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The Role of Irrigation in Enabling Dietary Diversity in Afghanistan

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About LANSA

Leveraging Agriculture for Nutrition in South Asia (LANSA) is an international research partnership. LANSA is finding out how agriculture and agri-food systems can be better designed to advance nutrition. LANSA is focused on policies, interventions and strategies that can improve the nutritional status of women and children in South Asia. LANSA is funded by UKaid from the UK government. The views expressed do not necessarily reflect the UK Government's official policies. For more information see www.lansasouthasia.org

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Abstract

This paper adds to the sparse literature on irrigation-diet linkages by contributing fresh evidence from Afghanistan and addresses the lacuna regarding the pathways through which such linkages may operate. Using data from the latest round of the nationally representative Afghanistan Living Condition Survey (2013-14), this study explores the role of irrigation in dietary diversity in Afghanistan. Results show that possession of irrigated land and garden plots are positively associated with household dietary diversity. Two pathways underlie this relationship. On the one hand, irrigation facilities are positively correlated with diversity of food intake from own production. On the other hand, irrigated garden plots are positively associated with greater diversity of food purchased at the market. The study also finds that dietary diversity is positively associated with households' ratio of dietary diversity from own production. Evidence suggests that irrigation facilities could be important but not sufficient conditions in addressing dietary diversity among smallholders in Afghanistan. A multi-sectoral approach including initiatives to strengthen market integration and provision of education to farmers to grow nutritious crops is called for.

Keywords: Dietary diversity, Irrigation, Afghanistan

1. Introduction

Recent estimates show that 795 million people worldwide are food insecure and one in less than ten people worldwide do not have enough daily food, daily protein, and energy required to spend healthy and active lives (FAO 2009; FAO 2015,). The vast majority of those food- and nutrition-insecure people live in low-income countries, where agriculture plays a critical role in the diets of 75 per cent of people who live in rural areas (Haddad 2000; Pinstrup-Andersen 2007). Farm households frequently rely on own production as an important source of food consumption and as the main source of income through sales at the market (World Bank 2007). Therefore, uptakes of innovations enhancing crop production, both in term of yields as well as the range of crops cultivated, has the potential to directly and indirectly affect farm households' diets. This study investigating the role of irrigation on nutrition in Afghanistan adds to a growing body of literature that studies the role of agriculture and nutrition in low-income countries.

While the latest Afghanistan Living Condition Survey (ALCS) 2013-2014 shows that one- third of the total population is food insecure, more detailed information on the nutrition situation in Afghanistan is sparse. Summary results from a National Nutrition Survey conducted in 2013 and reported in Varkey et al. (2015) show that the prevalence of stunting in children under 5 years of age is 41 per cent. D'Souza and Jolliffe (2012, 2013, 2014) show how the food price surge in 2008 worsened Afghan diets. More recently, Flores-Martinez et al. (2016) reported a link between agricultural asset ownership (sheep) and a nutrition outcome (haemoglobin concentration) in Afghanistan that they suggest is at least partly due to consumption arising from own production in the presence of market incompleteness.

Afghanistan is an agriculture-oriented economy, but poor infrastructure and political instability over the past decades have reduced the government's capability to manage the food production and distribution network. The combination of an arid environment and high mountains makes irrigation both a critical factor and an opportunity for the development of the Afghanistan agriculture sector (IRA MAIL 2010; Kawasaki et al. 2012). According to ICARDA (2002), agricultural land with irrigation infrastructure produces 85 per cent of food crops in Afghanistan. Formal and informal irrigation systems co-exist in Afghanistan (Rout 2008). The formal system, which includes large-scale irrigation schemes developed by the government, accounts for 10 per cent of the irrigation from surface water, with the remaining used by informal irrigation systems. Data suggest that current water resources are enough for a potential intensification of irrigation; yet lack of irrigation infrastructure seems to be a crucial obstacle at present (Frenken and Gillet 2012). According to ALCS 2013-2014, 40 per cent of households reported lack of irrigation water as the main reason for not cultivating available land (CSO 2016).

Three types of land use differentiated by kinds of irrigation co-exist in Afghanistan: irrigated land and garden plots, and rain-fed land. Irrigated land is mainly used to grow wheat, fodder crops, potato, maize or sorghum, whereas only wheat production usually takes place in rain-fed land (ALCS 2013-2014). The Afghan Ministry of Agriculture, Irrigation and Livestock (MAIL) estimates that, typically, yield of wheat from irrigated fields is 2.7 times higher than that from rain-fed fields (IRA MAIL 2010). Garden plots are mostly used for cultivation of fruits and nuts. Almost 40 per cent of all households in Afghanistan own some irrigated farmland, while around one in six households own rain-fed land (CSO 2016). Garden plots are cultivated by 24 per cent of households.

Lack of adequate irrigation infrastructure does adversely affect agricultural possibilities; however its nutritional impact remains unclear. Irrigation can potentially affect nutrition through various transmission channels, from production to market. For example, irrigation could encourage the focus on a small number of remunerative crops, exerting a negative influence on dietary diversity arising from own production. However, increased income arising from irrigation may improve dietary diversity via market purchase.

This research aims to investigate the role of irrigation in the dietary diversity of Afghan households by using the ALCS 2013-14 data and deploying multivariate regressions and a Dirichlet model. Three research questions drive this study:

1. What role does irrigation play in the dietary diversity of Afghan households?
2. How is irrigation associated with the different ways in which households source their food (own production, market, and others (e.g. aid, gifts)) to build their dietary diversity?
3. How are households' dietary diversity patterns from various sources of food correlated with irrigation?

