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Food as the Basis for Development and Security

A Strategy for Yemen

Clemens Breisinger

Olivier Ecker

Jose Funes

Bingxin Yu

Development Strategy and Governance Division

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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AUTHORS

Clemens Breisinger, International Food Policy Research Institute
Research Fellow, Development Strategy and Governance Division
C.Breisinger@cgiar.org

Olivier Ecker, International Food Policy Research Institute
Postdoctoral Fellow, Development Strategy and Governance Division
O.Ecker@cgiar.org

Jose Funes, International Food Policy Research Institute
Research Analyst, Development Strategy and Governance Division
J.Funes@cgiar.org

Bingxin Yu, International Food Policy Research Institute
Research Fellow, Development Strategy and Governance Division
B.Yu@cgiar.org

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ABSTRACT

Yemen has been facing severe development challenges in recent years, but rapidly depleting oil and water resources combined with large population increases and a lack of job-creating growth are making a difficult situation even more complicated. In order to provide opportunities for Yemenis to escape the current situation of widespread poverty and food insecurity, the Government of the Republic of Yemen, under the leadership of the Ministry of Planning and International Cooperation, has developed a strategy to help all Yemeni people gain access to sufficient and nutritious foods in order to live active, productive, and healthy lives. The main objectives of the National Food Security Strategy, developed with the support of the International Food Policy Research Institute, are to (1) cut food insecurity by one-third by 2015, (2) reach moderate food security levels—meaning 90 percent of people have enough to eat year-round—by 2020, and (3) reduce child malnutrition by at least one percentage point per year. As a contribution to this process, the authors of this paper identify seven priority actions to help achieve these goals.

1. Leverage the fuel-subsidy reform process to promote food security.
2. Improve the business climate to foster pro-food-secure private investments in promising sectors.
3. Use qat reduction policies to enhance agricultural development.
4. Strengthen food security risk-management practices.
5. Implement the water-sector strategy decisively.
6. Target public investment to the food insecure more accurately and improve service provision, especially in rural areas.
7. Launch high-level awareness campaigns for family planning, healthy nutrition, and women's empowerment.

The government, civil society groups, and international partners need to quickly, decisively, and jointly implement these seven actions in order to fulfill the strategic goals. The implementation process is likely to be most effective if conducted in a transparent and inclusive manner with effective follow-up and appropriate monitoring and evaluation mechanisms.

Keywords: food security, poverty, economic development, Yemen, Middle East

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ABBREVIATIONS AND ACRONYMS

CGE	Computable General Equilibrium
CSO	Central Statistical Organization
DCGE	Dynamic Computable General Equilibrium Model
DMSP	Defense Meteorological Satellite Program
ESRI	Economic and Social Research Institute
FAO	Food and Agriculture Organization (of the United Nations)
FDI	Foreign Direct Investments
GDP	Gross Domestic Product
GIS	Geographic Information System
GLC	Global Land Cover
GOY	Government of the Republic Yemen
GTZ	German Agency for Technical Cooperation
HAZ	Height-for-Age Z-score
HBS	Household Budget Survey
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
kcal	Kilocalories
MBS	Marginal Budget Shares
MENA	Middle East and North African
MOAI	Ministry of Agriculture and Irrigation
MOFW	Ministry of Fish Wealth
MOPIC	Ministry of Planning and International Cooperation
NFSSP	National Food Security Strategy Paper
NGO	Nongovernmental Organization
NWSSIP	National Water Sector Strategy and Investment Program
OLS	Operation Linescan System
SAM	Social Accounting Matrix
SRTM30	Shuttle Radar Topography Mission
TFP	Total Factor Productivity
UAE	United Arab Emirates
USAID	United States Agency for International Development
WHO	World Health Organization
wrt.	With Reference To
YR	Yemeni Riyals

1. INTRODUCTION

Yemen has been facing severe development challenges in recent years, but rapidly depleting oil and water resources combined with large population increases and a lack of job-creating growth are making a difficult situation even more complicated. In fact, major development indicators in Yemen paint an alarming picture. Poverty levels increased from 34.8 percent in 2005–06 to 42.8 percent in 2009 as a consequence of the triple global crisis, falling oil exports, and slow growth in non-oil sectors, which fails to trickle down to the poor, especially in rural areas (Breisinger et al. 2010). Food security[1] has also deteriorated in recent years, at both the macroeconomic and household level. The country's ratio of total exports and food imports (a measure of a given country's ability to import food) has dramatically deteriorated due to declining oil exports and increasing food imports. The share of people without access to enough food—the ultra poor—rose to 32.1 percent, or 7.5 million people, in 2009 (Ecker et al. 2010). The number of these food-insecure people who live in rural areas is more than five times higher than those who live in urban areas. Child malnutrition due to the insufficiency of nutritious foods available, insufficient health services, and extremely high population growth is widespread. In 2009, 59.4 percent of children aged 0–59 months were stunted (that is, too short for their age), implying potentially very serious effects for the health and productivity of future generations (Ecker et al. 2010).[2]

To add to the "perfect storm" of factors contributing to development problems in Yemen, the country's difficult economic situation is further complicated by issues of national security. The failed bombing of a US airplane in December 2009 and attempted terrorist attacks using parcel bombs in October 2010 have raised widespread concerns.

The mission to realize food security[3] for all Yemenis requires a comprehensive, cross-sector, decisive approach. In the quest to identify which actions should take priority to achieve that mission, the Government of Yemen, with support from the International Food Policy Research Institute and international donors, developed the National Food Security Strategy. During the consultative process—which started in May 2009 and included a series of technical and policy workshops—a joint vision and strategic objectives were formulated. The vision is for all Yemeni people to have access to sufficient and nutritious food at all times in order to live active and healthy lives—that is, that all people are food secure. The strategic objectives against which success will be judged and progress will be monitored are to (1) cut food insecurity by one-third by 2015, (2) ensure that 90 percent of Yemenis are food secure by 2020, and (3) reduce child malnutrition by at least one percentage point per year. In addition to these objectives, a set of broad policy actions were defined during the consultative process. The 18 priority action areas identified (see Appendix) serve as the basis for the quantitative analysis presented in this paper.

[1] Food security is a situation "when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 2009).

[2] For 2006, Ecker et al. (2010) estimated child malnutrition (via stunting) at a prevalence rate of 57.9 percent nationwide, 45.4 percent in urban areas, and 62.1 percent in rural areas. To be consistent with food security estimates, child malnutrition estimates were updated for 2009 by incorporating the impacts of the triple crisis, using the Yemen Child Nutrition Model (presented in Section 2).

[3] Food security is often preferable to poverty as a measure of development, especially in the case of Yemen. First, it food security actually is a measure of poverty—*extreme* poverty, at that—because it represents the number of people who do not have enough food to eat. Second, food security takes into account child malnutrition, which is an important indicator for *future* development prospects of a country. Finally, food security encompasses macroeconomic aspects of development, which is important for a country like Yemen that heavily relies on international markets for covering the domestic demand for food.

The objective of this paper is to prioritize alternative policy, investment, and program options to reach the stated food security goals based on rigorous quantitative analysis. To help design a comprehensive action plan for Yemen, we have developed an innovative analytical framework that essentially links a computable general equilibrium model to an econometric micro-simulation model. The main indicators include the ratio of total exports to food imports on the macro level as well as various household-level food security indicators, including the prevalence of food insecurity, the per capita "calorie gap," and the prevalence of child malnutrition (as defined by the height-for-age z-score). The remainder of this discussion paper is organized as follows: Section 2 describes the methodology used to analyze the options; Section 3 presents and discusses policy options; Section 4 discusses investment and program options; and Section 5 concludes with a seven-point action plan for achieving Yemen's food security goals.

2. METHODOLOGY: LINKING MACRO, SECTOR, SPATIAL, AND HOUSEHOLD LEVELS

Research-based evidence can make an important contribution to improving food security by providing policymakers with analytical support for their decisionmaking. This section presents an economywide model with microsimulations to assess the various impacts of selected options (presented in Sections 3 and 4) on different dimensions of food security. Section 2.1 presents the dynamic computable general equilibrium model, which links to both a microsimulation model on household food security and a microsimulation model on child nutrition. The two integrated models are referred to as the Yemen Food Security Model and the Yemen Child Nutrition Model, respectively. The microsimulations use parameter estimates that are derived from parametric regression models. Section 2.2 presents the regression models and the microsimulations. To incorporate the effects of spatial factors on household food security and child nutrition, the regression models include spatial variables estimated from a spatial model. The spatial model, which is also used to simulate investments in road and health service infrastructure (Sections 4.2.1 and 4.2.4), is explained in Section 2.3.

2.1. The Dynamic Computable General Equilibrium Model

To estimate the impact of policy changes, we built a dynamic computable general equilibrium (DCGE) model to assess how these changes affect the macroeconomy, different economic sectors, factor markets, and the incomes of households by different household groups. The DCGE model is constructed consistent with the neoclassical general equilibrium theory. The theoretical background and the analytical framework of computable general equilibrium (CGE) models are well documented in Dervis, de Melo, and Robinson (1982), while the detailed mathematical presentation of a static CGE model is described in Löfgren, Harris, and Robinson (2002). The recursive dynamic version of the CGE model is based on this standard CGE model, with the incorporation of a series of dynamic factors. The early version of this dynamic CGE model can be found in Thurlow (2004), while its recent applications include Diao et al. (2007) and Breisinger, Diao, and Thurlow (2009). A summary of the main equations is shown in Table 1.

Table 1. Core DCGE model equations

Production function	$Q_{ct} = \alpha_{ct} \cdot \prod_f F_{fct}^{\delta_{fc}}$	(1)
Factor payments	$W_{ft} \cdot \sum_c F_{fct} = \sum_c \delta_{fc} \cdot P_{ct} \cdot Q_{ct}$	(2)
Import supply	$P_{ct} \leq E_t \cdot w_c^m \perp M_{ct} \geq 0$	(3)
Export demand	$P_{ct} \geq E_t \cdot w_c^e \perp X_{ct} \geq 0$	(4)
Household income	$Y_{ht} = \sum_{fc} \theta_{hf} \cdot W_{ft} \cdot F_{fct} + r_h \cdot E_t$	(5)
Consumption demand	$P_{ct} \cdot D_{hct} = \beta_{hc} \cdot (1 - v_h) \cdot Y_{ht}$	(6)
Investment demand	$P_{ct} \cdot I_{ct} = \rho_c \cdot \left(\sum_h v_h \cdot Y_{ht} + E_t \cdot b \right)$	(7)
Current account balance	$w_c^m \cdot M_{ct} = w_c^e \cdot X_{ct} + \sum_h r_h + b$	(8)
Product market equilibrium	$Q_{ct} + M_{ct} = \sum_h D_{hct} + I_{ct} + X_{ct}$	(9)

Table 1. Continued

Factor market equilibrium	$\sum_c F_{fct} = s_{ft}$		(10)
Land and labor expansion	$s_{ft} = s_{t-1} \cdot (1 + \varphi_f)$	f is land and labor.	(11)
Capital accumulation	$s_{ft} = s_{t-1} \cdot (1 - \eta) + \sum_c \frac{P_{ct-1} \cdot I_{ct-1}}{\kappa}$	f is capital.	(12)
Technical change	$\alpha_{ct} = \alpha_{ct-1} \cdot (1 + \gamma_c)$		(13)

Subscripts

c	Commodities or economic sectors
f	Factor groups (land, labor, and capital)
h	Household groups
t	Time periods

Endogenous variables

D	Household consumption demand quantity
E	Exchange (local/foreign currency units)
F	Factor demand quantity
I	Investment demand quantity
M	Import supply quantity
P	Commodity price
Q	Output quantity
W	Average factor return
X	Export demand quantity
Y	Total household income

Exogenous variables

b	Foreign savings balance (foreign currency units)
r	Foreign remittances
s	Total factor supply
w	World import and export prices

Exogenous parameters

$\acute{a}$	Production shift parameter (factor productivity)
$\hat{a}$	Household average budget share
γ	Hicks neutral rate of technical change
$\ddot{a}$	Factor input share parameter
η	Capital depreciation rate
$\grave{e}$	Household share of factor income
κ	Base price per unit of capital stock
ρ	Investment commodity expenditure share
υ	Household marginal propensity to save
φ	Land and labor supply growth rate

Source: Source: Authors' calculation.

The Yemen DCGE model is dynamic and runs from 2010 to 2020, the time period of Yemen's food security strategy horizon. The base year of the model is 2009, for which a 2007 social accounting matrix (SAM) is updated to represent Yemen's economy in 2009 as the main database. Given the lack of more recent official data, we updated the 2007 SAM to 2009 using changes of GDP components between 2007 and 2009, as calculated by Breisinger et al. (2010). The authors estimate that GDP grew by 3.87 percent from 2007 to 2009, whereas private consumption shrank by –5.63 percent, investment increased by 24.38 percent (mainly investment in the gas sector), government consumption reduced by –15.0 percent, imports decreased by –3.82 percent, and exports almost stagnated at 0.83 percent. Imposing these changes on the 2007 macro SAM yields a new 2009 SAM, which is shown in its aggregate form in Table 2. A detailed overview of all sectors and institutions is provided in Table 3.

Table 2. Macro SAM for Yemen, 2009

	PROD	COM	FAC	ENT	HH	GOV	SAV	ROW	Total
Production	0	7,225							7,225
Commodities	2,408				2,493	613	1,491	1,410	8,416
Factors	4,817								4,817
Enterprises			1,927			158		76	2,162
Households			2,890	0		126		285	3,301
Government		–593		1,179	72			271	929
Savings				326	736	22		408	1,491
Rest of world		1,784		656		10			2,451
Total	7,225	8,416	4,817	2,162	3,301	929	1,491	2,451	

Source: Authors' calculation.
Note: Row headings are abbreviated forms of respective column labels.

