produce biogas for cooking. Then the biogas slurry and residues can be used as fertilizer in orchard or field around farmer’s house, while the anaerobic digestion effluents can be used to feed pigs mixing with fodders

Many governments have already recognized the potential of off-grid renewable energy solutions and have set ambitious targets: 1) Rwanda - 22% of population with access to decentralized grids by 2018; 2) Tanzania - 10% of population with solar installations by 2017; 3) Ghana – 100,000 households with solar installations; 4) Sierra Leone – 250,000 households with solar installations by 2017.⁵³ Africa as a continent has been promoted internationally for its abundant renewable resource potential such as hydropower, solar, wind and geothermal. Similarly, India’s renewable energy potential is significant, and being rapidly developed through Prime Minister Modi’s ambitious *India Solar Mission* targets to generate 100,000 MW by 2022.⁵⁴

⁵² Although not taken up in this report, it is important to note the potential competition between land for food production and land for biofuel production. For a comprehensive read on this issue, please follow: xxxxxxx

⁵³ <http://www.renewableenergyworld.com/articles/2016/06/policy-not-finance-biggest-obstacle-to-scaling-decentralized-renewable-energy-energy-access-summit.html>

⁵⁴ <https://www.iisd.org/sites/default/files/publications/investment-sustainable-energy-commentary.pdf>

Intermediate Infrastructure: Training, awareness raising, and community organization

The deployment of DRE infrastructure requires both hardware and software elements. Local users need to be adequately trained on the installation, operation and maintenance of the infrastructure, and awareness-raising activities need to take place to develop the local knowledge required for effective and sustainable use. The local capacity of technology suppliers and users is of the utmost importance to the success of DRE infrastructure.

One approach to effective long term sustainability of the DRE infrastructure is to build community based approaches for ownership, operations and maintenance (Nepal, UNDP 2011). This can be done by creating inclusive local participation in planning and execution to enable direct control of local players in monitoring and management of resources. This approach leverages the benefits of decentralization, which can increase space for local actors.

Commercial and policy challenges

Off-grid renewable energy has some notable challenges on both the policy and commercial side, which need to be addressed, especially when relying on private sources of financing. One of the main barriers – if not the main barrier – to the uptake of more DRE infrastructure is the financial one. The unit cost of off-grid energy is significantly higher than the price of electricity on the grid, making it more expensive to the individual user than grid energy. DRE solutions therefore require good design and innovative business models to be financially feasible⁵⁵. The financing challenge encompasses not only upfront installation cost, but also costs of operation and management of the projects over time.⁵⁶

Studies show that DRE investment is often discriminated against by the capital markets, and that the technology development has been constrained by limited length and amount of funding.⁵⁷ These barriers make role of government and other external actors indispensable – but at the same time, given scarce resources, competing demands from other economic sectors (e.g. education, roads, health), and limited local financial capacities, government budgets alone may not be able to finance the energy infrastructure. The following presents some ways these barriers have been successfully addressed.

Financing Approaches

Investment incentives

While user fees can be charged for DRE, they are often not high enough to fully cover the capital and operating expenditures, but more importantly, to compensate investors for the project risks they take on. In the past, various investment incentives have been successfully used to upscale renewable energy in both developed and developing countries.

⁵⁵ WB Report

⁵⁶ http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2642791

⁵⁷ Terrapon-Pfaff et al. 2014

i. Tax Incentives

While their effectiveness is limited on a standalone basis, tax exemptions at the different stages of the DRE transaction can encourage DRE deployment both on the supply and demand side. An alternative form of tax incentive is the accelerated green depreciation. It is an accounting method, which allows eligible green assets to depreciate faster during the early years of the project, effectively providing a tax break for the sponsor (i.e. the owner of the asset). In practice, this decreases the cost of the asset by “borrowing” from the government in the form of upfront tax deductions.

ii. Investment Grants

Investment grants can range from financial aid to providing land usage rights free of charge for a limited time period. Only certain asset types and projects with a high economic and/or social multiplier should be eligible for these grants. Similarly to viability gap funding discussed earlier, this “bridging capital” would enable DRE projects to become bankable in rural areas, where the perceived risks of investment are the highest. For example, out of the USD 82 million of capital available for rural DRE deployment in India, USD 71 million is grant capital⁵⁸.

iii. Concessional Loans

Loans with preferential interest rates provided either by the government or an international development agency enable DRE projects to have access to finance at a lower cost, with better terms, and/or longer grace periods. Concessional financing does not need to cover the entire project costs, but instead serve as a trigger to attract additional private financing. For example, the Japan International Cooperation Agency (JICA) signed a loan agreement with the Indian Renewable Energy Development Agency (IREDA) to provide up to 60 billion yen ODA (official development assistance) loan for renewable energy projects⁵⁹.

iv. Blended capital

The sustainable energy sector in rural areas are still considered to be unprofitable and high risk by most institutional investors such as commercial banks, pension funds and insurance companies.⁶⁰ However, DRE projects without an attractive risk-return profile can also explore alternative sources of private financing. As these projects usually have a high development impact, they can be potential investment opportunities for impact investors, whose mandate allows them to make investments with subpar returns if the environmental and social impact

⁵⁸ <http://www.ckinetics.com/DRE-Financing/>

⁵⁹ https://www.jica.go.jp/english/news/press/2014/140901_01.html

⁶⁰

https://www.researchgate.net/profile/Dominique_Diouf/publication/266740971_Exploring_the_Barriers_to_Impact_Investing_in_the_Sustainable_Energy_Area_in_West_Africa/links/543b170d0cf2d6698be2f51b.pdf

are high enough. Impact investors can provide both equity and debt financing and they are often more willing to invest in small scale projects than traditional institutional investors.

Impact investors interviewed by IISD emphasized that their interest in sustainable infrastructure projects is often subject to the participation of the local government or a multilateral development bank (MDB) as investors. These entities can either provide risk capital (in the form of an equity investment for example) de-risking the project for other investors or just simply signal their confidence in the viability of the project by committing any form of direct capital (equity, subordinated debt, senior secured debt, etc).

MDBs can also encourage the development of DRE projects by providing “enabling capital”. As opposed to becoming an investor (direct capital), development banks can use their balance sheet to create financial instruments, de-risking socially important projects. These instruments include external credit enhancement such as guarantees, where the MDB takes on specific risks of the project e.g. credit risk (partial credit guarantee) construction risk, political risk, etc. Often this is a more efficient way to leverage their limited resources. Similarly to impact investors, MDBs have a development mandate, allowing them to take higher risks if the social and economic impact of the project justifies it.