Previous literature showing the relation between irrigation and dietary diversity is reviewed in Section 2. Section 3 provides an overview of the study area, describes the nature of the dataset at hand, and describes the methods used. The results are presented and discussed, respectively, in Sections 4 and Section 5. Section 6 concludes. All figures and tables are in the Appendix.

2. Review of Literature

Pinstrup-Andersen (2007) and World Bank (2007) suggest that smallholder farmers' diets are affected by agricultural technologies such as irrigation in two ways: first, through influencing the consumption of own production, and second, through impact on income generated by market participation. By increasing yields or by impacting the mix of crops and animals produced on the farm, irrigation can influence dietary diversity from own consumption. Note that the influence does not have to be positive. Irrigation may provide incentives to substitute food crops with cash crops, or may emphasise focus on a narrow range of high-value staples (Domenech 2015). Second, irrigation can generate higher income via market participation and improve dietary diversity as a consequence.

A recent review of literature by Domenech (ibid.) gathers together the evidence on how irrigation influences nutrition indicators, including dietary diversity, and the specific components of the pathways used. She finds that irrigation generally has an encouraging effect on cash crop production, which has the potential to boost dietary diversity via the income pathway. Several studies in various geographical contexts show that household farmers with access to irrigation produce more diverse and high-value crops compared to counterparts depending on rain-fed agriculture (e.g., Namara et al. 2005; Hossain 2009; Hussain and Wijerathna 2004).

Production of fruits and vegetables, a nutritionally important food group, is particularly influenced by irrigation availability. For example, Namara et al. (2007) find that adoption of micro-irrigation projects in India resulted in increased and diversified crop production, and in particular, production and consumption of fruits and vegetables. In another South Asian application, Upadhyay and Samad (2004) suggest that drip irrigation positively influences vegetable production in Nepal. Livestock production is another nutritionally-important food group in which irrigation can play a key role. For example, Murphy and Allen (2003) find that fodder production supported by irrigation improves livestock productivity, increasing consumption of animal-source foods and generating nutritional benefits for young children.

Domenech (2015) however observes that only a handful of studies connect irrigation directly to dietary outcomes, such as the Namara et al. (2007) study discussed above. For example, Dillon (2008) notes that canal irrigation increases caloric intake in Mali. Underlining the notion that irrigation can also influence diets in a negative way, Hossain et al. (2005) find that expansion of small-scale irrigation projects in Bangladesh resulted in reduction of household dietary diversity of the poor arising from the increased production and consumption of rice and reduction in production and consumption of oilseeds and pulses.

Apart from the general paucity of literature linking irrigation to dietary outcomes, an important gap identified by Domenech (2015) is the lack of clarity in the literature about the pathway (own-consumption or market-income based) through which the link operates. An additional shortcoming of the majority of studies identified in that review is the small sample sizes in most of the studies, resulting in low statistical power in detecting effects. This has also been commented on in the context of agriculture-nutrition studies more generally by Masset et al. (2012). Using a large dataset of 11,326 households, this paper adds to the sparse literature on irrigation-diet linkages by contributing fresh evidence from Afghanistan and also addresses the lacuna regarding pathways through which such linkages may operate.

3. Setting, Data and Methods

3.1. Setting

Afghanistan is classified among least developed nations by the United Nations Conference on Trade and Development (2015). Decades of conflicts and instability have suppressed the development of the economy. Recent figures suggest that a quarter of Afghanistan's Gross Domestic Product (GDP) is generated by the agriculture sector (CSO 2014) and 40 per cent of the total work force of the country is estimated to be engaged in agricultural and agriculture-related activities (World Bank 2014).

Agricultural production throughout the country is challenged by erratic precipitation. More than 50 per cent of the area in the country typically receives less than 300 mm of rain per annum, with the eastern region being an exception. Around half of the precipitation is in the form of snow in the central provinces in winter (January to March), with another 30 per cent occurring in spring (April-June). Runoff from snowmelt in the spring and summer months is crucial for the Afghanistan agriculture sector, making the valleys fertile areas for agricultural production. Only a few areas tend to receive sufficient rainfall during the spring months, and for most areas the rainfall level is incompatible with ideal agricultural production conditions (Qureshi 2002). While an appropriate supply of water is essential for the country's agriculture sector, years of conflict have degraded much of the rural water supply system and prevented investments in upgrading infrastructure.

Wheat is the major agricultural enterprise, contributing in 2014 to 25 per cent of agricultural GDP and 6 per cent of national GDP. Most wheat crops (70 per cent) are cultivated on irrigated land, with the planting season in October/November and harvest between May and July. Maize, rice, pulses and cotton harvested in the late summer or autumn are the second tier of important agricultural products in Afghanistan. During spring, vegetables and tubers are harvested. Depending on the region, the lean season stretches between December and April, in which little agricultural activity takes place.

3.2. Data

This study uses the latest available data from 2013-14 of the Afghanistan Living Condition Survey (ALCS), a nationally representative and multi-purpose survey for Afghanistan collected by the Central Statistical Organization of the Islamic Republic of Afghanistan (CSO 2016). The survey gathered information on 20,786 households from all 34 provinces of the country, and covers an entire agricultural season (from December 2013 to December 2014). To ensure representativeness of the survey across geographical areas (national and provincial levels) and seasons, the sampling design was based on 35 strata, one for each province plus one for the Kuchi nomadic pastoralists. Moreover, in order to account for seasonality within each province, the data were collected over 12 months.