The DCGE model is calibrated to the Yemen SAM—that is, the model's base year is consistent with the structure of the Yemeni economy in 2009. In addition, the baseline scenario replicates historical growth patterns and includes emerging trends such as the increase in gas exports and the decrease in oil exports. The model is recursive dynamic, which means the dynamics occur between two periods at a time—in the case of the Yemen model, it occurs between each of the 10 different years. Private investment and, hence, capital accumulation are determined by a Solow model of savings decision, in which savings are proportional to the income, and not endogenously solved from a Ramsey[4] type of intertemporal utility function. In the baseline scenario, as well as in all other scenarios, we assume that the nominal exchange rate is flexible. Exogenous variables in the model include government consumption, transfers to households, foreign inflows, population growth, and, hence, growth of the workforce, which all expand exogenously according to their historic trends in recent years. Investments are savings driven, and savings grow proportionally to households' income. Investments are in construction, industrial, and service sectors. Most capital goods related to investments are not produced locally; thus, investments are highly import-intensive. The government budget is flexible, which means the government can adjust to changes in revenues and spending by increasing or decreasing the budget deficit. At the sector level, total factor productivity (TFP) increases exogenously to account for the differential growth patterns across sectors.

Table 3. SAM disaggregation, 2009

Activities/Commodities		**Factors of production**
Agriculture	***Industry***	***Labor***
Sorghum	Oil	Private sector, unskilled
Maize	Gas	Private sector, semi-unskilled
Millet	Other mining	Private sector, skilled
Wheat	Beverages	Public sector, unskilled
Barley	Bread	Public sector, semi-unskilled
Other grains	Other cereal-based food	Public sector, skilled
Bananas	Dairy products	***Capital***
Grapes	Vegetable oil	Capital
Mangoes	Sugar, processed	Oil capital
Citrus fruits	Camel meat	Gas capital
Other fruits	Beef meat	***Land***
Potatoes	Poultry	
Onions	Goat and sheep meat	**Households**
Tomatoes	Other processing	***Rural***
Other vegetables	Fish processing	Farm, food secure
Pulses	Textiles and clothing	Farm, food insecure
Coffee	Leather and shoes	Nonfarm, food secure
Sesame	Wood	Nonfarm, food insecure
Cotton	Paper	***Urban***
Qat	Printing	Urban, food secure
Tobacco	Oil refining	Urban, food insecure
Camel	Chemicals	

[4] See Diao et al. (1998) for the discussion of Ramsey-type intertemporal utility function and its role in determining consumers' consumption and saving behaviors

Table 3. Continued

Activities/Commodities		Factors of production
Agriculture	***Industry***	***Labor***
Cattle	Fertilizer and pesticides	**Other accounts**
Chicken	Nonmetals	Enterprise
Goats and sheep	Metals	Government
Fishery	Machinery	Direct taxes
Forestry	Other manufacturing	Sales taxes
	Electricity	Import tariffs
	Water	Savings-investment
	Construction	Rest of world
	Services	
	Trade	
	Hotels and restaurants	
	Transport and communication	
	Business services	
	Health	
	Education	
	Public services	
	Other services	

Source: SAM 2009.

Nonhydrocarbon capital is fully mobile across all sectors, and its intertemporal allocation follows the highest profitability by sector and period. Population growth, land, and productivity growth are all exogenously determined. In the model, baseline growth is driven by population growth (3 percent), supply of labor (3 percent), annual TFP growth changes in all nonagricultural sectors for 2013–2020, and an increase in government spending consistent with annual growth rates (3.8 percent). Given the scarcity of land and water, the total amount of land for agricultural production is fixed. Labor is fully mobile across sectors, and the wage rate is an endogenous variable determined by the market equilibrium between total labor supply and total labor demand. Accordingly, there are different wage rates for labor employed with the government and the private sector. Within each group, wage rates differ among skilled, medium-skilled, and highly skilled labor. For example, if overall economic growth is led by labor-intensive sectors (such as textiles), additional demand for labor from these sectors can cause wage rates to rise relative to the returns to the other factors (for example, to capital). On the other hand, if growth is led by sectors that are highly capital intensive (such as oil extraction), demand for labor may not increase much during the growth process ("jobless growth"). Given similar labor supply growth, wage rates may thus fall or rise less than the returns to capital, depending on the driving sector of growth. Changes in the wage rate (in particular the wage rate for unskilled, private-sector labor) affect the distribution of income and poverty reduction during the period of the food security strategy.

In addition to the SAM as the main data source for calibrating to a set of parameters in both production and demand functions, a DCGE model also requires several elasticities. The main elasticities include the substitution elasticity among primary inputs in the value-added production function, the elasticity between domestically produced and consumed goods and exported or imported goods, and the income elasticity in the demand functions. The income elasticity is estimated from a semilog inverse function suggested by King and Byerlee (1978) and based on the household budget survey (HBS) 2005/06 data for rural and urban households separately (CSO 2006). From the estimated results, together with the average budget share for each commodity consumed by each household group directly calculated using the Yemen SAM data, we derive a series of marginal budget shares (MBS) that are applied in the

model. These elasticities range, for example, from 0.28 for cereals to 3.2 for some services. For elasticities that could not be estimated econometrically due to the lack of data, we use international standards numbers based on IFPRI and Hertel et al. (2007). For the intermediate inputs in the production function, we use a Leontief technology. With this assumption, a set of fixed input–output coefficients can be directly derived using the Ghana SAM data. For the factor substitution elasticity, we choose 1.2; the elastic of transformation is 3.0; and the Armington elasticity is 10.0 for highly traded cereals, 3.0 for other agricultural sectors, 6.0 for manufacturing, and 4.0 for services.

Table 4 details how the assumptions change to model a change in the baseline assumptions. The main parameters to implement the shocks imposed on the model to reflect policy changes include changes in TFP, population growth, foreign savings, remittances, world market prices, government transfers, and tax rates. More detailed nontechnical descriptions can be found under the respective scenarios in the text.

Table 4. Overview of CGE model simulations

Annual growth rate/changes in selected exogenous variables

	TFP	Population	Foreign savings	Remittances	World market price	Government transfers	Taxes
First set of scenarios:							
Fuel subsidy reform (changes, 2010-20)							
Scenario 1: Reduce fuel subsidy only	as base	as base	as base	as base	as base	as base	30-50% decrease of subsidy on fuel for 2010-2015
Scenario 2: Scen. 1 plus add transfer to the food insecure	as base	as base	as base	as base	as base	50% increase of transfers to food-insecure households for 2010-2013	30-50% decrease of subsidy on fuel for 2010-2015
Scenario 3: Scen. 2 plus productivty- enhancing investment	4-6% in construction, utilities, private services bw. 2011-2013. TFP increase of 2% in all sectors	as base	as base	as base	as base	50% increase of transfers to food-insecure households for 2010-2013	30-50% decrease of subsidy on fuel for 2010-2015
Second set of scenarios:							
Growth in promising sectors (changes, 2009)							
Scenario 4: Growth in promising sectors	2-7%increase in mining, food processing, communication, transport, trade, tourism	as base	6% increase for 2010-2020	as base	as base	as base	as base
Scenario 5: Fishery and fish processing	3% increase in fishery and fish processing	as base	1% increase for 2010-2020	as base	as base	as base	as base
Scenario 6: Qat and agriculture	3% increase in cereals and coffee production and processing	as base	as base	as base	as base	as base	Qat tax rate of 14% of qat value in 2011 and 20% in 2012
Third set of scenarios:							
Population growth, remittances and trade							
Scenario 7: Population growth	as base	Reduction of 0.13%age points	as base	as base	as base	as base	as base
Scenario 8: Remittances	as base	as base	as base	3% annual increase	as base	as base	as base
Scenario 9: Trade	as base	as base	as base		3% decrease for cereals and products for 2011-2015	as base	as base
Combined scenario	**Joint**	**Joint**	**Joint**	**Joint**	**Joint**	**Joint**	**Joint**

Source: Authors' calculation.

2.2. Household Food Security and Child Nutrition Regression Models and Microsimulations

Food security is measured as per capita calorie consumption adequacy, whereas child nutrition is measured based on the height-for-age z-scores (HAZ) of children aged 0–59 months who were last born in the surveyed households (if their HAZ is in the biological plausible range).[6] The proposed policy options presented in Section 3 affect food security and child nutrition mainly through their link to household income. The reference year for all scenarios is 2009. Consistent with the DCGE model, a constant population growth of 3 percent annually is assumed for all scenarios except for the population growth reduction scenario (scenario 7) and the combined scenario.

To model the economic impact of the different scenarios on food security, the estimated real income changes from the DCGE model and the estimated calorie-income elasticities from a household calorie consumption regression model enter a microsimulation that expresses each household's per capita calorie consumption in a given year as an outcome of its real income change.[7] The new per capita calorie consumption amount of each household is related to its specific calorie requirement level. Based on this information, the new prevalence rate of food insecurity is calculated for the total population or specific population groups—that is, urban, rural farm, and rural nonfarm households.[8]

The same procedure is used for modeling the impact on child nutrition. This paper uses anthropometric data of young children under 5 years of age, because they are most exposed to nutrition and health risk and are most vulnerable to external shocks in general. From the three common child anthropometric indicators (height-for-age, weight-for-age, weight-for-height), height-for-age is chosen, because it best reflects the long-term nutritional health status of children. A child is considered as stunted (or too short for its age) if its HAZ is below –2. Thus, the prevalence of stunting gives the percentage of children below this cutoff level.

2.2.1 Regression Models

The relationship between per capita calorie consumption and household income and other food security–relevant factors, as well as the relationship between children's HAZ and household income and other child nutrition–relevant factors, is estimated by using a microeconometric approach; more precisely, parametric regression models are applied. Based on specification tests, both models are run for rural and urban households separately to account for structural differences between these household groups. Nonparametric regressions suggest that the functional form between the dependent variable (per capita calorie consumption / child HAZ) and household real income (measured as total per capita expenditure) requires curvature, while quadratic specification yields the highest overall model fits. The fits of the household calorie consumption regression model could be increased by using logarithms for all continuous variables. Continuous variables enter the child nutrition regression model in linear form. Accordingly, the household calorie consumption regression model is of log-log form, whereas the child nutrition regression model is of lin-lin form. The estimation equations take the following functional form:

$$y = \alpha + \beta_1 x + \beta_2 x^2 + \gamma Z + \delta A + \varepsilon, \quad (1)$$

where y is the amount of the households' per capita calorie consumption (in kilocalories [kcal] per day) reported for the last of the four survey weeks of the 2005/06 HBS (before making adjustments for outliers and food consumption outside the home, as explained in Ecker et al. (2010) in the household calorie consumption regression model (CSO 2006). Calorie consumption data for the last surveyed week are usually more reliable because people's remembering of food consumption is better over a short period. In the child nutrition regression model, the dependent variable is the children's HAZ.

[6] For more information, see Ecker et al. (2010).

[7] Elasticities express the percentage change of the dependent variable (here, per capita calorie consumption amounts and children's height-for-age z-score) as a result of a change in the independent variable (here, per capita household expenditure) by 1 percentage point.

[8] Ecker et al. (2010) report the applied calorie requirement levels.

The independent variable x gives households' total per capita expenditure (including estimated opportunity values for home consumption of food) in both models. Instead of reported income data, reported total expenditure data are applied, as they are usually a better proxy for household real income (Deaton 1997).

Z is a vector of household-specific and individual-specific factors relevant to household food security and child nutrition, respectively. The vector A comprises an index variable that measures both the physical access to local markets in the household calorie consumption regression model and the physical access to quality health services in the child nutrition regression model, as well as several location-specific variables. The physical health access indexes are derived from a spatial gravity model (see Ecker et al. 2010). The z and a variables were selected from a large pool of various (and alternative) potentially explanatory variables based on findings from Part I of the NFSSP and econometric testing. Variables are only included in the models if they support theoretically plausible relationships and show statistical significances for at least one of the household groups. Nonparametric regressions and indicators of model fits are used to find evidence of the underlying functional form between the dependent variables and the independent (continuous) variables.

In the estimation equation (1), α, β, γ, and δ are parameters to be estimated, and ε is a random error term. Tables 5 and 6 describe the models' variables and report its estimation results.

Table 5. Estimation results and variable description of the household calorie consumption regression model

Independent variables			**Rural**			**Urban**		
Var.	***Description***	***Form***	***Coeff.***		***Std. err.***	***Coeff.***		***Std. err.***
x_1	Per capita household expenditure (YR/day)[1]	log	1.712	***	0.197	1.050	***	0.129
x_2	Per capita household expenditure squared (YR/day)[1]	log	-0.115	***	0.018	-0.058	***	0.011
z_1	Household size (heads)	log	-0.105	***	0.014	-0.021	*	0.011
z_2	Farm	0=no, 1=yes	0.038	**	0.015			
a_1	Local market access	0=no, 1=yes	0.038		0.052	-0.059	**	0.029
a_2	Spatial index of local market access[2]	log	0.012	***	0.002	0.015	***	0.002
a_3	Lower Highlands Zone (1,500--1,900 m)[3]	0=no, 1=yes	-0.094	***	0.019	0.026		0.017
a_4	Red Sea and Tihama Zone[3]	0=no, 1=yes	-0.029		0.024	0.014		0.019
a_5	Arabian Sea Zone[3]	0=no, 1=yes	-0.162	***	0.046	0.000		0.021
a_6	Internal Plateau Zone[3]	0=no, 1=yes	-0.231	***	0.038	0.185	***	0.036
a_7	Desert Zone[3]	0=no, 1=yes	-0.169	***	0.051	0.299	***	0.079
Constant			2.123	***	0.536	3.354	***	0.384
Observations			4,863			8,273		
F-value			160.33			171.63		
R-squared			0.267			0.172		

Source: Authors' estimation based on 2005/06 HBS data (CSO 2006).
Note: The dependent variable (y) is per capita calorie consumption (kcal/day) in logarithmic form.
[1] YR stands for Yemeni Riyals.
[2] See Section 2.3 for more information about the estimation method of the index.
[3] The reference variable is Higher Highlands Zone (> 1,900 m).