For example, Argentina is in the process of doing a tender for the installation of 7,500 rooftop solar arrays in rural areas of eight provinces. 70% of the USD 58 Mio project costs will come from the World Bank and the rest from the government. The World Bank’s loan features a variable margin, with a 35-year maturity period and a 4.5-year grace period. “Through these projects we intend to close the service access gap between rural and urban inhabitants,” said Jesko Hentschel, World Bank director for Argentina, Paraguay and Uruguay. The project is expected to bring solar and wind energy to roughly 725,000 people via small-scale wind and solar projects totaling 200 MW⁶¹.

Policy support

The bankability of renewable energy solutions has improved considerably during the last decade. Technological improvements allowed construction costs to decrease and thus decreasing the levelized cost of electricity (LCOE) of DREs. While their reliance on incentives and subsidies have decreased somewhat over the years, business models are still heavily exposed to policy and regulatory changes, which can materially affect the financial viability of these projects. These include uncertainties surrounding various financial incentives for renewable energy, feed in tariffs, fossil fuel subsidies, air pollution laws and plans for future grid integration.

Indeed, investing in DREs has become more too much of a bet on the changes of the local (and in some cases international) policy and regulatory environment than simply optimizing the value drivers of the project. “Decentralized renewable companies still have to work overtime to

⁶¹ <http://www.pfie.com/rooftop-build-out-sees-new-tender/21268620.article>

find capital because of perceived policy risk. This risk gives investors cold feet" said Cathy Zoi, CEO of mini-grid developer Axess Energy⁶². Nicole Poindexter, CEO at Energicity, also pointed out that "policy framework to de-risk financing is the top need to achieve universal energy access"⁶³.

i. Grid Extension

When it comes to decentralized energy, one of the most pressing questions is what happens when the grid is extended to the rural area covered by the DRE project. The cost of energy from the national grid might be cheaper due to its scale and to different sources of energy used. This can potentially result in the DRE asset to become financial unviable and eventually stranded. DRE investors need to price in this risk unless there is a clear roadmap of how DRE projects would intragate into the grid.

For example, in the EU, the Renewable Energy Directive⁶⁴ clearly outlines that member states need to ensure that renewable energy sources have a guaranteed and priority access to national grids, so DRE producers can sell and transmit electricity in accordance with connection rules at all times. If grid integration is not technically possible, an appropriate financial compensation should be given to the producers. Furthermore, the directive emphasizes the important role of renewable energy in promoting technological development, innovation, providing opportunities for employment and regional development in rural and isolated areas.

ii. Feed-in Tariffs (for projects with grid access)

Once renewable energy producers have access to the electricity grid, feed-in tariffs (FiT) can also be used to support further the development of renewable energy in the region. FiTs set the selling price of the electricity at a premium to the market price: The additional costs are shared either by the customers of the utility or funded through a government scheme. FiTs are determined based on the cost of production for the renewable technology used, supporting the deployment of renewable energy solutions.

On the other hand, similarly to power purchase agreements, they lock in the sale price of energy for the long term, thus decreasing the output price volatility for the project. As per the European Commission, FiTs are the most efficient and effective support scheme for promoting renewable energy⁶⁵. For longer term FiTs, it is important that the tariff is decreased overtime to adjust to the changing costs and risks as the technology matures.

⁶² <http://www.renewableenergyworld.com/articles/2016/06/policy-not-finance-biggest-obstacle-to-scaling-decentralized-renewable-energy-energy-access-summit.html>

⁶³ <http://www.renewableenergyworld.com/articles/2016/06/policy-not-finance-biggest-obstacle-to-scaling-decentralized-renewable-energy-energy-access-summit.html>

⁶⁴ <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=EN>

⁶⁵ <http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52008SC0057&from=EN>

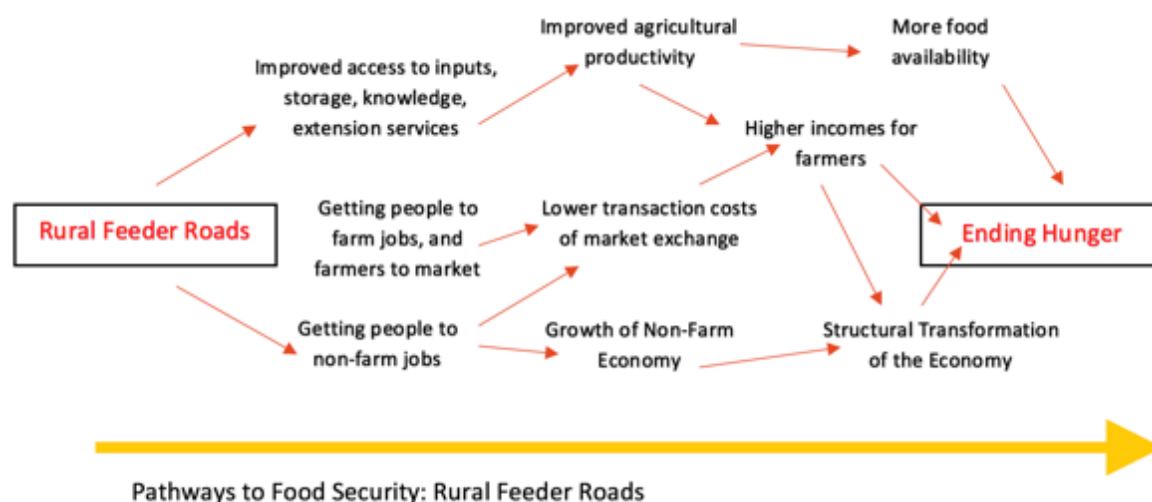
For example, Kenya first implemented FiTs in 2008 (with revisions in 2010 and 2012). They cover wind, biomass, hydro, geothermal, biogas, solar and municipal waste energy. Utilities are required to connect renewable energy producers to the grid and guarantee priority purchase of the electricity generated. Utilities are allowed to recover 2.6 cents / kWh from their customers. The scheme offers price certainty for investors by guaranteeing the sale price for 20 years (subject to inflation). In order to accommodate smaller installations, a standardized power purchase agreement (PPA) was created for renewable energy projects with a capacity up to 10 MW⁶⁶, which is especially important for installations in rural areas.

Necessary Conditions

Decentralized renewable energy, being a revenue generating asset, is easier to finance in principle than assets where charging a usage fee is neither economically, nor socially possible. While there are some inherent challenges that need to be addressed, there is a functioning business model here for private investors. This also implies that in the case of DRE, the government's role will be different than the one discussed earlier for roads. Its main focus should be on how to mitigate the major project risks on the policy and regulation side and identify incentive schemes, which are the most efficient in the country or regional context. Incentives are needed to improve the bankability of these projects, bringing their levelized costs more in line with (the directly / indirectly subsidized) fossil fuel solutions.