The ALCS 2013-14 data were collected using household- and community-level questionnaires consisting of 17 sections. The main household questionnaire was completed by the male head of the household and covered aspects such as agricultural production and household assets. Six additional sections were directed to the spouse and covered information on general living conditions of the household, food security, and child- and gender-related aspects. Household food consumption information has been captured based on a 7-day recall of nine food groups. Furthermore, community-level data on facilities (infrastructure), projects and development priorities were collected at Shura (community) level by interviewing a representative group of males.[1] The study includes 1,954 Shuras.

Given the focus on irrigation in this study, the analysis has been confined to the sub-sample of households that have access to agricultural land. This consists of 11,342 households who had access to agricultural land (irrigated land, rain-fed land, or garden plot) and excludes Kuchi nomadic pastoralists who represented less than 3 per cent of the total households surveyed.

3.3. Dietary diversity measurements

To measure household dietary diversity, the Food Consumption Score (FCS), developed by the World Food Programme (2008) and extensively validated as a measure associated with nutritional status of adults and children (see Steyn et al. 2006; Arimond and Ruel 2004; Ruel 2003), has been used. The FCS is a composite score based on dietary diversity, food frequency and relative nutritional importance of different food groups. It is based on a seven-day recall of food consumption by households. The food items are classified into eight food groups and weighted based on nutritional attributes. The weights range from 0.5 to 4, depending on the nutrient level of the food consumed. Meat, fish, milk and other dairy products have the highest weight of 4, whereas oil and sugar have the lowest weight of 0.5. In addition, vegetables and fruits have a weight of 1 each and main staple foods have a weight of 2. For each food group, frequencies are truncated at 7 to reflect a week's worth of food consumption. A weighted food group score is generated by summing up all the frequencies of the food items of the same group multiplied by their respective weights. The food groups include main staple food (cereals and tubers),[2] pulses, vegetables, fruit, meat/fish and all types of eggs, dairy and dairy products, sugar/honey and oils/fats. The FCS ranges from 0 to 112, where a higher score indicates a more diverse diet, which is a proxy for higher-quality and micronutrient-abundant intakes.

Unique to the ALCS 2013-14 dataset, the source of each food was also recorded. Such information allows the deconstruction of the FCS, based on whether the food comes from own production, or purchased from the market using cash or credit, or derived from other sources such as food aid or gifts. Assessing the role of irrigation on household dietary diversity based on this classification can provide a greater understanding of the link between irrigation, type of the agricultural land owned by the households, food sourcing and household dietary intakes. Thus, the deconstructed FCSs based on the sources of food facilitates addition to the current literature on dietary diversity by examining the multiple pathways from irrigation to diets, enabling a more fine-tuned policy perspective. Finally, in addition to the FCSs based on the different sources of food, their ratios, divided by the total FCS, have been constructed in order to capture the relative patterns of food sources.

[1] Shuras are the smallest administrative units in Afghanistan.
[2] The ALCS (2013-2014) includes an additional food group, tubers (e.g. potatoes, sweet potatoes, etc.). As per WFP (2008), we merged tubers and cereals in the same food group.

3.4. Empirical specification

A multivariate ordinary least squares regression is first used to capture the association between access to irrigation and a household's dietary diversity. The model has the following specification: $y = \beta_0 + \beta_1 \boldsymbol{X_1} + \beta_2 \boldsymbol{X_2} + \beta_3 \boldsymbol{X_3} + \beta_4 \boldsymbol{X_4} + \beta_5 \boldsymbol{X_5} + \beta_6 \boldsymbol{X_6} + u$ FCS as the dependent variable (y) has been initially used and the model has been estimated later with the individual FCSs based on the various sources of food (own production, food purchase from the market, and other sources such as aid or gift). The various models share the same specification. $\boldsymbol{X_1}, \boldsymbol{X_2}, \text{and } \boldsymbol{X_3}$ are the vectors of the households, farm level and infrastructure characteristics, respectively. Similarly, t geographical conditions and climatic conditions are reflected in $\boldsymbol{X_4}, \boldsymbol{X_5}, \text{and } \boldsymbol{X_6}$ respectively.

The household characteristics vector $(\boldsymbol{X_1})$ includes age, marital status, sex, and literacy status of the household head, the dependency ratio of the household and whether it was surveyed during the month of Ramadan. Wealth is measured as an index based on a principal component analysis of the ownership of the various household assets and endowments (Rutstein and Johnson 2004). The vector of farm level characteristics $(\boldsymbol{X_2})$ includes household access to irrigated land, garden plots and rain-fed land. Irrigated land tends to be used for cultivation of staple foods, cash crops, vegetables and fruits, while garden plots are mostly used for cultivating fruits and nuts. Both systems feature irrigation infrastructure. Rain-fed land is widely used for cultivating wheat and depends on rainfall.

The vector of infrastructure characteristics $(\boldsymbol{X_3})$ includes distance to market as well as distance to a road usable all-year round. . Distance to the nearest market for the household is used as a proxy of access to market and the nearest drivable road to the community measured in km is used as a proxy of access to road. These control variables are used to capture the households' transaction costs and marketing opportunities to buy or sell agricultural products.

$\boldsymbol{X_4}$ consists of a dummy capturing whether the household resides in rural areas, $\boldsymbol{X_5}$ is a vector of 33 dummies for provinces (Herat province as reference) and $\boldsymbol{X_6}$ **is** a vector of three dummy variables capturing seasons (autumn as reference). The models were estimated weighted at the household level and clustered at the Shura level to account for the large heterogeneity.