Table 6. Estimation results and variable description of the child nutrition regression model

Independent variables			Rural			Urban		
Var.	*Description*	*Form*	*Coeff.*		*Std. err.*	*Coeff.*		*Std. err.*
x_1	Per capita household expenditure (YR/day)[1]	lin	0.002	**	0.001	0.001	***	0.000
x_2	Per capita household expenditure squared (YR/day)[1]	lin	0.000	**	0.000	0.000	*	0.000
z_1	Sex of child	0=male, 1=female	0.251	***	0.072	0.327	***	0.057
z_2	Dependendy ratio: number of children (<14 years) and elderly (>59 years) divided by household size	lin	-0.465	*	0.246	-0.467	**	0.188
z_3	Years of education of the child's mother/ guardian	lin	0.036	***	0.014	0.030	***	0.006
z_4	Share of qat expenditure on total household expenditure	lin	-0.576		0.476	-0.844	**	0.347
a_1	Time spent for fetching water per day (min)	lin	-0.004	***	0.001	-0.008	*	0.004
a_2	Sewage network connection	0=no, 1=yes				0.348	***	0.063
a_3	Index for access to health facilities with breastfeeding education program[1]	lin	0.000	***	0.000	0.000	***	0.000
a_4	Lower Highlands Zone (1,500—1,900 m)[3]	0=no, 1=yes	0.743	***	0.096	0.259	***	0.087
a_5	Red Sea and Tihama Zone[3]	0=no, 1=yes	0.577	***	0.118	-0.027		0.094
a_6	Arabian Sea Zone[3]	0=no, 1=yes	0.849	***	0.245	0.444	***	0.094
a_7	Internal Plateau Zone[3]	0=no, 1=yes	1.028	***	0.169	0.522	***	0.152
a_8	Desert Zone[3]	0=no, 1=yes	-0.588	**	0.276	-1.001	***	0.359
Constant			-3.076	***	0.227	-2.624	***	0.149
Observations					2,278			3,415
F-value					11.80			25.66
R-squared					0.064			0.096

Source: Authors' estimation based on 2005/06 HBS data (CSO 2006).
Note: The dependent variable (y) is per capita calorie consumption (kcal/day) in logarithmic form.
[1] YR stands for Yemeni Riyals.
[2] See Section 2.3 for more information about the estimation method of the index.
[3] The reference variable is Higher Highlands Zone (> 1,900 m).

2.2.2 Microsimulations

The coefficients of the continuous variables estimated from the regression models are applied for dynamic simulations of policies in a separate step. The coefficient estimates of the expenditure terms (x, x^2) from the household calorie consumption regression model are used to calculate calorie-income (expenditure) elasticities. Subsequently, these elasticities enter two microsimulations that predict the economic impacts on respectively household food security and child nutrition under a specific policy scenario. Given the nonlinearity in the calorie consumption–income curve, calorie-income elasticities are calculated specifically for each household according to its individual income (expenditure) level. The household-specific calorie-income elasticity is

$$\eta_{yx} = \beta_1 + 2 \cdot \beta_2 \cdot x \,, \tag{2}$$

where η_{yx} is the calorie-income elasticity; β_1 and β_2 are the coefficients of the first and second expenditure terms in Tables 5, respectively; and x is the total per capita expenditure of a particular household in logarithmic form. Table 7 reports summary statistics of the calorie-income elasticities.

Table 7. Calorie-income elasticities

	Mean	Std. dev.	Min.	Max.
Rural	0.473	0.121	0.119	0.948
Urban	0.374	0.075	0.156	0.613

Source: Yemen Food Security Model based on 2005/06 HBS data (CSO 2006).

The predicted calorie consumption of a particular household under a given scenario and in a given year after experiencing a real income shock (that is, the outcome of the DCGE model) is

$$\hat{y}_{i,j} = y_{i,j-1} \cdot (1 + \eta_{yx} \cdot s_{x_{i,j}}) \,, \tag{3}$$

where $\hat{y}_{i,j}$ is the predicted per capita calorie consumption amount under scenario i and in year j, $y_{i,j-1}$ is the per capita calorie consumption amount in the previous year, η_{yx} is the calorie-income elasticity, and $s_{x_{i,j}}$ is the income shock for a certain household group expressed as an annual percentage change of real income.

For predicting children's nutritional status, the coefficient estimates of the expenditure variables from the child nutrition regression model are directly used in the microsimulation. The predicted HAZ of a particular child under a given scenario and in a given year after its household experienced a real income shock is

$$\hat{y}_{i,j} = y_{i,j-1} + \beta_1 \cdot x_{i,j-1} \cdot s_{x_{i,j}} + \beta_2 \cdot (x_{i,j-1} \cdot s_{x_{i,j}})^2 \,, \tag{4}$$

where $\hat{y}_{i,j}$ is the predicted HAZ under scenario i and in year j; $y_{i,j-1}$ is the HAZ in the previous year; β_1 and β_2 are the coefficients of the first and the second expenditure term in Table 6, respectively; $x_{i,j-1}$ is the per capita expenditure in the previous year; and $s_{x_{i,j}}$ is the income shock for a certain household group expressed as an annual percentage change of real income.

In addition to the dynamic simulation of the economic impact of the proposed policy scenarios, the impact of investments in infrastructure and social programs on food security and child nutrition are predicted in a static manner. Investments and programs that primarily affect the access to food, and thus food security, are simulated with the (continuous) nonexpenditure variables in the food security microsimulation model and their respective coefficient estimates; those that primarily affect individuals'

nutrition and health status are simulated with variables and coefficients from the child nutrition microsimulation model.

In detail, the food security impact of a particular investment amount for upgrading road infrastructure (for example, US$1 billion), which would improve households' access to food, is estimated using the resulting changes in the local market access index a_2 and the respective coefficients (δ) of the household calorie consumption regression model shown in Table 5.[9] Social investments and programs with a strong link to nutritional health—especially of children—including education campaigns, qat consumption-reduction programs, and investments in drinking water accessibility are assessed using the variables z_3, z_4, and a_1 of the child nutrition regression model and their respective coefficient estimates (γ, δ).

The microsimulation model of child nutrition is also applied to evaluate investments in health infrastructure and investments to improve people's access to quality health services and need-tailored health programs. This is done by comparing estimates from different indexes of access to health facilities having specific health and nutrition programs. The same model is run for all estimations but with different access indexes. The coefficient estimates are reported in Table 8.[10] Finally, the index leading to the overall highest model fit (a_{3c}) is used in the final Child Nutrition Model (Table 6).

Table 8. Coefficient estimates of indexes for access to quality health services

Var.	Description	Rural	Urban
a_{3a}	Index for access to health facilities (hospital, health centers, health units)	14.895	4.295
a_{3b}	Index for access to hospitals	22.954	3.790
a_{3c}	Index for access to health facilities with a breastfeeding education program	36.048	4.392
a_{3d}	Index for access to health facilities with a child growth-monitoring program	34.376	3.739
a_{3e}	Index for access to health facilities with a nutrition education program	32.104	3.670

Source: Yemen Child Nutrition Model based on 2005/06 HBS data (CSO 2006).
Note: Reported coefficients equal estimated coefficients multiplied by 1e + 09. All coefficients are statistically significant at the 1 percent level, except for a_{3e} in rural areas, which is statistically significant at the 5 percent level.

Similar to equation (3), the predicted calorie consumption of a particular household as a result of improved market access is

$$\hat{y}_i = y \cdot (1 + \gamma_{a_2} \cdot s_{a_{2,i}}), \tag{5}$$

where γ_{a_2} are the coefficient estimates of the local market access variable a_2 (Table 5) and $s_{a_{2,i}}$ is the percentage change of the access variable under the infrastructural investment scenario *i*. Similar to equation (4), the predicted HAZ of a particular child resulting from a change in nonincome factors is

$$\hat{y}_i = y + \gamma_{z_k, a_k} \cdot s_{z_{k_i}, a_{k_i}}, \tag{6}$$

where γ_{z_k, a_k} are the coefficient estimates of the variable z_k or a_k (Table 6) and $s_{z_{ki}, a_{ki}}$ is the percentage change of the variable indentifying the investment or program scenario *i*.

[9] See Section 2.3 for more details on the changes in the local market access index resulting from a US $1 billion investment in road infrastructure.

[10] Estimation results for the other independent variables in the different modifications of the Yemen Child Nutrition Model are not reported. Coefficient estimates do not significantly vary from the coefficient estimates shown in Table 6. They can be received from the authors upon request.

2.3. The Spatial Data and Model

Variables derived from spatial analysis include the definition of urban areas and local markets, market access or travel time (local markets, urban areas, Sana'a, Aden, and cities with populations greater than 20,000, 50,000, and 100,000 people), physical accessibility to healthcare centers and, local markets, and rainfall patterns.

2.3.1 Urban Areas

To support future spatial modeling of rural-urban linkages, we mapped urban footprints in Yemen's main urban cities and secondary towns.[11] To do this, different types of data sources (urban nighttime lights and population census data) and technologies[12] were combined. Alternative technologies/methodologies are rather complex and tedious because of this the study was done in two phases. The first phase consisted in revising the population census, which classified, in 2004, 114 out of the 330 districts as urban (CSO, population census 2004). The second phase was identifying urban footprints within the 114 urban districts already classified by the population census in 2004. We successfully used Google Earth Pro to pin point and map out urban footprints within Yemen's urban districts. The results were confirmed by comparing it to the coarse nighttime light data[13] as a proxy of urban sprawl. The coarse spatial resolution data provides a high temporal resolution from 1992 to the present, useful for many applications ranging from measuring the extent of urban development, regional economic activity, the extent of light population, and the extent of lighting for fishing and regional energy use, among others.

2.3.2 Local Markets

In order to identify local markets within each district, the study used the concept of urban–rural links, which takes into account the spatial symbiosis between urban and rural in social, economic, and financial aspects (Birner et al. 2008). Local markets were identified geographically within each district, and, in the case of urban districts, urban footprints areas were excluded. Within each district, "hot spots" of villages with a large population were identified using local indicators of spatial association. This technique uses the Local Moran statistic (Anselin 1995), which provides a means to assess the significance of "local" spatial patterns. It indicates local clusters (high–high or low–low) or local spatial outliers (high–low or low–high). For the definition of the weight matrix, both weight matrices, distance band-based and nearest neighbors, were used. In practice, there is no best weight and typically one compares the sensitivity of the results to the selection of the weights (Anselin 2002). To get a better sense of the biophysical context of these population village clusters, these clusters were overlapped on top of satellite images available online. As a final result we identified clusters of villages with large population sizes by using a fixed distance of 1.5 km. LISA analysis was performed using geoprocessing tools accessed from Python 2.6.

2.3.3 Travel Time

Physical access to markets and public and private service facilities, such as health clinics, post offices, banks, and policy stations, can be measured by travel time. In particular, the distance to markets is of high relevance for both producers and consumers of food. Farmers have to overcome this distance to sell their products, and market access matters for consumers to buy food and other goods and services. In addition, farmers rely on agricultural inputs such as seeds, fertilizer, and pesticides for production that are often obtained from specialized market places which are often different from those where farmers sell their products. The travel time to specific market hubs of a certain size (e.g., local markets, urban centers, sea ports) serves as an indicator for the individual access to marketing opportunities and, on the regional level, for trading, and thus the economic potential of communities. In addition, the travel time can

[11] Type of secondary towns: market towns, administrative towns, service towns, and satellite towns.

[12] Google Earth Pro and ArcGIS

[13] There are two main problems that arise when using the nighttime lights dataset as a baseline to identify urban extents: the insufficient detection of small settlements that are not frequently illuminated, and the blooming effect (Balk et al. 2006).

effectively serve to link the distribution of the population with the transportation infrastructure and terrain characteristics. In general, the further away the location of a rural community is from the nearest town, the lower the likelihood for potential interaction of the community residents with the opportunities available in the town.

For the spatial modeling exercises in Yemen, we estimated travel times to major cities[14], airports, a seaport (Aden), urban centers, local markets, and hospitals. In each case, accessibility was estimated using the cost distance function from ESRI[15], which is defined as the time needed to travel from a specific pixel to the nearest location of interest. Modeling accessibility required the creation of a friction surface, which represents the time needed to cross each pixel. Speeds both on and off roads[16] are affected by the friction surface, which is integrated by various input layers, for the case of Yemen, it takes into account the transport network (from Yemen authorities), land cover (GLC2000 land cover), urban areas (IFPRI data), slope (derived from SRTM30 elevation), international boundaries, and elevation (SRTM30 elevation). A more detailed description of the technique can be found in (Nelson et al. 2000; Ulimwengu et al. 2009). We also considered travel times by road type; Table 9 shows assumed velocities by transport type.

Table 9. Assumed travel times by road type

Transport type	Velocity (km/hr)
Paved	80
Unpaved	15
Other	10

Source: Authors' calculation.

One of the motivations for this analysis of travel time is to provide a perspective on forthcoming infrastructure investments. This section presents estimates of the impact of alternative road investment plans on access to market and food security and malnutrition. To do so, we calculated market access with respect to one scenario:

Our own "network plan": Upgrading 20,000 kilometers of unpaved roads to gravel roads would result in a more ambitious road network that would connect the most rural areas to paved roads (Table 10).

Table 10. Scenarios by road category

	Transport category (km)				
	Paved roads (80 km/hr)	**Loose gravel (40 km/hr)**	**Unpaved roads (15 km/hr)**	**Other (10 km/hr)**	**Estimated cost of each plan**
Current network	6,876	—	32,816	1205	n.a.
Future scenario					
"Our own network plan"	6,876	19,413	14,609		

Source: Authors' calculation.