⁶⁶ http://www.renewableenergy.go.ke/asset_uplds/files/Feed_in_Tariff_Policy_2012.pdf

Investment Priority # 3: Feeder Roads



Pathways

It is intuitive that roads are important for rural development. Without access routes to obtain inputs and reach markets, other food security investments – whether it be technical assistance, improved storage, access to capital or other investments – cannot perform. This point is well established, and remains an important consideration in the context of food security and nutrition.⁶⁷ As summarized by the World Bank, “Without effective rural transport systems, all rural development and poverty initiatives, agriculture and growth are substantially constrained.”⁶⁸

Figure X above summarizes the many links that have been made between new or improved feeder roads and food security. These pathways include, but are not limited to: linking rural areas and producers to markets thereby supporting market integration (getting prices and demand right); bringing improved inputs and extension services to the farm thereby improving agricultural productivity, and increasing nonfarm employment opportunities and rural wages thereby supporting the growth of the non-farm economy.

Since roads are a foundational infrastructure that enable other interventions (e.g. storage and distribution) to be successful, the linkages to food security are no doubt much greater in number and nuance than presented above. Annex 1 to this report presents a sample of studies assessing impact of roads on food security proxies, and provides details to those wishing to explore the empirical linkages in more depth.

⁶⁷ Juma, C. (2015). *The new harvest: agricultural innovation in Africa*. Oxford University Press.

⁶⁸ http://www.un.org/esa/dsd/susdevtopics/sdt_pdfs/meetings2010/ss0410-transport/presentation_oneill.pdf

Within the broad category of roads, *feeder* roads are emerging as a particularly important investment for food security. Feeder roads are those that serve as a traffic feeder to a more important road, and are thus the more remote, often lower quality, roads connecting farm plots to the wider transport network. Feeder roads demonstrate a robust correlation to poverty alleviation and agricultural productivity, performing above major tarmac roads a comprehensive IFPRI study covering China, Uganda, Thailand and India.⁶⁹ In another more recent study in China, the cost benefit ratio of low quality feeder roads was four times greater than for high quality roads in terms of national GDP.⁷⁰ Moreover, in terms of welfare, for every Yuan invested, lower-quality roads raised significantly more rural and urban poor people above the poverty line than did high-quality roads – and this is true for other countries as well (ibid). Feeder roads can be a win-win strategy for growth, poverty alleviation and food security.

A 2002 study of rural China found that road density was one of the significant determinants of household-level prospects of escaping poverty: for every 1% increase in the number of kilometres of roads per capita in poor regions in China, household consumption increased by 0.08%.⁷¹

Quality and Maintenance of Feeder Roads

In the specific context of improving food security outcomes, special attention needs to be paid to not only the existence of feeder roads, but also their quality. The condition of feeder roads is critical to maintaining the quality of fruit and vegetables on the way to market; rutted and potholed feeder roads will damage produce during transport and reduce their sales. Furthermore, where poor road quality significantly adds travel time, it can lower the value of the product to retailers or other ‘nucleus farms’ who will reject the produce in their screening process for not meeting quality standards. Especially in the absence of cold transport, the lag time to refrigeration will decrease the shelf life of many products.

Gravel roads deteriorate quickly, especially in countries that experience monsoons or a wet season. Therefore, it is important for infrastructure providers to think about and plan for maintenance from the beginning. All weather access should be ensured through regular maintenance and rehabilitation of the road surface. Financing this maintenance can come through *Roads Boards* with dedicated funding for maintenance derived from road user charges and fuel levies⁷², though the challenge of user charges will be discussed in the next section.

While the upfront costs of sealed roads are greater than for gravel roads, they can certainly more than pay for themselves in the lifetime cost of the asset – through not only the mitigated

⁶⁹ IFPRI 2012 study ROI from infra

⁷⁰ Juma 2015

⁷¹ Jalan, J. and Ravallion, M. (2002) ‘Geographic poverty traps? A micro model of consumption growth in rural China’, *Journal of Applied Econometrics* 17(4): 329-346.

⁷² <http://blogs.worldbank.org/transport/the-problem-with-rural-transport-is-that-it-is-rural-the-solution-is-in-branding>

costs of maintenance, and the social and economic benefits of 24/7 road access. Furthermore, local community members can, and should, be involved in the construction and maintenance of rural feeder roads where possible. Box X below presents an example of the use of local community members, and local materials, in the construction and maintenance of paved rural roads.

Green Road Procurement in Assam, India

The Public Works Road Development Agency, of the Government of Assam, India took a multi-pronged approach to implementing sustainable road infrastructure in rural areas.

- Firstly, a green policy for roadside vegetation was put in place, whereby local vetiver grass (with a deep root system) was used to stabilize soils and protect slopes alongside roads – as opposed to more energy intensive crushing of stones for the roadside. A community based cultivation program was put in place to prevent theft, destruction and any kind of pilferage of the grass and other plants.
- Secondly, a green road surfacing technology was used to lower CO2 emissions, in which cold mix technologies for bitumen is used instead of the traditional hot mix systems. The road surfacing was undertaken in collaboration with local communities and created many work days.
- Finally, some innovative funding avenues were leveraged for green roads in Assam: set asides from the central government for States that adopt green technologies, as well as funding through carbon credits with the “Clean Development Mechanism” carbon credit mechanism.

Need for Alternative Revenue Sources

The main challenge in financing feeder roads is that it is impossible to charge tolls on them due to structural limitations and the users’ unwillingness (and often inability) to pay. Construction and maintenance of roads are costly activities, and typically poor rural areas would not have enough economic activity nor projected traffic counts to attract much private investment.

While under a Public Private Partnership (PPPs) model, toll roads are a way to generate revenue from users to finance, operate and maintain major roads, such as highways, this is usually not feasible for remote feeder roads. For these, the source of revenue that would cover the costs and generate profit for investors has to be covered in an alternative way. That will be the focus of the next section.

Intermediate Infrastructure – Transport Services

The need for logistics infrastructure and competition in services is perhaps most pronounced (certainly most studied) in the case of road infrastructure. An analytic review of roads in developing countries by the Overseas Development Institute (ODI), gives a comprehensive overview of the compelling research conducted in this area.⁷³ Their findings show that competition in transport services seems a critical precondition for development and accessibility to the poorest.

Where there is a lack of competition in the provision of transport services, rent-seeking can be persistent and end up accounting for a significant portion of end-market prices – putting particularly remote farmers at a disadvantage. One study cited by ODI is a 2011 USAID analysis, showing that the transport and logistics costs of moving maize and livestock along key trading corridors between Burkina Faso, Ghana and Benin account for approximately 59% and 18% of the respective end-market prices. Of these, transport costs – i.e. fees paid to transport- service operators and losses in transit – were found to weigh most heavily on the end- market price along the corridors studied.⁷⁴

Furthermore, a study conducted by the IADB confirmed a positive and statistically significant association between transport-logistics infrastructure and foreign direct investment (FDI). This is because corporations look to operate in locations with adequate transport and logistics infrastructure to reduce delays and disruptions in the supply chain, inventory holding costs, depreciation costs as well as handling costs.⁷⁵ While “distance” is a frequent measure used by corporations to inform their investment decisions, this report showed that the quality of the logistics system in place is also important factor in the location decisions.