The same specifications were used to jointly model the ratios of FCSs based on the sources of food. A model based on Dirichlet distributions estimated the correlations of covariates with the three ratios (own food produced and consumed, foods purchased from the market, food from aid or gift).[3] The Dirichlet distribution is a generalised beta distribution applicable to the multivariate case that offers a considerable degree of flexibility and ease of use, and is able to accommodate skewness to the right or left or symmetry (Bouguila et al. 2004). The model estimates the correlations between a set of dependent variables and explanatory variables while ensuring that the dependent variables each lie between 0 and 1 and the sum does not exceed1. The estimates are more efficient than OLS or Logit regressions because of these restrictions on the joint model. Newhouse and Wolff (2014) define the probability density function of Dirichlet distributions mathematically as:

[3] The model was estimated using the dirift command in Stata (Buis et al. 2010).

$$f(y_1, \cdots, y_k) = \frac{\Gamma\left(\sum_{i=1}^{k} \alpha_j(X)\right)}{\prod_{j=1}^{k} \Gamma\left(\alpha_j(X)\right)} \prod_{j=1}^{K} y_j^{\alpha_j(X)-1}$$

where y_j is a vector of proportions for category j (in this case, proportions of dietary diversity arising from food that is own produced, purchased, and received free of charge), Γ is the gamma function and α_j is a parameter where ratio and variance for category j can be derived. Also $\alpha_j(X)$ is defined as below:

$$\alpha_j(X) = \frac{e^{\beta_j X}}{1 + \sum_{j=1}^{k} e^{\beta_j X}} \phi$$

where ϕ is a scale parameter which is required to identify the model. In addition to coefficients, marginal effects at the mean are reported.

Finally, it is worth noting that this paper maintains a conditional independence assumption that the variables that affect treatment as well as outcomes are observable. Doubtless, this is a strong assumption, although the conditioning on a range of key variables, including wealth, distances to markets and roads, and geographical confounders (via province dummies), offers some basis for the assumption.

4. Results

4.1. Sample characteristics

Descriptive statistics are reported in **Table A1**. The vast majority of households live in rural areas. Household heads are 44 years old on average, and are mostly male, married and illiterate. Dependency ratio (the proportion of the members of the households aged below 13 and above 65 years old) is 1.03. Seven per cent of the households were interviewed during the month of Ramadan. Households own, on average, 0.75 and 0.68 ha of irrigated and rain-fed land, respectively, and 0.1 ha of garden plot. The nearest driveable road is on average2.3 km from the household and 38 per cent of the households have markets in their local communities.

Households have, on average, a food consumption score of 41, a value that is classified as moderately food-insecure (World Food Programme 2008). The highest proportion of FCS is comprised of food purchased from the market (58 per cent), followed by food from own production (38 per cent) and the remaining from aid or gifts (**Figure A1).**

Table A2 reports the differences across households cultivating different land types: irrigated land (including garden plot) only, rain-fed land only, and a combination of irrigated and rain-fed land. Households with irrigated land tend to have higher FCS followed by households cultivating a combination of irrigated and rain-fed land. The lower dietary diversity is observed in households cultivating only rain-fed land. In Afghanistan, garden plots are widely used for cultivation of fruits and nuts which are both nutritionally-rich and valuable cash crops. On the other hand, irrigated land is generally used to cultivate various staple foods and, to a less degree, cash crops, vegetables and fruits. A smaller selection of agricultural products, mainly staples, is cultivated on rain-fed land. Households with access to a combination of irrigated and rain-fed land tend to have higher FCS from food from their own production than households with access to either irrigated or rain-fed land. A combination of irrigated and rain-fed land is expected to provide a larger variety of agricultural products than irrigated land and rain-fed land alone.

On average, households with access to irrigated land have higher FCS from food purchased from the market, followed by households with access to rain-fed land and a combination of irrigated and rain-fed land. Households with irrigated land may have comparatively higher income as they can cultivate higher value and cash crops which may increase their purchasing power and enable them to purchase more nutritious foods from the market. On the other hand, a combination of irrigated and rain-fed land may have comparatively more variety of agricultural products which may possibly restrict them to purchase food from the market. Households owning only rain-fed land have limited options in terms of crop selection, thus they are expected to purchase nutritious food from the market.

Access to the market significantly varies across different agricultural systems. Almost half of the households with access to irrigated land are located in a community with a weekly food market. The proportion decreases to a third and a quarter for households with a mix and rain-fed land only, respectively. Households cultivating only rain-fed plots are also located farther from transport infrastructures, with an average of 3.1 km from the nearest drivable road as against 2.1 km for households with access to irrigated land. Household heads who cultivate irrigated land have, on average, higher literacy followed by those cultivators of a combination of irrigated and rain-fed land, or rain-fed land only. Gender and marital status of the household heads are not different across the groups.

4.2. Empirical results

Table A3 sets out the different specifications of the determinants of dietary diversity. Results are in line with previous literature, where age and gender of the household head and literacy levels are associated with greater dietary diversity (D'Souza and Jolliffe 2014; Namara et al. 2007; Hussain et al. 2002). Consistent with the recent strand of literature looking at the effect of markets on dietary diversity, the presence of a market in the community is positively associated with greater dietary diversity (Jones et al. 2014).

Access to irrigation, either as irrigated land or garden plot, is positively associated with increased dietary diversity. Irrigated land nurtures the conditions for a greater range of crops to be grown, providing a constant source of water. Moreover, more demanding crops in term of water requirements tend also to be more nutritious in nature (e.g., fruits, vegetables, nuts) and more profitable if marketed. Results of the contribution of irrigated land and garden plots are robust across specifications and do not vary in magnitude when wealth, seasonal dummies, and province dummies are successively added. Rain-fed land, however, becomes insignificant when controlled for location.