Prioritization of areas for road investment was based on three criteria: areas where most of the food-insecure people live, the prevalence of food insecurity, and the connectivity of a secondary network to secondary cities. Both food insecurity indicators were transformed into measures of relative food

[14] Major cities include Sana'a and cities with population equal or greater than 20,000, 50,000 and 100,000.

[15] For more details about the cost distance, refer to "http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=How%20Cost%20functions%20work".

[16] Off-road travel distance is assumed to be covered by foot and modeled based on dominant land cover type and local terrain steepness. Because of varying local conditions and differences in the quality of the road network, the estimated travel time may differ from the true travel time in some locations but provide a good approximation in general.

insecurity. The transformation resulted in a rescaling of the food insecurity values onto a scale from 0 to 1. Each variable was rescaled from 0 to 1, and the unweighted average of the rescaled variables were used to rank the most-needed district with connectivity of secondary roads to paved roads.

2.3.4 Healthcare Centers and Facilities

Information was retrieved from the Yemen health analyzer[17] geographic information system (GIS) tool developed by United States Agency for International Development (USAID) in collaboration with local authorities.

2.3.5 Physical Access to Health Centers

Yemen is experiencing an unprecedented population growth. By the year 2025, it is predicted that the population will increase from 23 million in 2010 to 48 million (UN 2010), which will translate in an increased demand for transportation, telecommunication, health care and education, among others. During this massive expansion, a major challenge for planners is to allocate public facilities and services in order to optimally serve this growing population (Radke and Mu 2000). To address this issue, emphasis is placed on modeling the accessibility to health care and on further exploring the geographic relationship of physical access to health care facilities to food insecurity.

Access to health services is described, in the literature, as a multidimensional concept (Aday and Anderson, 1981). Penchansky and Thomas, 1981 describe access to health services in five dimensions: accommodation, affordability, acceptability, availability, and geographic accessibility. Recent evidence from research based in developed and developing countries has fostered the development of new methodologies to measure the last two aspects, namely availability and geographic accessibility to primary care (Guagliardo, 2004, Unal et al. 2007, Schuuman et al. 2010, Black et al. 2004). There is a large volume of literature on the use of GIS for measuring physical accessibility to health care. Examples and methodological issues can be found in Talen and Anselin (1998), Kwan et al. (2003), Guagliardo (2004), Unal et al. (2007) and Schuurman et al. (2010).

Modeling accessibility, according to Talen and Anselin (1998), relates to the analysis of spatial equity, which compares the locational distribution of facilities to the locational distribution of a target population. It was modeled by defining a measure of accessibility between population location (cluster of villages) and the public/private services facilities in both urban and rural areas. In order to relate both, distance was modeled as travel time using a shortest path algorithm applied to the existing street network and topographic characteristics between cluster of villages and the coordinates of health centers/hospitals (travel time methodology). Next, the physical accessibility index was computed to health care.[18] This index is derived from an exponential distance decay function related to household income (rural/urban) and urban/urban population.

Distance decay parameters:

$$Ai = \sum_{j=1}^{n} Pj\ (\textit{rural or urban}\ \text{population}) \times \text{Household income}\ (\textit{rural or urban income}) \times \text{Exp}(\lambda x dij)$$

where:

Ai = Physical accessibility index

Pj = Pj is the rural or urban population at village j

HH = rural or urban household income related to its respective population/villages

[17] The information can be downloaded from www.healthsystems2020.org/section/where_we_work/yemen/gis, accessed on July 9, 2010.

[18] The variables modeled were potential physical accessibility to: local markets, health facilities, health centers, hospitals, health facilities with nutritional educational program, breastfeeding, and child growth.

Dij = is the distance measured as travel time between i and j

λ= is the exponent of the function

The estimation of the exponent parameter λ is crucial (Table 11). The higher the estimate, the more abrupt is the ”cut off” of influence of populations being situated at greater distances. As stated by Fortheringham (1981, 425), a distance-decay parameter measures the relationship between observed interaction patterns and distance when all other determinants of interaction are constant. Distance-decay, both in terms of the function involved and the parameters, varies between different regions and the different modes of transport. For this exercise the following range of values were adopted.

Table 11. Exponential distance-decay parameter

Travel time (minutes)	Parameter estimates
0	–0.9
1–14	–0.8
15–24	–0.7
25–34	–0.6
35–44	–0.5
45–59	–0.4
60–79	–0.3
80–120	–0.2
> 120	–0.1

Source: Authors’ estimation.

The accessibility measures defined above do not have a natural unit, thus they were transformed into measures of relative accessibility. Each variable was re-scaled from 0 to 1. The district with Ai =1 has the highest accessibility among the 333 districts.

$$RAi = \frac{Ai - \min Ai}{\max Ai - \min Ai}$$

i = 1,…,333 i=1,…,333

where:

RAi = Index of relative accessibility

Ai = is the measure of accessibility value at district i

min Ai = is the minimum accessibility value at district i

max Ai = is the maximum accessibility value at district i .

3. POLICIES FOR IMPROVING FOOD SECURITY

This section presents the simulation results using the Yemen Food Security Model and the Yemen Child Nutrition Model. In total, 10 scenarios were estimated: one baseline scenario (Section 3.1) and nine policy option scenarios (Sections 3.2–3.10).

3.1. No Food Security Action from 2010 to 2020 (Baseline)

To compare the impact of policies on food security, it is important to first assess a situation that reflects the absence of policies—a "business-as-usual," or baseline, scenario. The Yemen Food Security Model is dynamic and runs from 2010 to 2020, the period of Yemen's food security strategy horizon. The baseline assumes that the economy will continue to grow at its precise level average of 3.8 percent annually, with average annual growth of 5.1 percent in the nonhydrocarbon sector, and –2.3 percent growth in the hydrocarbon sector (oil and gas combined); this is consistent with estimates from the International Monetary Fund (IMF 2009). Under this scenario, the share of the hydrocarbon sector in the economy will fall from about 23 percent in 2009 to 12 percent in 2020. The initial share of investment in the gross domestic product (GDP) is high and is driven by foreign direct investments (FDIs) in the gas sector; however, it will decrease to about 27 percent in 2020. In the model, this growth is driven by capital accumulation (endogenous), a growing labor force that follows population growth (3 percent), and a modest increase in total factor productivity (TFP) in manufacturing and service sectors (0.5 percent annually). Given Yemen's severe land and water constraints, the total amount of land available for agriculture is fixed.

Under this baseline scenario, Yemen will miss its food security goals by 2015 and 2020, and the absolute number of food-insecure people will increase (Table 12). The prevalence of food security will remain high, at 24.3 percent overall and 29.4 percent in rural areas. Consistent with historical patterns, urban households will benefit most from growth; food security in urban areas will fall to 9.4 percent, even without specific policies or investments by 2020. Given continued high population growth, however, the absolute number of food-insecure people will rise, despite a decrease in relative numbers. The total number of food-insecure people will increase from about 7.5 million in 2009 to 7.8 million in 2020. Child malnutrition is highly inelastic to economic growth and will remain at very high levels in both rural and urban areas in 2020. On the macrolevel, the ratio of exports to food imports will improve, from 3.8 in 2009 to 5 percent by 2020; this increase will initially be driven by a spike in gas exports and then by a reduction in total food imports. Although the import of wheat and other cereal products will continue to increase, the import of processed foods will decline. One important reason for this decline is the depreciation of the exchange rate, which will make imported food more expensive and domestic food processing more competitive.

Table 12. Baseline scenario

	2009	2015	2020
Food security			
Household-level			
Prevalence of food insecurity (percent)			
National	32.1	25.3	24.3
Rural	37.3	30.9	29.7
Farm	33.4	26.7	25.4
Nonfarm	39.2	32.9	31.8
Urban	17.8	9.7	9.4
Number of food-insecure people (in thousands)	*7,483*	*7,033*	*7,833*
Per capita calorie gap (wrt. 2009)	*–480*	*–369*	*–348*
Child malnutrition (percent)			
National	59.4	58.1	57.8
Rural	63.5	62.3	62.0
Urban	47.7	46.2	45.9
Macrolevel			
Total exports/food imports	3.83	4.72	4.96
GDP			
GDP growth	6.6	3.9	3.6
Hydrocarbon	4.3	–2.3	–2.3
Nonhydrocarbon	7.3	5.2	4.5
Composition by sector			
GDP at factor cost (share)	100.0	100.0	100.0
Hydrocarbon	23.4	16.7	12.4
Nonhydrocarbon	76.6	83.3	87.6
Composition by expenditure			
GDP at market prices (share)	100.0	100.0	100.0
Private consumption	58.3	62.3	63.5
Investment	35.4	29.9	27.2
Government consumption	14.7	14.6	15.1
Exports	33.4	29.8	30.7
Imports	–41.9	–36.6	–36.5

Sources: Yemen Food Security Model and Yemen Child Nutrition Model.

3.2. Fuel Subsidy Reform

About one-third of the government's budget (US$3.8 billion, or US$172 per capita) is spent on fuel subsidies (Table 13).[19] About 76 percent of fuel subsidies go to diesel and 20 percent go to petrol used in cars; the remainder is split between kerosene (mainly for Air Yemenia) and natural gas. The price of fuel at the pump is fixed, exposing the amount of annual subsidy to large annual fluctuations. For example, an increase in the world market price would raise the cost of subsidizing fuel for the government, whereas lower world market prices would decrease the difference between local pump prices and import prices for fuel.

[19] This number varies and strongly depends on the world market prices for oil. See Section 3 for more details on fuel subsidy developments over the past decade.

Table 13. Subsidies by fuel type

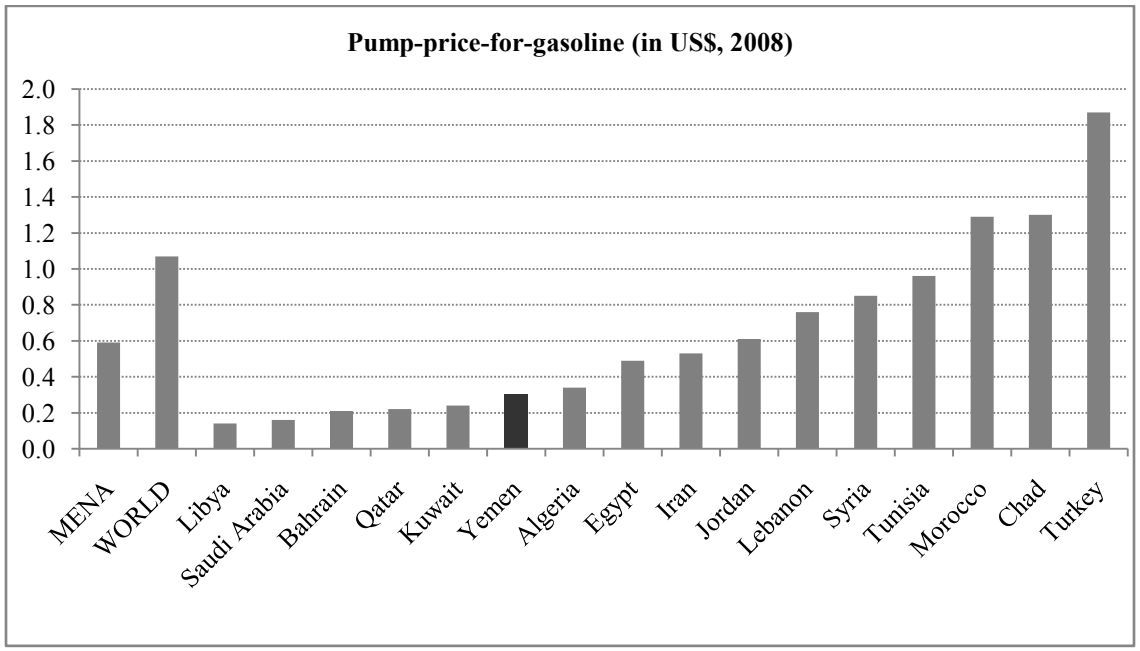
	Yemeni Riyal (YR) (in billions)	U.S. Dollar (US$) (in billions)	Share (percent)
Petrol	148.0	0.8	19.6
Diesel	574.0	2.8	75.8
Kerosene	26.0	0.1	3.4
Gas	8.9	0	1.2
Total fuel	**756.9**	**3.7**	**100.0**

Source: Ministry of Finance 2010.

Fuel prices in Yemen are among the lowest in the world and are only undercut by high-income, neighboring Gulf countries and Libya. Whereas most countries in the world impose high taxes on fuel to capture the negative external effects associated with fuel consumption and to earn revenue for their general budgets, several countries still subsidize fuel. Most of these fuel subsidies began when fuel consumption was lower, oil exports higher, and other mechanisms for transfers not well known. Today, mostly oil-rich countries with high per capita incomes continue fuel subsidization policies. In fact, Yemen has the lowest per capita income in the group of high subsidizers; the only other countries with lower fuel prices are Venezuela, Libya, Saudi Arabia, Bahrain, Turkmenistan, Qatar, and Kuwait (Figure 1), which all have a significantly higher per capita income. Recently many countries, including Iran, Egypt, and Syria, have reformed or are in the process of reforming their subsidy systems.

Reform is urgently needed in Yemen, as maintaining fuel subsidies is fiscally unsustainable, especially given that oil resources as the main source of government income are depleting. Net exports of oil are likely to cease around 2015 due to both rapidly increasing domestic demand and decreasing domestic supply (Breisinger et al. 2010). Starting in 2010, gas exports are expected to partly fill this gap, but they will not be able to fully compensate for the loss in oil revenues. In addition, fuel subsidies are not well targeted to the poor and food insecure, making it a blunt tool for reaching the neediest in the society.