In as far as improved transport services enhance farmer’s income and purchasing power, there is a need for this “pathway” to food security to be supported. Governments need to preempt these challenges when they invest in new road infrastructure by a) simultaneously creating supportive competition policies for transport services, to reduce the costs of transport b) improving and harmonizing regional transport programs and policies to build investor confidence and c) including clear specifications on the quality and maintenance of road infrastructure in their tendering process, to ensure its longevity and reliability for the most vulnerable populations.

Similarly, donors need to be aware of the political economy of freight logistics when investing in roads, and have constructive dialogues with governments and other funders on how best to deploy their funds in a way that can target food security.

⁷³ <https://pdfs.semanticscholar.org/043e/62efb6f053374d3f9e0fa772848ecfde7a76.pdf>

⁷⁴ US Agency for International Development (USAID). (2011) Regional agricultural transport and trade policy study. West Africa Trade Hub Technical Report 41. Washington, DC: USAID.

⁷⁵ https://usitc.gov/research_and_analysis/documents/LogisticsInfrastructureandtheInternationalLocation.pdf

Financing Approaches

Alternative financing solutions

The inability to charge users directly for the usage of the asset does not imply that a project could not be bankable and an attractive investment opportunity for investors. Different financing schemes exist where the government, or a government related entity, fills this revenue gap.

i. Availability Payment

Under an availability payment scheme the public party pays a predetermined amount on a regular basis (annual or semi-annual) to the private party for the operation and maintenance of the asset as long as it meets the pre-agreed performance requirements. As the government transfers the performance risk to the concessionaire, it limits its own liabilities and through the fixed payments it caps the return of the private party. Under this setup, the public entity retains the demand risk, so irrespective of the usage of the asset it will have to pay the same amount, potentially overpaying for the service provided.

The Ostregion Motorway in Austria had a similar setup. The 52 km road project, completed in 2010, had a concession period of 33 years with 70% availability payments and 30% shadow tolls. It was awarded the “Best European Project to Sign” award in 2007⁷⁶. Another, more recent example of availability payments was the 4G highway in Colombia (financial close in 2015). USD 1.2 billion of the USD 1.68 billion project cost was financed through debt. Tolls backed by a contingent guarantee from Agencia Nacional de Infraestructura (the government agency) and annual availability payments from budgetary allocations from the government covered the debt⁷⁷.

ii. Shadow Toll

If the government is unwilling to assume the demand risk of the road project, it can enter into a shadow toll agreement with the private party. In this setup the government pays a predetermined amount per user (depending on vehicle type and distance travelled) on an annual basis, for the construction, operation and maintenance of the asset. This scheme was first implemented in the UK by Margaret Thatcher. As the concessionaire only gets paid once the asset is operational, it has a strong incentive to expedite construction. The limitation of this approach is that traffic can be difficult to measure accurately and depending on the technology used it can notably increase project costs. Also, as additional risk is allocated to the private party, the risk premium demanded will be higher, raising the cost of finance for the project.

⁷⁶ http://ec.europa.eu/enlargement/taix/dyn/create_speech.jsp?speechID=21216&key=1343c4d2c3f47360913bcd145c32c742

⁷⁷ <http://www.pfie.com/colombia-on-the-road-again/21228511.article>

The Bina Istra semi-motorway in Croatia used shadow tolls (and for some parts real tolls). The 145 km road project had a concession period of 32 years and a project cost of EUR 500 million⁷⁸. Another example for shadow tolling is the Rio Verde-Ciudad Valles highway in Mexico, built in 2008. The cost of the project was USD 201 million for the 112 kilometre long highway. Mexico's Ministry of Transport and Communication (SCT) provided the revenue stream in the form of a shadow toll without guaranteeing a certain level of revenue (which would be the case for an availability payment for example). There was no minimum equity contribution set for the private partner⁷⁹.

While shadow tolls have been mainly used for highways, Australia and the USA have been experimenting with them for rural road projects as well. The Florida Department of Transportation recognized that toll roads in more desolated rural areas would not yield high enough revenues for private capital participation, but shadow tolling could be a possible solution. Its discussions with Santander and other financial institutions confirmed that with the “appropriate financing and risk-sharing structures, any corridor can be developed with private participation”⁸⁰.

A 2001 study in Indonesia showed that a 1% increase in road investments was associated with a 0.3% decrease in the incidence of poverty.⁸¹

iii. Stakeholder Finance

Feeder roads in rural areas can also be financed through the financial contribution of local communities and/or the main users of the road. This type of structure was successfully implemented in Uganda, where a not for profit rural development fund was setup to finance and maintain a feeder road network that connected sugar cane farmers with the processing facility. The initial capital for the fund was provided by grants from donors as well as from the processing facility and a levy was put on each unit of sugar cane sold by farmers to the processing facility, supporting the continued operation of the fund. The responsibilities of the fund included the maintenance, upgrading of existing roads and the financing the construction of new roads to facilitate the transportation of sugar cane⁸².

Community participation in financing and operation, does not only make rural PPP solutions more bankable, but it also has other important benefits such as improved social acceptance of the project, increased local employment and potentially slower deterioration of the asset.

⁷⁸ <http://siteresources.worldbank.org/INTTRANSPORT/Resources/336291-1122908670104/1504838-1151587673078/PPPStructureExamples.pdf>

⁷⁹ <http://www.pfie.com/country-tenders-toll-road/390972.article>

⁸⁰ Thomson Reuters PFI Issue 347 – October 18, 2006 - <http://www.pfie.com/lenders-look-at-florida-tolls/392150.article>

⁸¹ Kwon, E. (2001) 'Infrastructure, growth, and poverty reduction in Indonesia: a cross- sectional analysis'. Mimeo. Manila: Asian Development Bank

⁸² <http://www.fao.org/3/a-i0465e.pdf>

Another example where beneficiaries participated in the PPP structure of rural roads was the Morogoro Village Travel and Transportation Programme (VTTP) in Tanzania. Communities were involved in the design of the projects and contributed raw materials, labour and some cash payments. The local government mainly provided specialized expertise and other resources not available locally. Funding, in the form of grants, came from the central government and other donors, who also provided technical assistance. The private sector was responsible for the rehabilitation and maintenance of the projects using performance based contracts⁸³.