Table A4 presents the results of the segregated FCS by the sources of food. Access to irrigation facilities has a mixed effect on difference sources of food. Access to greater irrigated and rain-fed land and garden plots are all associated with greater diet diversity from own production. However, irrigated and rain-fed land seem to be associated with a lower contribution of dietary diversity from market sourcing. Garden plots, on the other hand, are strongly associated with greater dietary diversity sourced from the market.

Capturing the role of irrigation on the *relative* sourcing of dietary diversity from different sources (own production, market, and others sources), **Table A5** conveys the results from the Dirichlet model (marginal effects at the average are reported in **Table A6**).

The Dirichlet model shows that irrigated agricultural land (irrigated land and garden plot) as well as rain-fed land have a relatively strong positive correlation with households' ratios of FCSs sourced from own consumption compared to ratios of FCSs derived from the market and other sources. Marginal effects displayed in **Table A6** reveal that greater access to *any* agricultural land (whether irrigated, rain-fed, or garden plot) is associated with greater share of dietary diversity from own production and the effect is counterbalanced by a reduction on dietary diversity from the market.

4.3. Robustness checks

The regressions reported above applied a series of best practices. Weights have been applied throughout to ensure the representativeness of the estimates. To control for heterogeneity and mitigate potential heteroscedasticity, standard errors have been clustered at the Shura level. Variance inflation factor tests were conducted and they provided reassurance about the lack of multicollinearity in the model.

Although the estimations assume conditional independence, the relative stability of key parameter estimates to the addition of wealth, seasonality and province covariates provides some reassurance about robustness. Additional checks were also carried out. The models in **Table A4** were estimated, replacing FCS as dependent variables with both a variable capturing food security (WFP food security index) and a household coping strategy index[4] (results available upon request). In both cases, the results were broadly consistent with those presented here on the basis of the FCS.

5. Discussion

The results suggest that enhancing agricultural productivity through irrigation infrastructure by ensuring sufficient water for farming is associated with greater household dietary diversity in Afghanistan. Greater access to irrigated land and garden plots has positive and statistically significant associations with household dietary diversity, whereas an increase in rain-fed land has no influence on dietary diversity (**Table A3**). The positive association between irrigation and food security has been suggested by previous literature (e.g., Dillon (2008); Fraiture and Giordano (2014); Haji et al. (2013); Herforth (2010); Rosegrant et al. (2009)). However, the results of this study further an insight into the pathways from irrigation to dietary diversity obtained from different sources of food. On the one hand, access to any type of agricultural land (irrigated and rain-fed lands, and garden plots) is positively associated with household dietary diversity from own production. The relationship is particularly strong in the case of irrigated land, and is likely to reflect the fact that irrigation in Afghanistan mostly opens up the possibility of growing fodder crops and food crops such as potatoes and maize. On the other hand, household dietary diversity from food purchased at the market is positively associated with irrigation only through access to garden plots. This highlights the

[4] The weights and strategies used by ALCS (2013-2014) are: Relay on less preferred and less expensive food (1); Limiting portion size at meal time (1); Reducing the number of meals eaten in a day (1); Borrow food or relay on help from relatives or friends (2); and Restricting consumption by adults for small children to eat (3).

particular status of garden plots mostly growing fruits and nuts in Afghanistan as a primary source of income generation from agriculture via market participation.

These results provide a basis for a nuanced policy strategy. Expansion of irrigated infrastructure can increase dietary diversity from own production. In particular, irrigation facilities may have a greater role in improving dietary diversity for households who are off-grid and rely on their own production for most of the requirements. In contrast, if the priority is to improve dietary diversity through the market, expanding access to garden plots and provision of road infrastructure might be the way forward.

In the case of Afghanistan, irrigation can be seen as an important means to, but not a sufficient condition for, improving dietary diversity. For instance, evidence suggests that in rural areas, in particular, limited knowledge and lack of awareness about nutritious food are among the key challenges adversely affecting food choice and quality of the Afghan diet (Islamic Republic of Afghanistan, Ministry of Public Health 2009; LANSA 2014). Complementary education and awareness initiatives informing households of the greater spectrum of nutritious crops to grow are likely to be important in improving dietary quality. In addition, encouraging profitable sale of agricultural products in the market through market development and access to roads is also likely to be important, alongside irrigation infrastructure development.

Finally, it is important to acknowledge two important limitations of this study, relating to: endogeneity and seasonality. There may be some underlining unobservable characteristics that improve expansion of irrigation and FCS at the same time. Potential instruments such as provincial rainfall were experimented with, but an instrumental variables strategy did not prove fruitful in this case. It is also recognised that agricultural seasons (harvest, post-harvest and lean seasons) may have an important bearing on the irrigation-nutrition linkage, and a case could be made to split the sample by season during estimation. However, due to Afghanistan's heterogeneous agricultural seasons and different climatic condition across the provinces (e.g., two harvests in some provinces and one in other provinces; multiple climates across provinces), it was not possible to accurately split the sample based on seasons.

Steps have been taken to examine or mitigate potential endogeneity as well as seasonality problems: the robustness of main results to an alternative set of model specifications have been examined; and a full set of season dummies have been included in the estimations. This provides some reassurance about the validity of the results.

6. Conclusion

The focus of this study is to assess whether Amulspray, a fortified milk product produced by a The key findings of the study highlight the extent to which households' dietary diversity in Afghanistan is positively correlated with irrigated land and garden plots, with a greater role for the former. However, when the role of individual sources of food is analysed, it was found that irrigation is positively correlated with households' dietary diversity from own-produced food. Moreover, there is a significant association between garden plots and household dietary diversity from purchased food. It was finally found that expansions of irrigated agricultural land (irrigated land and garden plots) and rain-fed land is positively associated with greater ratio of dietary diversity by own-produced food consumed.