Figure 1. Fuel prices in the Middle East and North Africa (MENA)



Source: Authors' compilation based on GTZ (2010).

There is widespread concern that removing fuel subsidies will negatively impact growth and lead to an increase in food insecurity. Households consume about 10 percent of all fuel, with the remainder being used as intermediate inputs in agriculture, industry, and services. About 42 percent of all fuel is used for transportation, followed by the mining sector (mainly oil production) and industries. Agriculture uses 12 percent of all fuel for crop production, and fuel is agriculture's single largest expenditure item, despite the subsidized price for agricultural production. As a share of sector output, fuel makes up 14 percent for transport and 10 percent for manufacturing. The transport sector is an important input for the production of other sectors; industry and services are the most transportation-intensive sectors, with transportation making up 14 and 8 percent of their output, respectively. Urban households spend more on fuel and transportation than do rural households; the direct expenditure for fuel is modest, at 1,474 Yemeni riyals (YR) per capita and per year, or about 1.2 percent of household expenditure on average. In absolute terms, the per capita amount is higher for urban households (1,984 YR) than for rural households (1,474 YR). However, rural households spend a higher share of their income on fuel. Indirect consumption of fuel matters: Expenditure on transportation (which is fuel intensive) in rural areas is about eight times higher than expenditure on fuel and accounts for 8.7 percent of household expenditure nationwide.

A reduction of fuel subsidies is expected to have positive effects, including freeing up a large share of the government budget to be spent on measures that improve food security and that sustainably increase agricultural productivity. To analyze the potential impact of fuel subsidy reform, the following scenario looks at the impact of removing the subsidy to assess changes in growth and food security.

3.3. Phasing Out Fuel Subsidies

The assessment of whether and how the phasing out of fuel subsides will affect growth and food security is based on the Yemen Food Security Model. It is assumed that fuel subsidies will be reduced over a six-year period, from 2010 to 2015. The gradual reduction will be designed so that the absolute amount of annual reduction remains constant over the first four years of reform; then the remaining subsidy will be reduced by 50 percent annually (Table 14). Under this scenario, domestic prices will rise relative to the baseline, especially prices for fuel and transportation. Indexed to 100 in 2009, fuel prices will rise to 165 points by 2015, and the cost of transportation will rise to 125 points.

Table 14. Fuel subsidy reduction until 2015

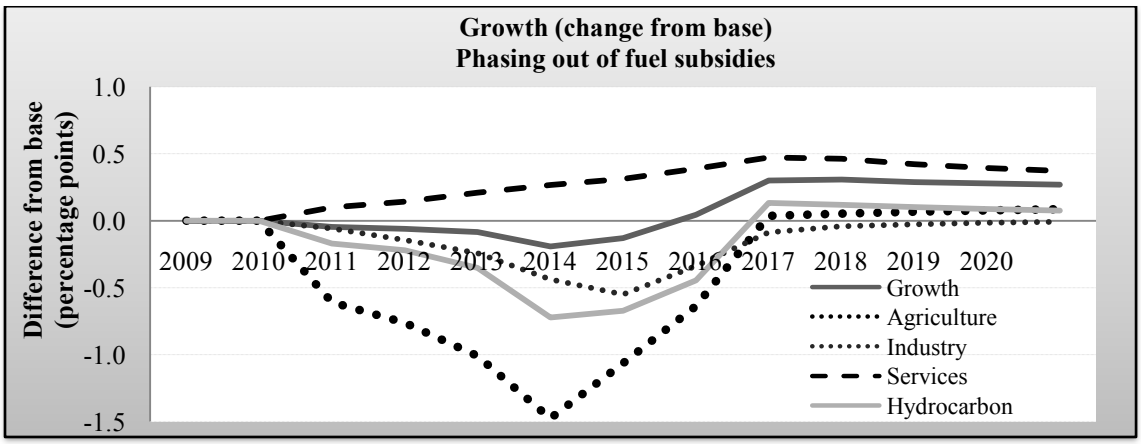
	2009	2010	2011	2012	2013	2014	2015
Subsidy reduction (billion YR)		130.4	130.4	130.4	130.4	85.0	42.5
Remaining subsidy (billion YR)	–652.0	–521.6	–391.2	–260.8	–130.4	–65.2	–32.6
Percent change		*–20.0*	*–25.0*	*–33.3*	*–50.0*	*–50.0*	*–50.0*
Price change (Index 100)							
Fuel	100	105	112	123	141	155	165
Transport	100	102	105	109	116	121	125

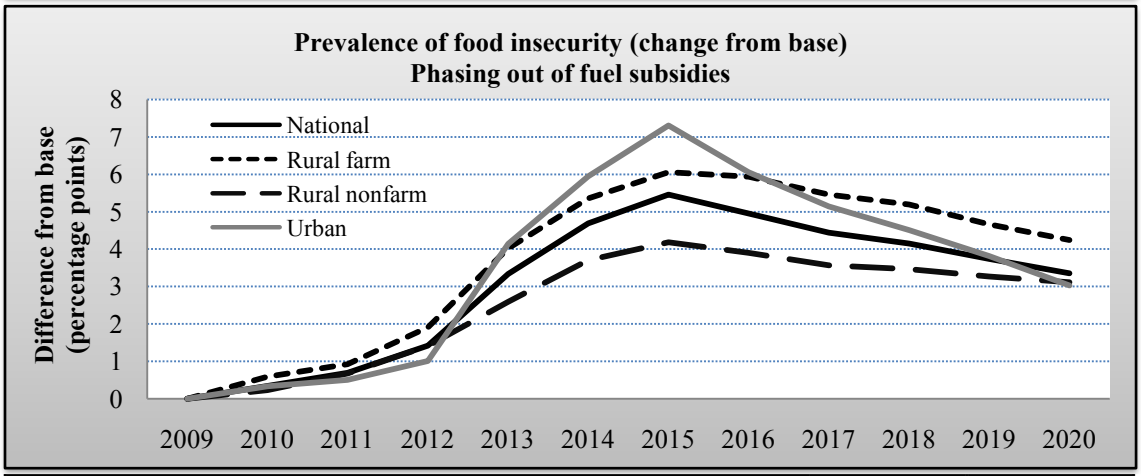
Sources: Authors' calculations and DCGE model output.

Overall economic growth is hardly affected by phasing out the fuel subsidy. However, this phasing out will affect sectors differently. Agriculture would be the hardest-hit sector, given its strong dependence on diesel for irrigation—in particular, the output of water-intensive crops like fruits, vegetables, and qat will decline, with the positive side effect of reduced groundwater extraction. The manufacturing sector will slightly decline; however, as in all sectors, growth will return to baseline levels after the reform is complete in 2015. Given the low substitutability (lack of alternatives) of transport for industrial production, services, and households, the transport sector will not be affected, and the service sector as a whole will benefit from the reform. When interpreting the graph (Figure 2), note that the lines represent changes from the baseline scenario. In other words, the overall growth of the agricultural sector,

for example, will be –1.5 percentage points lower than it would have been in the absence of the reform, as predicted by the baseline scenario (and not –1.5 percent in 2014).

Figure 2. Phasing out of fuel subsidies: Model results





Food security	2009	2015	2020
Household food insecurity (percent)	32.1	30.7	27.6
Number of food-insecure people (in thousands)	7,483	8,548	8,919
Per capita calorie gap (wrt. 2009)	–480	–449	–414
Child malnutrition (percent)	59.4	59.0	58.7
Rural	63.5	63.0	62.6
Urban	47.7	47.6	47.4
Total exports/food imports	3.83	4.68	4.86
GDP (growth)	6.5	3.9	3.8
Hydrocarbon	4.1	–2.8	–2.2
Nonhydrocarbon	7.3	5.3	4.7

Source: Authors' calculations.

Although phasing out the fuel subsidy over five years will increase food security, it will also provide ample fiscal space for complementary measures. According to the proposed phasing-out plan, about 130 billion YR could be allocated to alternative uses over the first four years of the plan; this

amount would fall to 85 billion YR in 2014 and 42.5 billion YR in 2015. Most countries actually tax petrol, which would be an obvious measure for Yemen once the subsidies were phased out. (Note that our analysis does not account for this possibility. In fact, a future tax on petrol could sustain revenue flows and become an important source of government income in the future.) If no additional measures are taken, food insecurity will increase gradually during the course of reform. By 2015, the food insecurity rate will be about 5 percent higher as compared with the baseline. It is important to note that this increase is relative to the baseline scenario in 2015 and is *not* relative to 2010. Compared with 2010, food insecurity will still decline from 32.1 percent to 30.7 percent, albeit at a much slower rate. In the baseline, and therefore in the absence of fuel subsidy reform, food insecurity will have declined to 25.3 percent.

Farmers and the urban food insecure will be most affected by a reduction in fuel subsidies, because urban households have higher fuel consumption and use more fuel-intensive services, especially transportation. Farmers will be hit by higher prices for diesel, which is the major cost component for many crops. In particular, farmers who subsist close to the food security line and who rely on irrigation-intensive crops, such as fruits, vegetables, and qat, will be especially affected. The rural nonfarm households, which are the most food-insecure group of all, will be the least affected, because they are often too poor to afford transport by bus, car, or motorbike and instead rely on donkeys or walking for transport. To a large extent, people in Yemen do not use bicycles; although this may be explained by the topography in some parts of the country, bicycles might provide a fuel-free and relatively efficient transport option for some households and should thus be further promoted. In the absence of alternatives and action, food insecurity is projected to rise by 7 percent for urban households, 5.5 percent for farm households, and 4 percent for rural nonfarm households. Section 3.2.2 explores how this negative effect could be mitigated.

3.3.1 Phasing Out with Targeted Compensation of the Food Insecure

Given that the food insecure will be negatively affected by a reduction in fuel subsidies, compensatory measures are required. Because the reduction of fuel subsidies creates fiscal space, one option is to transfer part of the savings directly to households (that is, direct income transfer). The highest impact is expected from directly targeting the food insecure. Thus, the following scenario focuses additional direct transfers on the most food-insecure households in rural and urban areas. To make the transfers fiscally sustainable, the total amount of transfer payments suggested here does not exceed the equivalent of 4–5 percent of GDP (Table 15).

Table 15. Transfer payments to the food insecure (in billion YR)

	2009	2010	2011	2012	2013	2014	2015
Food insecure							
Rural farm	8	13	19	28	28	28	28
Rural nonfarm	49	74	111	167	167	167	167
Urban	13	19	29	43	43	43	43
Share of GDP (percent)	1.5	2.2	3.3	4.9	4.9	4.9	4.9

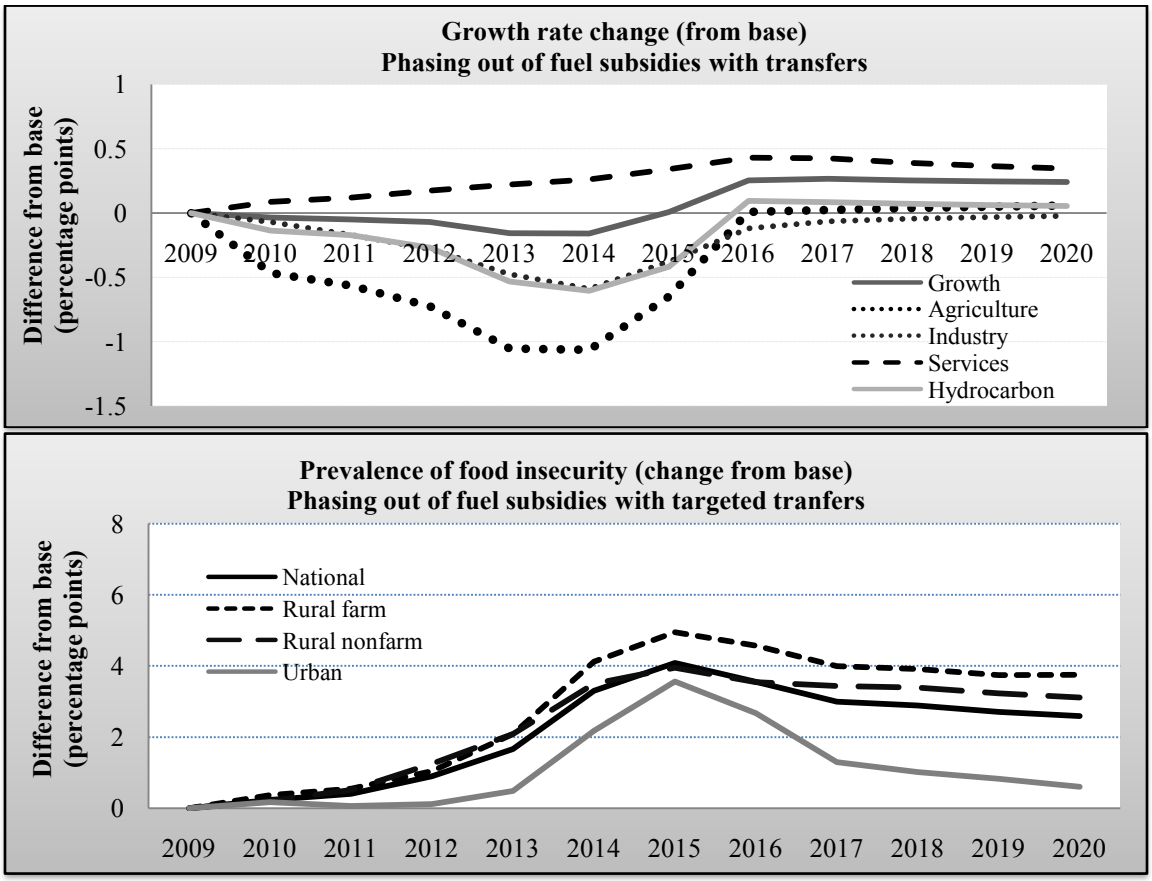
Source: Authors' calculations based on 2005/06 HBS data (CSO 2006).