Funding the alternative schemes

All alternative finance schemes discussed earlier rely on some form of government financing. This funding can come from the following sources in case of rural road infrastructure:

i. Taxes

In order to ensure sufficient resources for the construction and maintenance of road infrastructure, there should be taxes specially earmarked for road development. These can be in the form of local taxes, property tax, fuel tax (arguably the most efficient way to raise funds) and levy on agriculture production. As road infrastructure supports economic activity, an increase in tax receipts could be expected overtime. The Conference Board estimates that even if only the construction phase is considered, governments can recover 30-35% of public infrastructure spending through higher personal, corporate and other indirect taxes.⁸⁴

ii. Road fund

Innovative financing solutions are often as good as the institutions supporting them. A national road fund, or infrastructure development fund, can provide the necessary credibility and stability to assure investors that their long-term agreements will be met and the project risks allocated to the public entity credibly mitigated. Indeed, these funds often have an internationally recognized credit rating, allowing them to attract a wider range of private investors to the projects they support.

At the same time, infrastructure funds have the financial capacity to provide funding to economically and socially important projects. The mandate of these funds can set specific targets for funding rural roads (as a percentage of all projects), encouraging investment in road projects with strong links to food security. Road funds can get their own funding from a two-tier tariff system: *access fees* such as vehicle registration fees and *usage fees* including fuel taxes, international transit fees⁸⁵. The involvement of these funds goes beyond the financing of

⁸³ <http://www.fao.org/3/a-i0465e.pdf>

⁸⁴ <http://canada2020.ca/crisis-opportunity-time-national-infrastructure-plan-canada/>

⁸⁵ http://www.worldbank.org/transport/roads/rd_fnds.htm

greenfield or brownfield projects, and also includes the maintenance of the existing road system.

Other incentives and solutions

Securing a stable revenue stream, as discussed earlier, is often not sufficient to attract investors to projects in a more challenging economic, social and political environment. Other incentives are needed to make the deal more appealing, finding ways to improve the overall risk-return profile of the project.

i. Co-financing

When municipalities, national governments or MDBs co-invest in the project, it gives a strong signal for investors about the project's legitimacy and viability. In addition, it shows a political commitment that is essential both during the construction and operation phases. In fact, construction risk, one of the major barriers of investing into infrastructure for many investors, can originate from a lack of political support. For example, construction delays are often due to difficulties in issuing all the relevant permits, which can have a significant impact on the overall bankability of the project.

Co-financing can take the form of equity, subordinated / mezzanine debt or senior secured debt. Equity or other subordinated capital contribution gives a stronger signal of the MDB's commitment to the project as this type of capital serves as a first loss provision in the deal structure. Indeed, having a sufficient amount of equity buffer, and thus lower debt / equity ratio, is often a requirement for debt investors to be engaged in the project and for sponsors to have a lower cost of financing.

ii. Viability gap funding

Viability gap funding (VGF) is a one-time grant awarded to projects, which otherwise would not be commercially viable. VGF should be used selectively, only projects with high economic and / or social multipliers should be eligible. Furthermore, in order to best leverage the limited public resources, it should be used to unlock additional capital as opposed to funding the whole project. VGF can be applied during the construction and / or operation phase and is usually included in the bidding process, ranging up to 20% of project costs. For example, the Indian Institute of Technology estimates, that INR 400 million can be mobilized by the government by providing INR 50 million as a direct VGF grant into a project, with another INR 50 million equity investment as a risk reduction and another INR 50 million as a guarantee for user fees during the initial years of operation⁸⁶.

Dau Giay–Phan Thiet Expressway project in Vietnam is being financed through a mix of VGF provided by the government of Vietnam, World Bank-linked debt and private equity. A PPP

⁸⁶ <http://www.iitk.ac.in/3inetwork/html/reports/IIR2007/03-Financing.pdf>

DBFO (Design, Build, Finance, Operate) structure was set up for the development of the 98.7 kilometre highway with a concession period of 30 years. As part of the tendering, bidders had to submit the amount of VGF they would require to make the project bankable⁸⁷.

iii. Project bundling

Project bundling is another way to overcome the barriers of financing projects with higher risk and / or limited revenue potential. In this case a less commercially attractive project is bundled and tendered together with a project (or projects) with a much more favourable risk-return profile. In other words, the investor can only invest in the “good” project if it also finances the “bad” one.

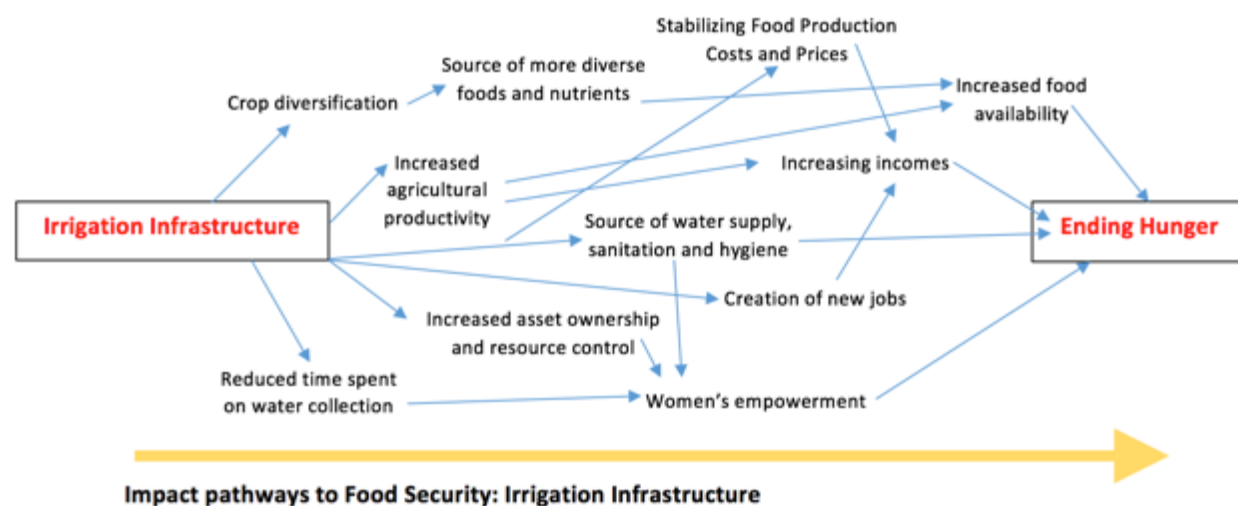
Bundling also offers a solution for two important challenges of rural infrastructure financing: scale and revenue uncertainty. Below a certain project size institutional investors might be hesitant to invest due to the high fixed transaction costs involved. Indeed, scale is often the single biggest barrier when it comes to impact infrastructure (i.e. projects with high environmental and social impact) even when the economics of the project are otherwise solid. Project bundling could also serve as a way to diversify other project related risks (depending on how much the assets are correlated), notably the revenue risk. Project sponsors receiving revenues from a toll road and from a feeder road in the form of an availability payment for example, can rely on the latter when demand for the toll road falls below forecast at some point of the asset lifecycle.