Implications from the results suggest that in order to sustain the Afghan households' dietary diversity and nutrition, effective action to bring more arable land under cultivation through irrigation infrastructure can effectively improve diet diversity from own production. Remote households living off-grid that greatly rely on own production for their subsistence would have the most benefit. Importantly, pathways in which irrigation infrastructure can influence dietary diversity from purchased food are likely to be different. Fruits and nuts predominantly grown in garden plots are not only highly nutritious food but also cash crops, increasing opportunities for farmers to consume their own production and as also trade for other food. Hence, if the priorities are to improve dietary diversity from the market, expanding garden plots through irrigation and developing roads and markets might be essential.

Nevertheless, irrigation might not be a sufficient condition to improve dietary diversity in Afghanistan. Provision of education and awareness to farmers about creating agricultural diversity can play a greater role in enhancing dietary diversity from own production. Farmers may be educated to a greater extent to recognise and appreciate the nutritious importance of each type of food for their health. That may provide options to grow a variety of nutritious food for own consumption or profitably sold at the market.

Multi-sectoral action is required to address diet. Agricultural production, markets and trade systems, consumer purchasing power, food transformation and consumer demand are all determining the food environment, and policies with collaborative action by relevant governmental and non-governmental actors (for example, the Ministry of Agriculture, Irrigation and Livestock and the Ministry of Public Health) are required. Strong political will and coordination among key stakeholders may be pre-conditions to improving dietary diversity in Afghanistan; this will help place the importance of nutrition at the government's list of top political and developmental priorities and also facilitate an enabling milieu for improving food environments.

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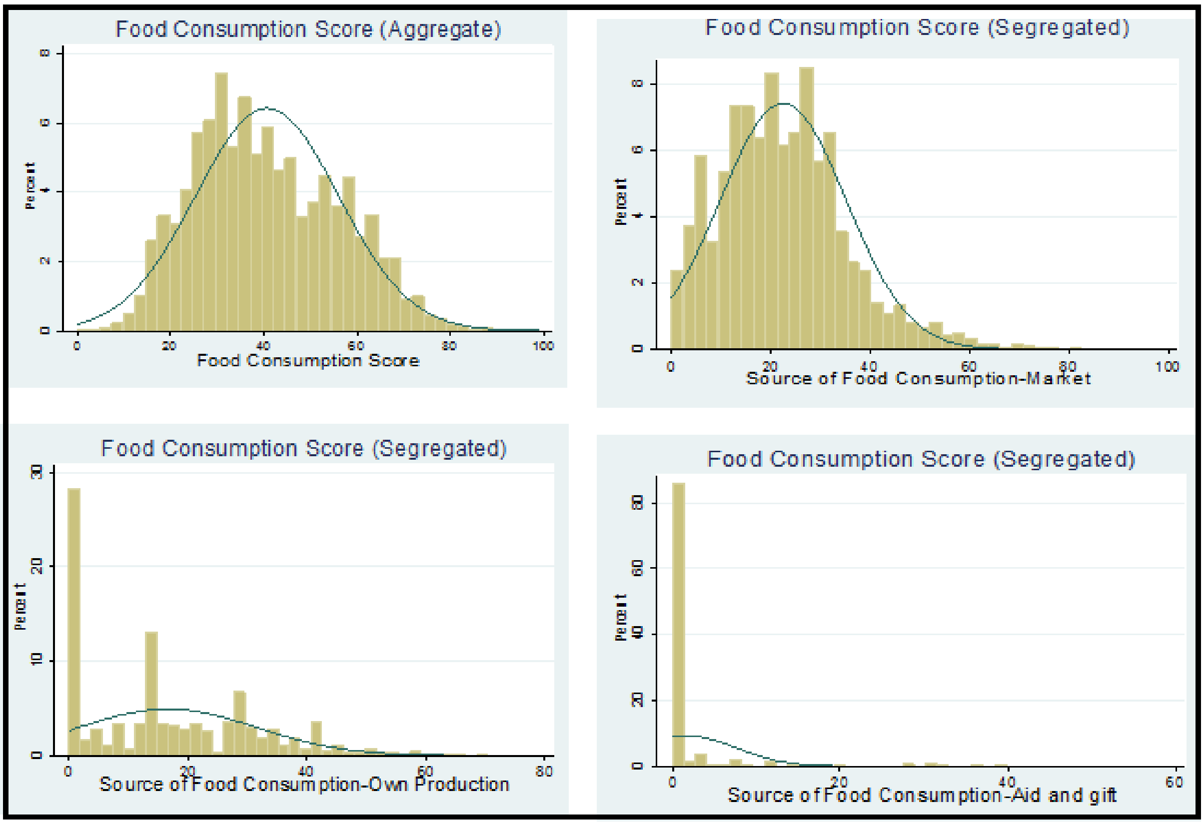
Appendix

Figure A1: Food consumption score, aggregate and based on source of food



Source: Computed and plotted by the authors

Table A1: Summary Statistics (n=11,342)