Direct transfers to the food-insecure population will cushion some of the negative short-term growth effects that result from higher fuel prices (Figure 3). Growth in all sectors is higher than without the subsidies, because households receiving the transfer now spend more money on goods and services. These income-multiplier effects are comparatively low, because Yemen's import intensity is high and because the food-insecure population consumes large amounts of imported goods. These imported goods include wheat and other cereals as well as simple consumer goods, such as plastic buckets; this creates little value added for the domestic agricultural and manufacturing sectors.

Direct transfer payments will also make an important contribution toward alleviating negative effects on food security during the initial years of reform. Because the transfers benefit all household

groups, food insecurity could be maintained at an almost constant level during the first two years. This positive effect is due to both the direct impact of having more money to buy food and the multiplier effect, which creates additional income for households through increased spending. However, once the initial positive mitigation effect levels off in the third year, food insecurity will increase, despite the transfers to 4 percent above baseline levels. Thus, although direct transfers are critical for protecting the poor from the immediate impact of reform, transfers consistent with the existing budget constraints are not sufficient to compensate the food insecure. Therefore, additional long-term measures are needed to complement the subsidy reform.

Figure 3. Phasing out of fuel subsidies with transfers: Model results



Food security	2009	2015	2020
Household food insecurity (percent)	32.1	29.3	26.9
Number of food insecure people (in thousands)	7,483	8,155	8,669
Per capita calorie gap (wrt. 2009)	–480	–440	–408
Child malnutrition (percent)	59.4	58.9	58.5
Rural	63.5	62.9	62.6
Urban	47.7	47.4	46.9
Total exports/food imports	3.83	4.65	4.83
GDP (growth)	6.6	3.9	3.8
Hydrocarbon	4.2	–2.8	–2.2
Nonhydrocarbon	7.3	5.3	4.7

Source: Authors' calculations.

3.3.2 Phasing Out with Compensation to the Food Insecure and Investment

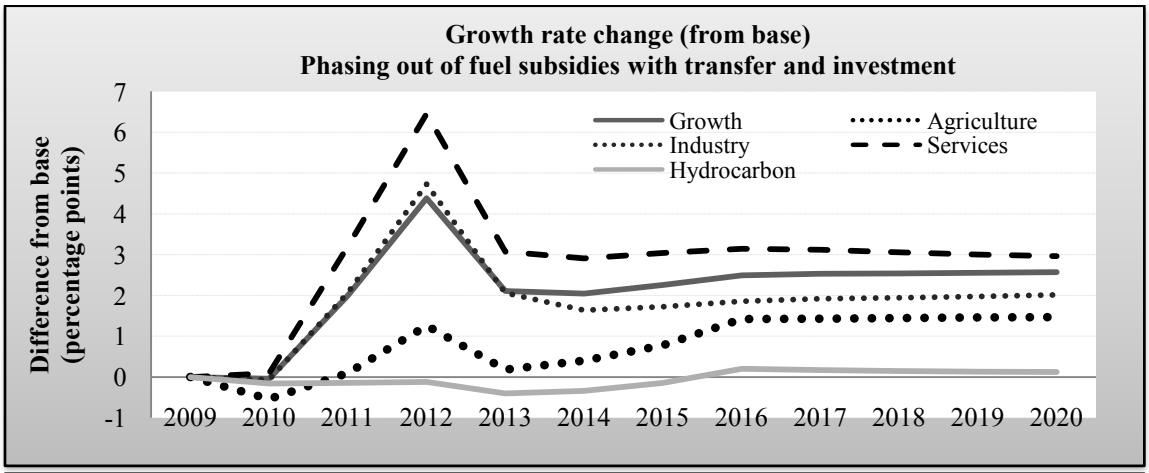
Direct transfers will not be sufficient to alleviate the negative effects of fuel subsidy reform; therefore, additional measures are needed. Productivity-enhancing investments make an important contribution to development and provide the foundation for food security and growth. This scenario thus reflects a case in which the remaining savings of the fuel subsidy are used to improve infrastructure, such as transport and communication. Based on the experience of many other countries, it is assumed that after an initial lag of several years, this public investment will trigger additional growth in all sectors by lowering transaction costs and creating higher economywide efficiencies.

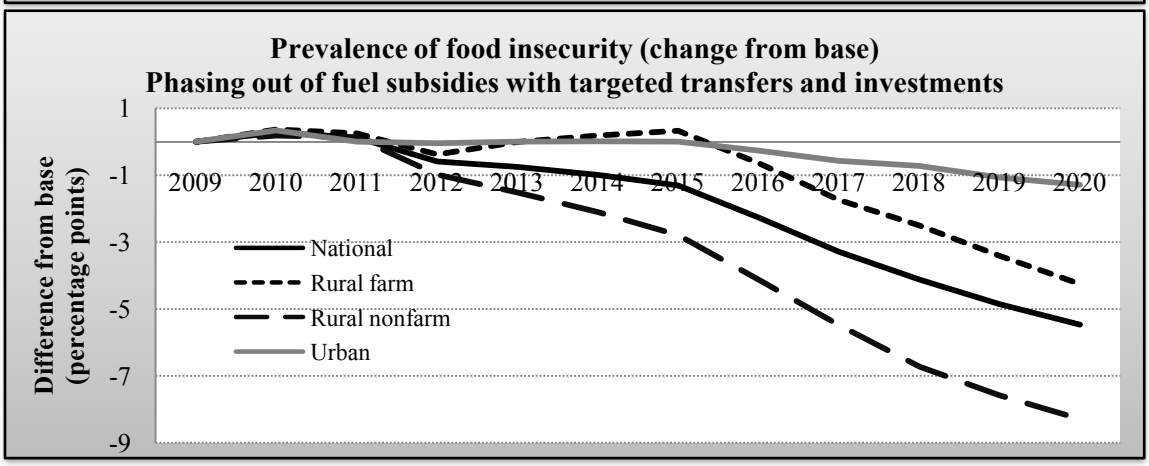
The combination of direct transfers and investment is a promising strategy for a subsidy reform that promotes food security. Transfers, investments, and resulting long-term productivity effects complement each other and lead to a significant reduction in the food insecurity rate (Figure 4). During the initial years, investment-related income—for example, from construction jobs—will create additional income for the food insecure. Then, when investment-induced effects phase out and other sectors start benefiting from new infrastructures, growth will accelerate economywide and boost the incomes of all households, including the food insecure. Growth will be especially strong in the industry and the service sectors. The impact on the agricultural sector is positive but limited, due to the sector's severe natural resource constraints.

Food security will improve sharply, especially when growth accelerates from 2015 onward. The combination of direct transfers and growth related to additional spending (such as construction) will completely mitigate the negative impact of higher fuel prices during the first years and will lead to a sharp improvement of food security in the following years. The food insecurity rate will drop below 24 percent by 2015 and below 20 percent, to 18.8 percent, by 2020. This reduction will mainly be driven by rising wages and employment in all sectors, as well as in sectors where the food insecure work. Wages for the unskilled, private-sector worker will benefit from strong growth, as many of the growing sectors are labor intensive.

Child malnutrition, however, is not very responsive to growth, and the calorie gap will remain large. Despite an overall average annual growth rate of 6.1 percent in nonhydrocarbon sectors, the child malnutrition rate will remain high, with more than half of the children projected to remain stunted in 2020. This result illustrates not only how difficult it is to reverse trends in stunting, but also that additional investments and programs are needed to reduce child malnutrition and thus to improve the prospects for the future generations in Yemen.

Figure 4. Phasing out of fuel subsidies with transfer and investment





Food security	2009	2015	2020
Household food insecurity (percent)	32.1	23.9	18.8
Number of food insecure people (in thousands)	7,483	6,665	6,062
Per capita calorie gap (wrt. 2009)	–480	–342	–183
Child malnutrition (percent)	59.4	58.0	56.5
Rural	63.5	62.0	60.6
Urban	47.7	46.2	44.7
Total exports/food imports	3.83	5.27	5.84
GDP (growth)	6.6	6.1	6.1
Hydrocarbon	4.1	–2.5	–2.2
Nonhydrocarbon	7.3	7.7	7.1

Source: Authors' calculations.

3.4. Promotion of Growth in Promising Sectors

Policymakers can make an important contribution to facilitate growth driven by the private sector by improving the investment climate. Doing so often involves political commitment to reform, rather than financial resources. This political commitment makes it an attractive and low-cost option for improving food security. Table 16 shows that there is room for improving the investment climate for private domestic and international investors. Yemen currently ranks 99 out of 183 countries in creating a

favorable investment climate; yet, several key indicators are significantly below the international average. Although Yemen ranks high in its favorability for starting a business and dealing with construction permits, access to credit, investor protection, and tax requirements need improvement in order to unleash private sector–driven growth, especially in promising sectors such as mining, food processing, tourism, transport, and communication services.

Table 16. Yemen investment climate indicators (ranking among 183 countries)

Ease of doing business	99
Starting a business	53
Dealing with construction permits	50
Employing workers	74
Registering property	50
Getting credit	150
Protecting investors	132
Paying taxes	148
Trading across borders	120
Enforcing contracts	35
Closing a business	89

Source: World Bank 2010a.

There is an ongoing debate in Yemen on what are the promising sectors. This point has also been discussed intensively during the Food Security Strategy Workshop on July 28, 2010 workshop. There was broad agreement that the NFSSP needs to include a definition of promising sectors, in other words, what do we mean by a promising sector? Usually for sectors to be promising, these sectors need to have the potential of above economy-wide average growth to distinguish themselves from others. Given that average overall growth rates in Yemen have been around 4 percent over the past years, promising sectors should have the potential to grow between at least 5-6 percent annually. A previous study by MOPIC and UNDP had suggested agriculture, fishery, industry, trade and tourism to be promising sectors. Based on these studies and applying the definition of "above economy-wide average growth", the NFSSP finds that mining, food processing, tourism, transport, and communication services qualify as promising sectors. Please note that there is a big overlap between those two lists, however the NFSSP list of sectors is more detailed. First, the NFSSP sees transportation and communication as complementary to trade. Second, "industry" as a promising sector seems too broad, that's why NFSSP specifies industrial sub-sectors based on consultations with the food security committee and the World Bank to include mining and food processing. On the other side, given the severe natural constraints for both agriculture and fishery, it is hard to imagine how these sectors can consistently achieve average annual growth rates of 5-6 percent over the next ten years. In fact, very few countries in the world have achieved sustained growth at these levels, all of them with much more favorable natural conditions[20]. It also is important to note that identifying "promising sectors" by the state has its limitations. "Picking winner" strategies have almost always failed and growth in successful countries, with the possible exceptions of Japan and South Korea, mostly been driven by the private sector and has only indirectly been facilitated by governments, for example, through the creation of a good climate for businesses.

Foreign direct investment (FDI) plays an important role in fostering growth in promising sectors. The role of foreign investment in development goes beyond filling the investment gap and providing physical capital for growth; foreign investment comes with new technologies and fresh market opportunities, thus providing opportunities to create a more productive labor force and enhance management skills.[21] In fact, the government of Yemen is trying to attract foreign investment. However, FDI inflows have largely been concentrated in the hydrocarbon sectors (oil and gas) and in sectors with

[20] See Breisinger and Diao 2008 for more information.
[21] See Markusen (2002), Navaretti and Venables (2004), and Helpman (2006) for extensive literature reviews.

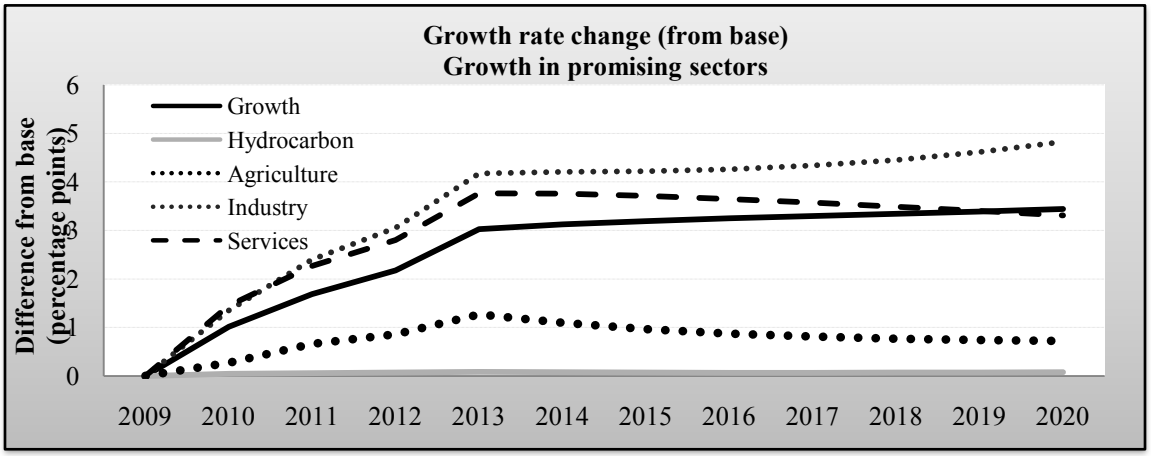
fewer linkages to the rest of economy and thus with relatively low spillover effects into technology and labor productivity.