The State of Pennsylvania in the USA, is also exploring bundling as a way to repair its 4,700 structurally-deficient bridges. In one of the proposals being considered, the private entity would fund the work in exchange for the right to toll the bridge⁸⁸.

⁸⁷ <http://www.pfie.com/govt-offers-first-road-ppp/21099460.article>

⁸⁸ <http://www.pfie.com/StorySubs.aspx?rtnurl=/story.aspx?storycode=21070377>

Investment Priority #4: Irrigation infrastructure



Pathways

As depicted in Figure X above, greater agricultural productivity resulting from irrigation can lead to increased food availability either for own consumption or for marketing and income generation. Irrigated production is more than twice as productive on a per hectare basis than rain fed production⁸⁹. In addition, the changes associated with a reliable water source can lead to better sanitation, women's empowerment, new local jobs – all of which can also have positive food security impacts. It is also observed that the number and type of crops that farmers grow also changes with irrigation – often towards more nutritious vegetables (e.g. iron-rich leafy greens) and fruits throughout the year, having important nutritional benefits for households. Irrigation used for supporting livestock-rearing activities can lead to an increased presence of animal-derived (protein rich) food at the household level.⁹⁰

As for other rural infrastructure asset classes, it is also true of irrigation that it is difficult – if not impossible – to directly trace the causality of improved irrigation to food security outcomes. Most studies do not specify whether the improvement in diet arises from more home-grown food availability or from an increase of marketable surplus leading to more food being purchased by the household.⁹¹ A 2015 study by the *International Food and Policy Research Institute* (IFPRI) nonetheless identifies five broad impact pathways linking irrigation to nutrition and health outcomes for Africa south of the Sahara⁹²:

⁸⁹ "Feeding ourselves thirsty: How the food sector is managing global water risks", Ceres, 2015.

⁹⁰ IFPRI 2015 <http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/129090>

⁹¹ <http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/129090>

⁹² <http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/129090>

- i. irrigation as a source of more and more diverse foods (through increased agricultural productivity and crop diversification);
- ii. irrigation as a source of income (from market sales and employment generation);
- iii. irrigation as a source of water supply, sanitation, and hygiene (through multiple water use);
- iv. irrigation as new vector-breeding habitat⁹³ and a source of water pollution (from agrochemicals); and
- v. irrigation as an entry point for women's empowerment (through increased asset ownership and control over resources)

An infrastructure programme in Ethiopia, which involved the construction of irrigation and roads and the organisation of beneficiaries, improved food access by 30%, an increase of about 700 kcal / adult / day.⁹⁴

Where in the water distribution network to focus?

In addition to irrigation infrastructure having multiple impact pathways, there are also multiple *types* of irrigation infrastructure and multiple *models* for managing it. Irrigation infrastructure is a broad category, encompassing the entire system of extracting water from its source and moving it to be applied on agricultural crops. This infrastructure includes: dams, canals, pipelines, aqueducts, pumping plants, drainage and flow regulating structures.

Table X: Typical types of irrigation infrastructure and associated costs

Type	Use	Cost	
		Operation, maintenance, repair	Capital
storage	holds water		
dam/reservoir		medium	high
tank		low	medium
farm pond		low	medium
canals	delivers water	low	medium
drainage	removes water	low	high
gates	delivers water	low	low
pumps	raises water	high	medium
pipes	delivers water	low	medium
wells	accesses water	high	medium
grading	levels land	low	medium
water application	delivers water to crop		
sprinkler		medium	high
gated pipe		low	medium
drip system		low	high
furrow		medium	low
flood		low	low
barrages	raises surface water	low	medium
levees	channels water	medium	medium
computers	times flows	medium	medium
meters	measures flow	low	medium

Source: Ward (2010)

⁹³ This can also disproportionately affect women, as they are more likely to take time to tend to the sick.

⁹⁴ (Abebawet al., 2010) in <https://www.oecd.org/derec/49558328.pdf>

One of the major challenges the development community has faced – and other investors seeking to support food security – is precisely deciding what type of irrigation infrastructure (as depicted in column 1 of Table X above) to invest in. The right investment will depend in large part on the proximity of the recipient farm(s) to a reliable water source, the organizational structure of the local community of farmers, and the access to other infrastructure for energy, transport and storage. Irrigated “units” can range from an individual farm up to massive integrated schemes covering thousands of hectares, and the management can be public, private, user-run, community based, or a combination. Typical management models are⁹⁵:

- ⇒ Large-scale public systems (e.g. paddy fields for rice production in humid areas or for staples and cash crops in dry areas);
- ⇒ Small- and medium-scale community-managed systems;
- ⇒ Commercial private systems for cash crops (often large scale); and
- ⇒ Farm-scale individually managed systems.

While the infrastructure needed to secure and distribute a reliable water supply (e.g. reservoirs, dams) is primordial, the politics of such ‘communal’ water infrastructure is often a major barrier. Unlike electricity, water is a very heavy substance, and is expensive to move over long distances. Furthermore, growing urban areas will often pay two to five times more for water than its economic value in agriculture, further complicating the issue⁹⁶. Hydropower is another major stakeholder, as is the environmental community. Taken together, this means that water for agriculture requires significant funding, political will, and cross-sector coordination. It also means that it is harder to link large-scale storage infrastructure with food security outcomes than it is for farm-level irrigation infrastructure improvements – even though the need for such water mobilization infrastructure is great in many impoverished areas.

In this context, agricultural development donors, namely the FAO and IFAD, have tended to focus on supporting smallholders that already have, or could have relatively easily, their own access to a local water source. Their experience shows that this household or community level model has been a relatively impactful and sustainable approach; farmers will tend to invest in the maintenance of their own infrastructure for their own water source, provided they are reaping the benefits of improved agricultural productivity.

This focus on the smallholder does not imply irrigation for subsistence agriculture only – but also supports market-oriented agriculture of cash crops or industrial crops. Even though the expansion of irrigation for cash crops such as sugar, cotton, and coffee does not lead to more nutritious food production for its farmers per se, these producers may make more money from such cash crops than from other more nutritious crops, thus also creating a strong food security pathway.

⁹⁵ <http://www.fao.org/docrep/017/i1688e/i1688e03.pdf>

⁹⁶ Ward 2015

In a particularly positive example from Zambia, the farmers of the Kafue district simultaneously secured irrigation infrastructure for their smallholders to grow food for their own consumption (pumping water from the local river) while also renting out surrounding land to large scale commercial agriculture. This model is now being rolled out in many communities across Africa by InfraCo and the World Bank⁹⁷.