	Mean	Std. Dev.	Min	Max
Food consumption score (FCS)	40.86	15.6	0	99
FCS (own production)	17.02	15.7	0	74
FCS (purchase from the market)	22.35	12.6	0	95
FCS (others, e.g., aid, gifts)	1.49	5.2	0	55
Ratio of FCS (own production)	0.38	0.3	0	1
Ratio of FCS (purchase from the market)	0.58	0.3	0	1
Ratio of FCS (others, e.g., aid, gifts)	0.04	0.1	0	1
Age of the household head (year)	44.20	14.2	12	98
Male household head (dummy)	0.99	0.1	0	1
Married household head (dummy)	0.98	0.1	0	1
Literate household head (dummy)	0.34	0.5	0	1
Household dependency ratio	1.03	0.8	0	7
Rural areas (dummy)	0.97	0.2	0	1
Month of Ramadan (dummy)	0.07	0.3	0	1
Irrigated land (Jerib)	3.61	9.6	0	330
Rainfed land (Jerib)	3.38	11.2	0	300
Garden plot (Jerib)	0.50	3.4	0	300
Distance from drivable road (km)	2.29	8.0	0	100
Market in the community (dummy)	0.38	0.5	0	1

Note: Statistics are weighted at household level

Table A2: Comparison of agricultural systems (irrigated, rain-fed, and mixed)

	Irrigated (A)		Rain-fed Land (B)		Irrigated and Rain-fed (C)		t-test		
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	A-B	A-C	B-C
Food consumption score (FCS)	42.78	15.46	34.77	14.29	38.27	15.75	8.01***	4.51***	-3.50***
FCS (own production)	16.98	15.77	14.83	14.92	20.42	16.01	2.15***	-3.41***	-5.59***
FCS (purchase from the market)	24.15	12.61	18.64	10.95	17.04	12.10	5.51***	7.10***	1.59***
FCS (others, e.g., aid, gifts)	1.65	5.66	1.31	4.06	0.79	2.88	0.35**	0.86***	0.52***
Age of the household head (year)	44.08	14.08	44.14	14.33	45.02	14.88	-0.06	-0.94**	-0.88
Male household head (dummy)	0.99	0.08	1.00	0.07	1.00	0.06	0.00	-0.02	-0.00
Married household head (dummy)	0.98	0.13	0.99	0.11	0.98	0.14	-0.01	0.00	0.01
Literate household head (dummy)	0.38	0.48	0.19	0.39	0.31	0.46	0.19***	0.06***	-0.12***
Household dependency ratio	1.02	0.79	1.05	0.79	1.00	0.77	-0.03	0.03	0.06*
Rural areas (dummy)	0.96	0.20	0.98	0.15	0.99	0.11	-0.02***	-0.03***	-0.01*
Month of Ramadan (dummy)	0.07	0.26	0.06	0.24	0.08	0.27	0.01	-0.01	-0.02*
Distance from drivable road (km)	2.05	8.18	2.72	6.98	3.09	7.81	-0.66***	-1.04***	-0.38
Market in the community (dummy)	0.42	0.49	0.27	0.45	0.33	0.47	0.14***	0.08***	-0.06***
Observations	8,536		1,588		1,218				

Note: Statistics are weighted at household level. * p<0.10, ** p<0.05, *** p<0.01

Table A3: Regression results (FCS as dependent variable)

	FCS (1)	FCS (2)	FCS (3)	FCS (4)
Age of the household head	0.423***	0.379***	0.380***	0.283***
	(0.069)	(0.068)	(0.068)	(0.058)
Square age of the household head	-0.004***	-0.003***	-0.003***	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)
Household head (male)	5.764***	5.491***	5.470***	3.340*
	(2.122)	(2.028)	(1.983)	(1.810)
Household head (married)	2.282	1.880	1.915	0.845
	(1.522)	(1.522)	(1.503)	(1.207)
Household head (literate)	4.035***	2.832***	2.847***	1.793***
	(0.455)	(0.439)	(0.437)	(0.355)
Household dependency ratio	-1.042***	-0.733***	-0.732***	-0.558***
	(0.211)	(0.207)	(0.207)	(0.182)
Month of Ramadan	3.952***	4.081***	2.952**	2.581***
	(1.322)	(1.313)	(1.475)	(0.811)
Rural areas	-3.072**	0.164	0.216	-0.295
	(1.382)	(1.411)	(1.399)	(1.175)
Distance from drivable road (km)	0.112	0.208*	0.223*	-0.098
	(0.121)	(0.120)	(0.121)	(0.094)
Market in the community	-1.671***	-1.355**	-1.297**	1.041**
	(0.646)	(0.633)	(0.631)	(0.513)
Irrigated land (log)	0.687***	0.570***	0.581***	0.646***
	(0.100)	(0.099)	(0.099)	(0.090)
Rain-fed land (log)	-0.507***	-0.388***	-0.382***	0.120
	(0.098)	(0.097)	(0.096)	(0.086)
Garden plot (log)	0.680***	0.498***	0.498***	0.539***
	(0.122)	(0.120)	(0.119)	(0.101)
Constant	27.184***	22.749***	22.135***	28.745***
	(3.382)	(3.348)	(3.335)	(3.066)
Wealth index (5 quantiles)	N	Y	Y	Y
Seasons (4)	N	N	Y	Y
Provinces (34)	N	N	N	Y
R-square	0.08	0.11	0.11	0.35
Adjusted R-square	0.08	0.11	0.11	0.35
Observations	11,342	11,342	11,342	11,342

Note: Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01. Y: Yes and N: No. Estimations are weighted at the household and are clustered at the Shura levels.