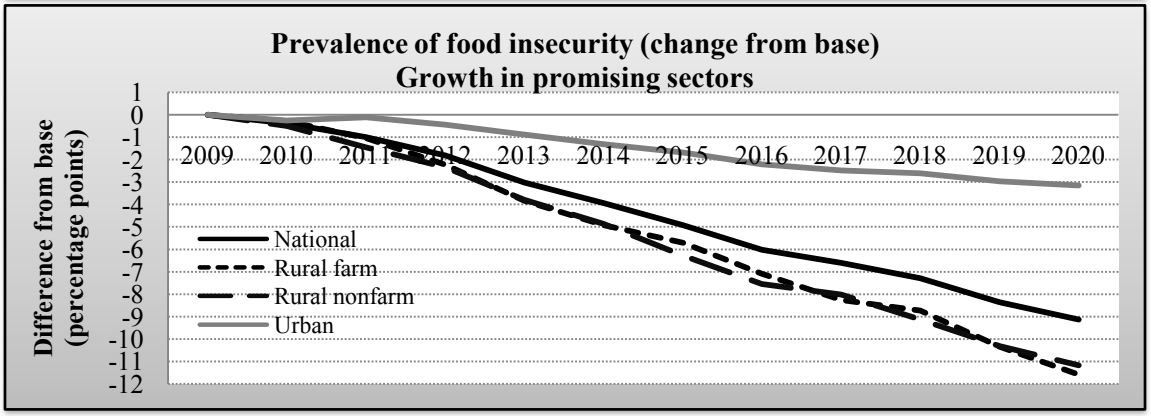
To demonstrate the potential impact of an improved investment climate that attracts private investment, the following scenario assumes that FDI inflows will increase by 6 percent annually and total factor productivity (TFP) in promising sectors will grow from 2 to 7 percent between 2010 and 2020.

Growth in promising sectors will increase the economywide growth rate and strongly improve food security. Driven by the promising sectors and its linkages to other sectors, the annual growth rate will rise to around 3 percent above baseline levels—that is, to about an 8 percent annual growth rate in nonhydrocarbon sector from 2013 onward (Figure 5). Driven by mining and related processing, food processing, and private services, both the industry and service sectors will contribute to a large increase in household incomes. Despite increasing demand from the food processing sector, agricultural growth will remain severely constrained by natural resources, so that the sector's growth will accelerate only by about 1 percentage point above baseline growth. Because promising sectors are also export oriented—especially tourism, transportation (aviation), artisan processing of mining products, and coffee processing—exports will increase under this scenario, improving the total exports to food imports ratio from 3.83 in 2009 to 5.88 in 2020, thus contributing significantly to higher food security.

Growth in promising sectors will strongly advance food security, especially in rural areas. Given that many promising sectors, such as mining, food processing, and tourism, generate employment in rural areas, the rural households stand to benefit most from this "prorural" growth. Results show that the rural households would indeed be the major beneficiaries, and their food insecurity rate will drop by 8 percentage points by 2020, as compared with the baseline. However, it is important to keep in mind that despite this sharper drop compared with urban households, the rural nonfarm households will remain the most food-insecure group. However, the food security of rural farm households will improve dramatically despite the sluggish growth of agriculture. Therefore, farm households will benefit to a large extent from nonfarm incomes, which will become an increasingly important source of income in the future. Growth in promising sectors will not reach the urban food insecure to the same extent, which can mainly be explained by their very low initial rate of food insecurity. In other words, the lower the food insecurity rate becomes, the more difficult it is to further reduce the rate by economic growth alone. The food insecure are often unable to participate in the labor market or do not possess the right skills to reap the benefits of growth.

Figure 5. Growth in promising sectors: Model results





Food security	2009	2015	2020
Household food insecurity (percent)	32.1	20.4	15.2
Number of food insecure people (in thousands)	7,483	5,666	4,904
Per capita calorie gap (wrt. 2009)	–480	–242	–39
Child malnutrition (percent)	59.4	57.0	55.2
Rural	63.5	61.3	59.6
Urban	47.7	44.7	42.5
Total exports/food imports	3.83	5.28	5.88
GDP (growth)	7.6	7.1	7.0
Hydrocarbon	4.3	–2.3	–2.2
Nonhydrocarbon	8.6	8.8	8.0

Source: Authors' calculations.

3.5. Promotion of Fishery

Although the fishery sector contributes only about 1 percent to GDP, it plays an important role for local economies and individual incomes. In 2008, about 73,400 people were directly employed in the fishery sector, living in 129 fishing communities (NFSSP Part I). Fish processing and marketing employs additional people, creates value added, and is one of the promising sectors for future growth and prosperity. In total, it is estimated that the fishery sector provides a livelihood for 642,000 people, or about 3 percent of the Yemeni population (GOPA 2006).

Yemen's long coastline would suggest high growth potential in the fishery sector, yet its potential depends on better-regulated access to fish resources and a restructuring of the sector. If these proposed reforms are successful, Yemen could have the potential to expand its fish production from 132,000 tons in 2009 to 1 million tons over the next several years, according to the Ministry of Fish Wealth (MOFW). Such a spike in production is expected to make a contribution to food security.

Achieving an output of 1 million tons will require a number of actions. For example, the Ministry of Fish Wealth suggests the following:

- Implementation and control of existing fishery regulations (also with respect to fish marketing)
- Upgrading of fishery fleet (through more modern vessels and reduction of small vessels)
- Improvement of fish handling on land
- Marketing of fish and fish processing
- Expansion of aquaculture[22]
- Training of fishermen
- Better control of fishing rights at sea through coast guards
- Improvement of fish quality control, especially through training of staff
- Upgrading of the fishing port in Al-Hodeida, based on a technical and environmental feasibility study
- Construction of a fish port on Socotra island (because of its favorable geographical location for fishery)
- Rehabilitation of the fishing ports in Hadjiv and Aldkiar and nearby Aden, including a large-scale central storage system with advanced refrigeration
- Construction of fishing ports in Abyan province and Shabwa governorate
- Establishment of a center for a fishery information system in the MOFW for collection, management, and analysis of fishery data
- Linking activities of fish landing centers along the coast with those of MOFW

Even assuming that the ambitious plans can be realized, the growth of the overall economy and an increase in food security due to fisheries will remain limited. This is largely due to the small initial share of fisheries (1 percent of GDP) in the economy. Thus, even high growth rates in the sector will not change overall growth a great deal.

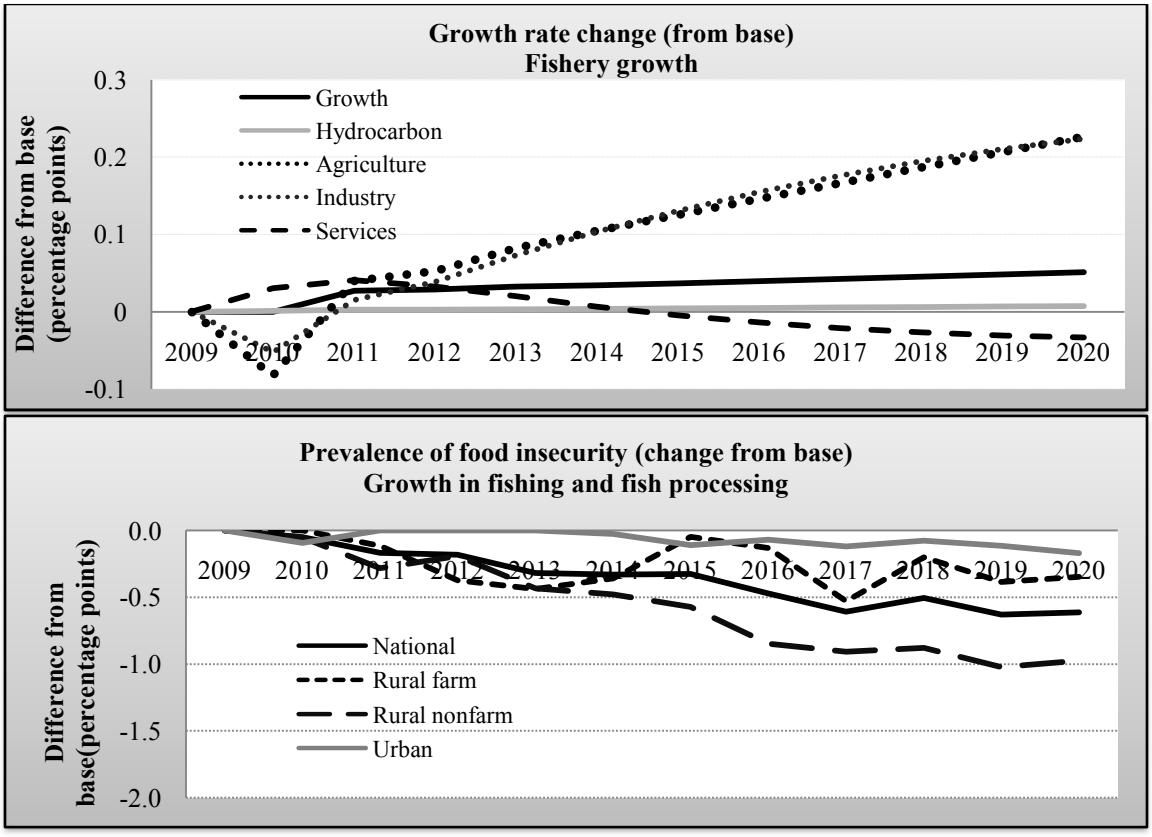
Positive effects will mainly occur within fishing communities and coastal areas. The size of the impact will depend on structural changes within the fishery sector. Rapid growth is unlikely to be achieved by local small-scale fishermen only and instead will have to be supplemented by large-scale fishing fleets and aquaculture, where feasible. Experience from other countries, such as Vietnam, shows that rapid growth that benefits local communities can be achieved with aquaculture, given its labor intensity and on-land processing opportunities. Fishery exports, in turn, increase substantially, as does the consumption of locally produced fish. However, this increase in local consumption in Yemen will be limited, mainly because people in Yemen do not abstain from fish consumption because of a lack of availability but because of a lack of financial resources to afford fish in the diet. Although it is beyond the scope of this strategy to give specific recommendations on whether and where aquaculture is feasible, the impact of scaling up fishery output under existing conditions can be assessed.

The overall impact of fishery-led growth on food security is modest, mainly because the income-generating effect is localized and most fish continues to be exported (Figure 6). However, food security does improve across all household groups. Fishery (farm) households are the biggest beneficiaries, and

[22] In 2009, there was only one shrimp farm in Yemen.

the per capita calorie gap narrows. These results clearly show that by simply creating a supply of fish, food security is unlikely to be improved significantly. The major constraint for food-insecure households in Yemen is not availability of fish but lack of financial resources to purchase fish (and other foods).

Figure 6. Fishery growth: Model results



Food security	2009	2015	2020
Household food insecurity (percent)	32.1	25.0	23.7
Number of food insecure people (in thousands)	7,483	6,952	7,649
Per capita calorie gap (wrt. 2009)	–480	–362	–335
Child malnutrition (percent)	59.4	58.0	57.7
Rural	63.5	62.1	61.8
Urban	47.7	46.2	45.7
Total exports/food imports	3.83	4.66	4.91
GDP (growth)	6.6	3.9	3.6
Hydrocarbon	4.3	–2.3	–2.3
Nonhydrocarbon	7.3	5.2	4.5

Source: Authors' calculations.

3.6. Qat and Agricultural Policies

Water is the major constraint for agricultural growth in Yemen. As such, reduced water availability is likely to significantly reduce agriculture and food production in the future. Given the rapidly falling groundwater levels in many regions and the fact that many households lack water for drinking, washing, and cooking, groundwater use for irrigation must be dramatically reduced. Growth in promising sectors

will further sharply limit the availability of water for agriculture due to the rising demand from households and other sectors, such as manufacturing and tourism. As a consequence, by some estimates, the share of water available for agriculture will fall from the current approximately 90 percent to 60 percent over the next few years. Although increasing the irrigation efficiency (more crop-by-drop) may compensate for parts of the declining availability of water, water constraints are likely to severely limit the potential for agricultural growth.

One of the few options for maintaining current food production levels is to sharply reduce qat production. Qat area increased from 8,000 hectares (ha) in 2007 to 153,000 ha in 2008. It is estimated that qat uses about 50 percent of all water from groundwater wells, constituting the single most important source of groundwater depletion by far. However, there are major concerns related to qat in terms of both production and consumption. Qat production and trade generate income for many people, including influential people. Qat consumption is so entrenched in society and daily life that any attempt to curb consumption may spark discontent among the population. Therefore, many people argue for a gradual approach to tackling this important issue. However, given the dramatic rise of qat production in recent years and the ever-increasing consumption, big steps and drastic measures may be required. Households spend a significant share of their income on the stimulant. This share is similar across household income groups, and even food-insecure households spend the same share on qat that food-secure households spend, and money spent on qat is obviously not available for buying food, especially for children.

Any measures for reducing qat consumption (and therefore production) will require a careful communication strategy. According to an estimate from one high-ranking government official within the Ministry of Agriculture and Irrigation (MOAI), the top 11,000 policymakers consume about 20 percent of all qat (in value terms). Given this high consumption among government officials, it will be important for policymakers to set a good example and credibly reduce their own consumption. In addition, anti-qat education in schools could help reduce qat use for future generations. Although most children below the age of 12 do not chew qat, the percentage of young people aged 20 who chew qat is as high as 80 percent.