Box X: Contemporary Irrigation Narratives on the African Continent (*may not be relevant enough to include*)

Irrigation infrastructure has been a particularly important topic on the African continent over recent decades for its potential to boost agricultural and economic growth and to improve security on a continent where currently only 6% of the total cultivated area is irrigated. This is in comparison to approximately 37% in Asia and 14% in Latin America.⁹⁸ And of Africa's irrigated land, over two-thirds is concentrated in only five countries, namely Egypt, Madagascar, Morocco, South Africa and Sudan.

One of the first major appeals for investment was with the 2005 *Commission for Africa* report called for a doubling of irrigation in Africa by 2015, with an emphasis on small scale irrigation.⁹⁹ In the years since this report, there have been numerous other studies to evaluate irrigation needs for food security and calls for action – notably the African Union's 2014 Malabo Declaration that committed to doubling agricultural productivity through irrigation, inputs and mechanization.

Irrigation is also seen as an “adaptive response” to climate change on a continent that is already experiencing changing precipitation patterns and increased extreme hydrological events such as flooding and droughts.

On the other hand, there have been concerns that the expansion of irrigation on the African continent will deprive other, downstream users of water – including fish and wildlife. And with the enormous sales of land to foreign investors over recent years (i.e. “land grabbing”) there are concerns that water demand would outstrip water supply resources if all of this land were to be put under irrigated production.¹⁰⁰

In reality it is likely that irrigation will be neither a panacea for African development nor result in hydrological suicide for the continent, but certainly improved agricultural productivity in the continent is expected, and an important element of this improvement will be from irrigation expansion.

⁹⁷ <http://elegtra.com/projects/chiansi-irrigation/>

⁹⁸ “What is the irrigation potential in Africa?”, International Food Policy Research Institute, 2010.

⁹⁹ <http://www.commissionforafrica.info/2005-report>

¹⁰⁰ <http://www.iisd.org/sites/default/files/publications/investing-land-water-converging-legal-regimes.pdf>

Intermediate Infrastructure – Irrigation Management Services

There is a broad acceptance in the development community that effective irrigation investment must include not just the physical assets, but equally the supporting services. Logistics and services related to irrigation infrastructure include: managing and maintaining tertiary levels of infrastructure (e.g. canal maintenance), drainage services, coordinating timing and flows across users and user groups, the monitoring of water use and others.

Generally speaking, these services are delivered most effectively when devolved from the authority and responsibility of government agencies to either: a) user groups (water user associations) or b) third party service providers. The latter is the approach currently promoted by the World Bank. In their view, “the multiple functions of an irrigation and drainage systems require high standards of management and professional skill. In some cases, and for some functions, the needed management capacity and level of skills may best be provided by private sector service providers, and PPP arrangements may be the best way of improving standards.”¹⁰¹

For the user group approach, the idea is that “increased ownership, decision-making authority, and active participation in the operation and maintenance (O&M) of irrigation systems would create or force a binding commitment from water users to be more effective and responsible towards their obligations.”¹⁰²

Either model can work, but either requires a strong institutional structure is in place, governing decisions regarding water fees, allocation of water within the community, and the maintenance of systems are managed in this collectively. This may require government to create an enabling environment through land tenure reform (to incentivize long-term investments and enable the land to be used for collateral), clearing titles to water rights, adequate and accessible inputs and markets, and access to affordable credit.¹⁰³

Financing Approaches

When it comes to funding irrigation infrastructure, a differentiated approach to investment is needed. Individual smallholders who are developing irrigation systems using water from a local source, and using their own land, might require access to credit for their initial investment, and access to training to learn effective techniques for cropping and for maintenance of the infrastructure. Groups or communities of farmers who organize themselves to gain access to a water resource will have larger scale infrastructure needs, and there the upfront capital requirements will of course be greater – usually necessitating a public subsidy of some sort. In

¹⁰¹ http://siteresources.worldbank.org/INTWSS/Resources/WS10_txt.pdf (2007)

¹⁰² <http://www.fao.org/3/a-a1520e.pdf>

¹⁰³ FAO 2009 - market oriented agricultural infrastructure

addition, in this situation there is a need to invest in building *institutions* of farmers who will be sharing the resource and the infrastructure (See Section on Service Providers).

Another model is one in which private commercial interests develop irrigation infrastructure on bought or rented land, and employ local labour. In this situation, the expectation is that the private enterprise is bearing most of the cost of irrigation.

Broadly speaking, however, irrigation projects are almost always of a highly social nature – using a public money to deliver water infrastructure (and water itself) to farmers at steeply subsidized rates. There is a long history of irrigation subsidies in most countries, either directly or through cross subsidies paid from hydroelectric power revenues. This is often a political strategy to encourage rural settlement, increase food production, and promote national food self-sufficiency.

Thus, there is a certain irony in any development discourse through which industrialized countries beleaguer developing nations to achieve full cost recovery in their irrigation infrastructure construction and operations. Indeed, in the United States, irrigation infrastructure – in the West in particular – has involved large public expenditures since the 1930s that the governments have never fully recovered from project beneficiaries over time¹⁰⁴. Only in more recent years have these subsidies gained critical attention from citizens and legislators.

Pricing & Public Subsidies for Irrigation

Any discussion on financing irrigation infrastructure quickly comes down to the pricing of irrigation water, and the extent to which the capital costs, O&M, and future investment – important elements of the longer-term sustainability of the system – can be covered through water tariffs. While most agree that irrigation has played, and will play, a major role in providing sufficient food for the world's increasing population, there is debate about whether or not subsidization from the public sector is justified.

On the one hand, if the full cost of irrigation is reflected in farm-level irrigation water prices, this can promote irrigation efficiency within agriculture and increase the likelihood of achieving economic efficiency across the sectors that compete for limited water resources.¹⁰⁵ On the other hand, other experts argue that irrigation infrastructure and services provide both public and private goods, justifying a degree of public subsidy.¹⁰⁶ For example, it is often the case that irrigation water serves multiple users (e.g. domestic, agricultural and industrial water consumers) and has diverse beneficiaries (e.g. flood control).

Ultimately, while subsidizing irrigation infrastructure and/or water can significantly improve farm incomes, and food security, in the short term, the longer-term problems associated with

¹⁰⁴ <https://www.oecd.org/unitedstates/45016437.pdf>

¹⁰⁵ <https://www.oecd.org/unitedstates/45016437.pdf>

¹⁰⁶ <https://www.oecd.org/unitedstates/45016437.pdf>

financing the maintenance and management of the infrastructure must be addressed for long term sustainability of the system and its benefits¹⁰⁷.