Table A4: Regression results (FCS the dependent variable based on the sources of food consumptions)

	FCS	FCS (Own Production)	FCS (Market)	FCS (Other)
Age of the household head	0.283***	0.328***	-0.011	-0.034*
	(0.058)	(0.061)	(0.044)	(0.019)
Square age of the household head	-0.002***	-0.003***	0.000	0.000
	(0.001)	(0.001)	(0.000)	(0.000)
Household head (male)	3.340*	1.626	2.217**	-0.510
	(1.810)	(1.512)	(1.116)	(0.543)
Household head (married)	0.845	-1.094	1.704*	0.227
	(1.207)	(1.199)	(0.996)	(0.309)
Household head (literate)	1.793***	0.706*	1.036***	0.052
	(0.355)	(0.378)	(0.265)	(0.095)
Household dependency ratio	-0.558***	-0.164	-0.291**	-0.107**
	(0.182)	(0.193)	(0.138)	(0.051)
Month of Ramadan	2.581***	-0.141	2.439***	0.295
	(0.811)	(1.038)	(0.825)	(0.247)
Rural areas	-0.295	7.027***	-7.413***	0.091
	(1.175)	(1.061)	(1.001)	(0.462)
Distance from drivable road (km)	-0.098	0.180*	-0.262***	-0.016
	(0.094)	(0.108)	(0.068)	(0.022)
Market in the community	1.041**	0.402	0.481	0.154
	(0.513)	(0.580)	(0.383)	(0.122)
Irrigated land (log)	0.646***	1.222***	-0.569***	-0.007
	(0.090)	(0.097)	(0.066)	(0.028)
Rain-fed land (log)	0.120	0.533***	-0.446***	0.033
	(0.086)	(0.098)	(0.068)	(0.022)
Garden plot (log)	0.539***	0.296***	0.272***	-0.028
	(0.101)	(0.110)	(0.075)	(0.027)
Constant	28.745***	1.815	23.320***	3.626***
	(3.066)	(2.908)	(2.247)	(0.958)
Wealth index (5 quantiles)	Y	Y	Y	Y
Seasons (4)	Y	Y	Y	Y
Provinces (34)	Y	Y	Y	Y
R-square	0.35	0.25	0.36	0.47
Adjusted R-square	0.35	0.24	0.36	0.47
Observations	11,342	11,342	11,342	11,342

Note: Standard errors in parentheses * p<0.10, ** p<0.05, *** p<0.01. Y: Yes. Estimations are weighted at the household and are clustered at the Shura levels.

Table A5: Regression results of Dirichlet model

	Ratio of FCS (Market)	Ratio of FCS (Other)
Age of the household head	-0.019***	-0.015***
	(0.006)	(0.004)
Square age of the household head	0.000***	0.000**
	(0.000)	(0.000)
Household head (male)	0.092	0.026
	(0.165)	(0.122)
Household head (married)	0.084	0.059
	(0.110)	(0.092)
Household head (literate)	-0.009	-0.013
	(0.032)	(0.025)
Household dependency ratio	0.034*	0.013
	(0.017)	(0.014)
Month of Ramadan	0.057	0.039
	(0.093)	(0.074)
Rural areas	-0.595***	-0.406***
	(0.072)	(0.060)
Distance from drivable road (km)	-0.017**	-0.011*
	(0.009)	(0.007)
Market in the community	-0.034	-0.008
	(0.048)	(0.038)
Irrigated land (log)	-0.106***	-0.080***
	(0.009)	(0.007)
Rain-fed land (log)	-0.049***	-0.031***
	(0.009)	(0.007)
Garden plot (log)	-0.021**	-0.015**
	(0.009)	(0.007)
Constant	1.784***	-0.081
	(0.275)	(0.219)
Wealth index (5 quantiles)	Y	Y
Seasons (4)	Y	Y
Provinces (34)	Y	Y
Wald Chi-Square	2,507.6	
Chi-Square	0.000	
Observations	11,326	

Note: Dirichlet model for FCS ratios whose food is from market and other sources (the base outcome: ratio of FCS from own produced and consumed food). Y: Yes. Standard errors in parentheses * p<0.10, ** p<0.05, *** p<0.01. Estimations are weighted at the household and are clustered at the Shura levels.

Table A6: Marginal effects at the average estimated by Dirichlet model for all three types of FCS ratios

	Ratio of FCS (Own Production)			Ratio of FCS (Market)			Ratio of FCS (Other)		
	Coefficient	**M.E**	**Std. err.**	**Coefficient**	**M.E**	**Std. err.**	**Coefficient**	**M.E**	**Std. err.**
Age of the household head	0.33	0.00	0.00	-0.31	0.00	0.00	-0.02	0.00	0.00
Household head (male)	-0.02	-0.02	0.04	0.02	0.02	0.04	0.00	0.00	0.01
Household head (married)	-0.02	-0.02	0.03	0.02	0.02	0.03	0.00	0.00	0.01
Household head (literate)	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00
Household dependency ratio	-0.04	-0.01	0.00	0.05	0.01	0.00	-0.01	0.00	0.00
Month of Ramadan	-0.01	-0.01	0.02	0.01	0.01	0.02	0.00	0.00	0.00
Rural areas	0.10	0.10	0.16	-0.10	-0.10	0.13	0.00	0.00	0.03
Distance from drivable road (km)	0.03	0.00	0.00	-0.03	0.00	0.00	0.00	0.00	0.00
Market in the community	0.01	0.01	0.01	-0.01	-0.01	0.01	0.00	0.00	0.00
Irrigated land (log)	0.22	0.02	0.00	-0.21	-0.02	0.00	-0.01	0.00	0.00
Rain-fed land (log)	0.10	0.01	0.00	-0.10	-0.01	0.00	0.00	0.00	0.00
Garden plot (log)	0.04	0.00	0.00	-0.04	0.00	0.00	0.00	0.00	0.00
Wealth index (5 quantiles)		Y			Y			Y	
Seasons (4)		Y			Y			Y	
Provinces (34)		Y			Y			Y	
Observations					11,326				

Note: Discrete change of dummy variable from 0 to 1. Marginal effects (M.E.) are calculated at the average. Y: Yes.