Separating capital expenditure and O&M

For the reasons described above, there is a strong case for financing capital expenditure (CAPEX) and O&M (OPEX) separately, i.e. structuring the deal such that the government (or an external donor) covers the former and users incrementally pay for the latter, using the income gains they receive from reliable irrigation. Eventually, ideally once the benefits of improved irrigation are felt by farmers, policy makers can begin the political process of increasing irrigation tariffs to include a part of the CAPEX (even 1-2%), thereby gradually reducing the public subsidy to irrigation.

Notably, this approach requires robust feasibility assessments that outline (strictly) what costs the government (national, state, local) can incur, what the expectations of the user groups will be, and if the projections for longer-term cost recovery are feasible based on willingness to pay assessments. In any case, a process should be put in place to revisit water rates every 5 years. As a rule of thumb, the Indian government stipulates that irrigation rates should lie within the range of 5 to 12 percent of the gross revenue of farmers in the canal command area.¹⁰⁸

It is worth repeating that water charges must, at a minimum, be sufficient to cover O&M costs. Without this minimum revenue base, service providers are unlikely to be able to afford O&M expenditures required to provide reliable services. This results in a “vicious circle” whereby the water delivery becomes less reliable as quality declines, and farmers become more and more reluctant to pay for irrigation, further eroding the revenue base.

Identifying and targeting food security beneficiaries

Irrigation subsidies must be designed and targeted to support the poorest, least food secure farmers; this will not just happen on its own. For example, a major finding of a study of irrigation subsidies in India by the World Bank, was that the vast majority of poor rural households in India did not directly benefit from the state’s irrigation subsidies.¹⁰⁹ In this instance, the subsidy was specifically for canal irrigation, which only 13% of agricultural households in used at the time, and little to none of these households were the poorest or most marginalized (Scheduled Caste and Schedules Tribe) households.

To focus on food security outcomes, however, what we would need to know from this study is whether or not these medium and large farms were providing employment to the poorest rural

¹⁰⁷ For those interested in calculating subsidies in irrigation, IISD developed a rigorous, transparent, and replicable methodology to provide the most comprehensive estimate of subsidies to irrigation that can be found here: <https://www.iisd.org/GSI/irrigation-subsidies/irrigation-resources>

¹⁰⁸ <http://ageconsearch.umn.edu/bitstream/25853/1/cp03su05.pdf>

¹⁰⁹ <http://ageconsearch.umn.edu/bitstream/25853/1/cp03su05.pdf>

households – thus providing another legitimate pathway to addressing food security. In this sense, the lesson is not a normative one (i.e. all irrigation subsidies should be designed to target only the poorest) but a call for policy makers to undertake a comprehensive study of the target population's options and preferences in seeking out their own food security pathway.

Public Private Partnerships

The challenge for PPPs in irrigation, not unlike for other assets described in this report, is that the private-sector partners need a degree of certainty that they will be able to recover their investments. Meanwhile the irrigation sector offers limited scope for revenue generation due to low water charges and poor recovery rates.

PPPs have been increasingly rolled out in irrigation infrastructure construction and maintenance, however, so it is important to understand how to best structure these deals.

Broadly speaking, the most likely financing scenario for PPPs in the irrigation sector is one whereby the concessionaire obtains part of its remuneration through fees charged to users, and another portion through availability payments (paid by the government based on the “availability” of the asset and service). Due to the inherent difficulties in fee collection, the availability payment reduces the risks of service demand and supply, price fluctuation, tariff level and noncompliance by users, and is a mechanism for guaranteeing the sustainability of the service.

A benefit of this approach is that availability payments can (and should) be based on performance; that is, the private partner will only be entitled to the availability payments if, during each reporting period (monthly, quarterly or another frequency), the service (e.g. properly maintaining and operating infrastructure) is delivered to farmers in a timely and adequate manner. The remuneration should be at least partially variable, according to the rating achieved by the private partner in terms of the various quality and performance requirements stated in the PPP contract. This can also be linked to energy- or water-saving targets.

In this way, the PPP model can still provide for a more targeted use of public sector funds to spur agricultural productivity. It can also be useful to establish the principle of financial autonomy, to raise professional standards by introducing improved management, to improve maintenance of the system, to promote water and energy efficiency, and to relieve the government of some fiscal and administrative burdens.

Conclusion

Based on an extensive meta-analysis of the literature on rural infrastructure and its ability to end hunger, complemented by interviews with experts, our report focused on four particular rural asset categories: storage/cold storage, feeder roads, decentralized renewable energy, and irrigation infrastructure. The aim of the analysis of each of these assets was to assist donors and investors who are dedicated to ending hunger to target their financial resources to these high-impact infrastructure categories, and to help them understand why.

While we cannot provide broad generalizations on whether or not specific projects represent a good investment or not, the many lessons provided in this report should help investors and policy makers alike to tailor infrastructure financing solutions to address their food security needs.

Despite the hopeful SDG Goal to end hunger by 2030, the challenges remain acute. Both developed and developing countries are facing large infrastructure deficits: USD 90 trillion infrastructure investment is needed by 2030, which is more than the entire current stock¹¹⁰. The lack of investment is particularly bad in rural areas, which are often neglected by policy makers and investors alike. In these regions, the financing of infrastructure faces a wide range of challenges due to the limited resources of local governments, the uncertainties surrounding revenue streams and the high perceived risks of these projects.

In spite of these barriers, with the right use of donor funding and public resources, it is possible to attract private capital to the four infrastructure asset types (storage, decentralized renewable energy, feeder roads and irrigation) covered in this paper. There are a wide range of financial instruments available (some of which have not been deployed to date in a rural context), which enable governments to leverage their limited funds available, to de-risk these projects and to mobilize private capital. Governments also need to assess carefully what projects have the highest economic and social multipliers and establish project pipelines accordingly. By identifying these multipliers, international donor funding can also be secured more easily. As needed, the international community should provide assistance with measuring these impacts and provide the necessary capacities for a more robust project development.

Furthermore, donors as well as governments should only commit funds to financially sustainable infrastructure. Projects not meeting this requirement will drain disproportionately the public resources available, not delivering value for money for stakeholders, and potentially having a shorter operating life. “Financially viable” does not imply that the asset has to be revenue generating in its strictest sense (i.e. charging user fees), but instead it has to have some form of revenue stream (also including availability based solutions) to cover debt servicing, operation and maintenance costs during the whole lifecycle of the asset. Developing bankable projects also opens up the possibility to engage private capital in the financing, which is a key ingredient in addressing the rural infrastructure deficit and ending hunger.

¹¹⁰ http://newclimateeconomy.report/2016/wp-content/uploads/sites/4/2014/08/NCE_2016Report.pdf