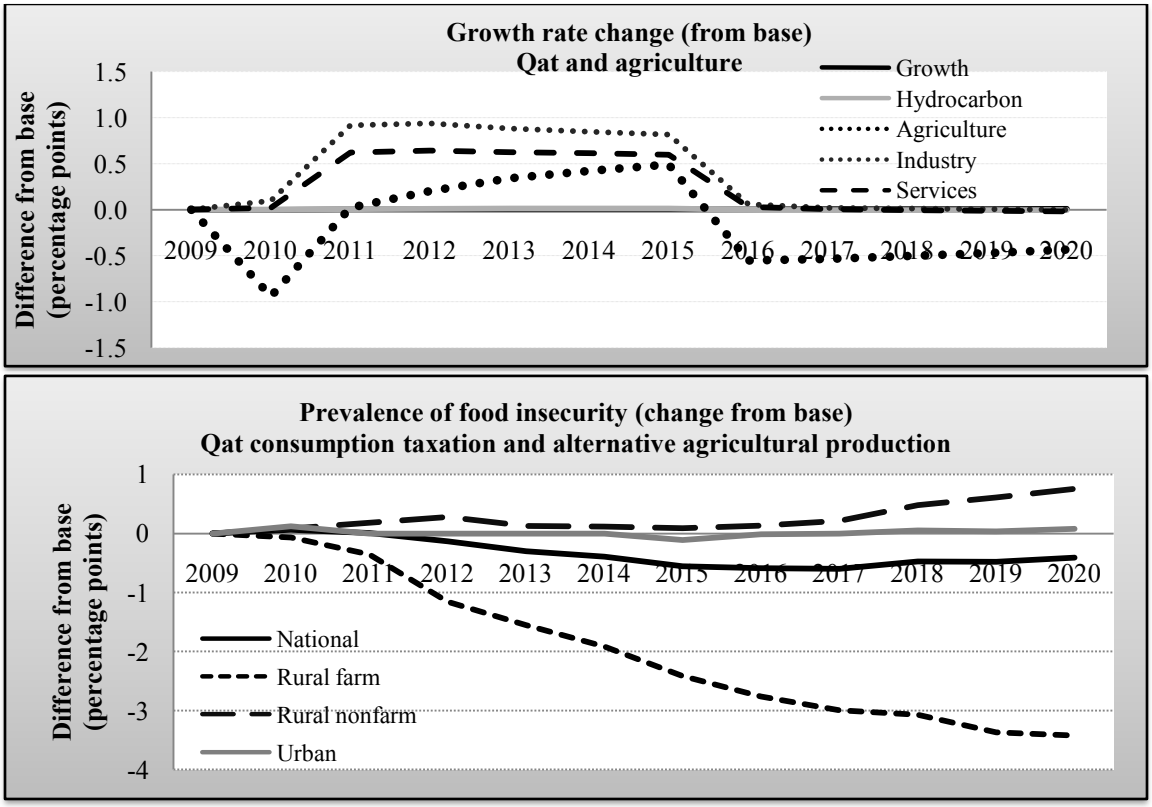
Although sharply cutting qat production and consumption is critical, reducing qat consumption is likely to have short-term negative effects on farmers, given qat's large share in agricultural GDP and farm income. To cushion the potential negative impact on farmers, the promotion of alternatives, such as coffee and to some extent cereals, should be an important part of any qat-reduction strategy. The following scenario examines the *income* effects of a qat-reduction strategy by taking the parallel promotion of alternative crops. It proposes the introduction of an excise tax for qat, similar to tobacco taxes in most countries. The initial tax is equivalent to 10 percent of qat output in the first year and then increases to 20 percent. The generated revenues are spent on the promotion of alternatives to qat, mainly cereals and coffee. The assumption is that public spending on cereals and coffee sectors and their marketing will increase agricultural productivity (TFP) by 3 percent annually in these sectors from 2011 to 2015. In addition, the capital stock for qat production will be reduced, reflecting a decrease in private investment over the period of the food security strategy.

As expected, a reduction in qat consumption and production will have a negative impact on agriculture (Figure 7). However, the promotion of cereals and coffee production and marketing will compensate for the loss. The agricultural sector growth will remain 1 percentage point below its baseline level, which is a modest decrease given that qat makes up about one-third of agricultural GDP. After the second year, agricultural growth will accelerate above its baseline levels for the years in which productivity grows. This results from the promotion of alternatives to qat, especially coffee, cereals, and related processing. Driven by growth in cereal and coffee production and their forward linkages to the food-processing industry, services and industry will also grow. Promoting these alternatives can be financed by revenues from the newly introduced qat tax.

Farmers are the biggest beneficiaries from the "qat reduction plus promoting alternatives" strategy. Farmers' food security will improve by 3.5 percentage points through an increase in income from agriculture. However, rural nonfarm households and urban households will not benefit from this strategy, because their real income will not change much. Essentially these households will spend the same amount of money for a lower quantity of qat due to a higher qat price driven by the tax and a

reduction in qat supply. But it is well known that the benefits of reducing qat go beyond the aggregate household income effects and include intrahousehold distribution of available resources and health effects. These effects will be analyzed in the "anti-qat" program in Section 3 of this paper.

Figure 7. Qat and agriculture: Model results



Food security	2009	2015	2020
Household food insecurity (percent)	32.1	24.7	23.9
Number of food insecure people (in thousands)	7,483	6,887	7,698
Per capita calorie gap (wrt. 2009)	–480	–356	–334
Child malnutrition (percent)	59.4	58.0	57.8
Rural	63.5	62.1	61.9
Urban	47.7	46.2	46.1
Total exports/food imports	3.83	5.08	5.18
GDP (growth)	6.5	4.4	3.5
Hydrocarbon	4.3	–2.3	–2.3
Nonhydrocarbon	7.2	5.9	4.4

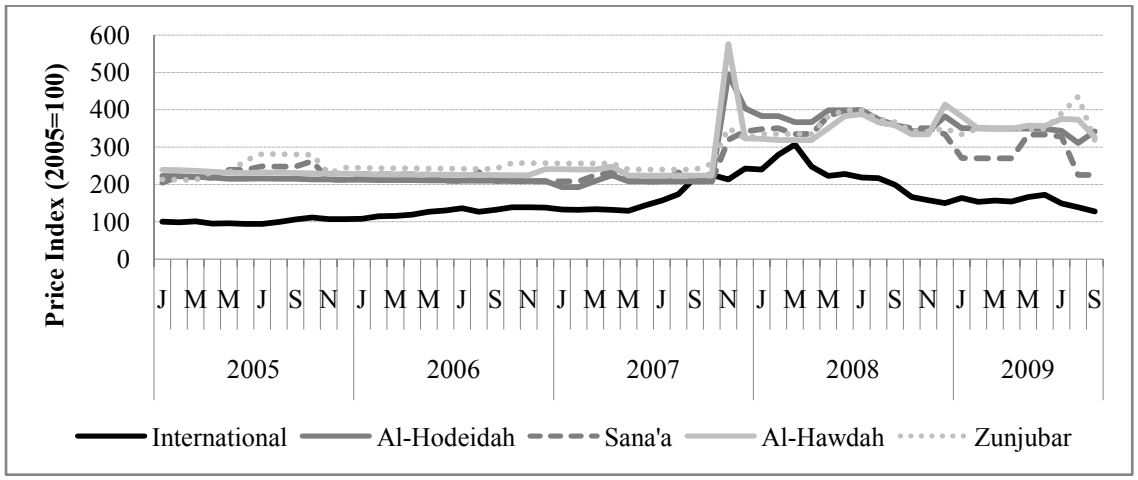
Source: Authors' calculations.

3.7. Trade Competition Policies

The oligopolistic structure of cereal importers has led to the general perception that more competition is needed in order to reduce local cereal prices. This perception is supported by results from a simple comparison of local market prices in selected markets in Yemen with international prices. Figure 8 shows that almost irrespective of the location of local markets, wheat prices in Yemen are, on average, twice as high as the average international price. Although part of the margin is explained by the usual trade margin

(including freight costs, storage, local transport, and so on), there is wide suspicion that the oligopolistic structure of cereal imports extracts additional rents. In fact, cereal imports are organized by only five major private companies, which effectively form an oligopoly. These five companies cover about 90 percent of all cereals imports, and the largest of those five controls about 30–40 percent of the market. Most cereal imports come from Australia, the United States, Pakistan, Turkey, and Uzbekistan. The state-owned Yemen Economic Cooperation currently accounts for about 5–10 percent of cereals imports. To enhance competition, and in response to the food price crisis, the Yemen Economic Cooperation has started to become a food importer itself and accounts for about 5 to 10 percent of the cereals imports.

Figure 8. Wheat price trends in local markets in Yemen compared with the international market



Sources: CSO 2010; IMF 2010.
Note: International wheat price (Gulf free on board, FOB) in January 2005 (157 USD/ton) equals 100 points.

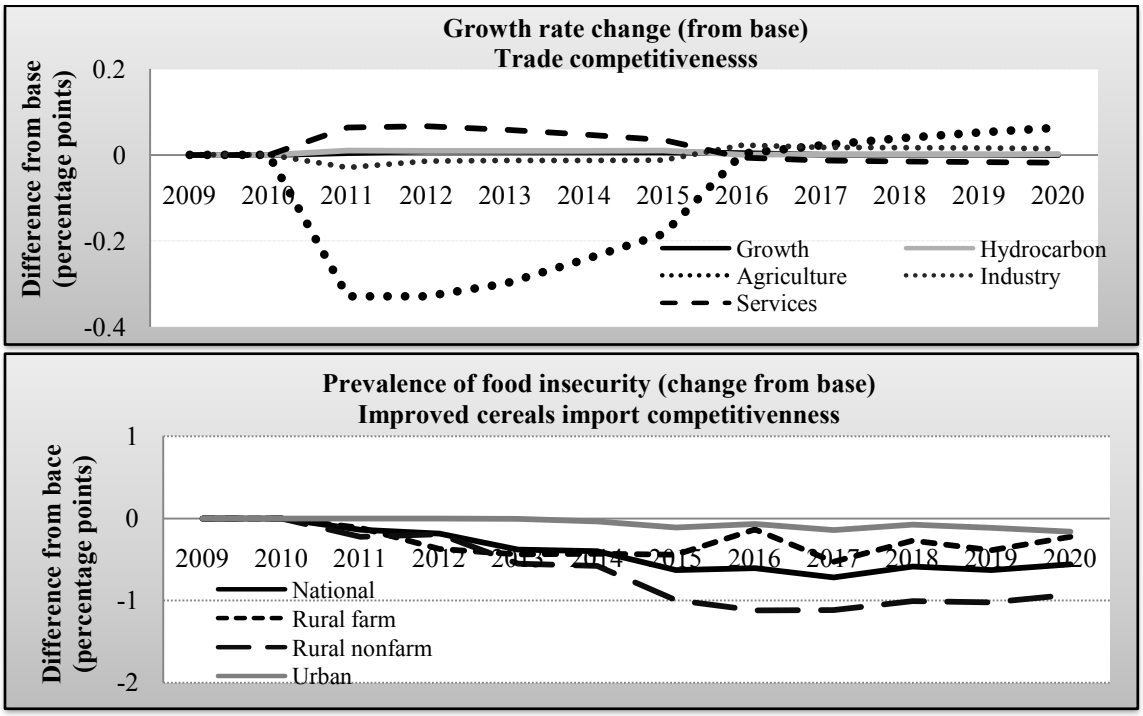
In addition, the 2007–2008 food price crisis highlighted the vulnerability of Yemen to sudden price spikes on the world market. Figure 8 shows how wheat prices increased much more dramatically in domestic markets as compared with world markets. This price surge, which hurt the food insecure most and led to food riots in Yemen, provides a rationale for keeping emergency physical stocks of grains that can be released in times of crisis to smooth price shocks and avoid overshooting.

This scenario illustrates the effects of a situation in which more competition for cereals and cereal products is created by introducing and enforcing laws and regulations. The assumption is that enforcing competition will reduce import prices for cereals by 3 percent annually from 2010 to 2015.

Generating competition in cereal import markets will reduce domestic prices for cereals. Lower prices will affect local cereal producers and thus lead to a reduction in agricultural output (Figure 9). However, most households in Yemen are net consumers of cereals; therefore, the overall effect on households will be positive. The service sector, especially trade, will also benefit through increased activity and, thus, compensation for the loss in growth in agriculture. Overall growth will be similar to the baseline.

Improving trade competitiveness will support food security by raising real household incomes. Overall, food security for household will improve by 1 percentage point. Rural nonfarm households will especially benefit from lower prices, given their high share of cereals in their consumption basket. Even farm households will benefit from lower prices, despite the reduction in agricultural output, which is not surprising, because the large majority of farm households are net cereals buyers. In conclusion, creating competition between importers that lowers cereal prices can contribute to food security in Yemen and would come at low fiscal cost; however, it requires the enforcement of appropriate legislation.

Figure 9. Trade competitiveness: Model results



Food security	2009	2015	2020
Household food insecurity (percent)	32.1	25.1	23.9
Number of food insecure people (in thousands)	7,483	6,989	7,722
Per capita calorie gap (wrt. 2009)	–480	–488	–488
Child malnutrition (percent)	59.4	58.2	57.9
Rural	63.5	62.4	62.2
Urban	47.9	46.2	45.6
Total exports/food imports	3.83	4.43	4.67
GDP (growth)	6.6	3.9	3.6
Hydrocarbon	4.3	–2.3	–2.3
Nonhydrocarbon	7.3	5.2	4.5

Source: Authors' calculations.

3.8. Population Growth Control

To address the key challenge of population growth, Yemen can learn from successful countries. One example is Iran, which has experienced the fastest decline in fertility over the past two decades (UN Population Division 2009). Iran has emerged as a model for family planning, in particular for countries that are seeking ways to reduce population growth. According to the Iranian Ministry of Health and Medical Education, between the mid-1970s and 2006, women went from having about 6.6 children on average to about 2 children. From an all-time high of 3.2 percent in 1986, Iran's population growth rate dropped to just 0.7 percent in 2007.

In Iran, policy played an important role in high population growth as well as in its reduction. In 1979, at the beginning of the Islamic Revolution, existing family-planning programs were removed, as they were seen as being under Western influence. During Iran's war with Iraq, procreation was encouraged by the government to bolster the nation's population. This strong pronatalist policy led to an annual population growth of about 3 percent from 1980 to 1988. Iran's population doubled in just two

decades, from 27 million to 55 million in 1988. By the late 1980s and early 1990s, Iran's rapid population growth was finally seen as an obstacle to development, and the government realized that the costs of this growing population were going to exceed its capacity to provide adequate food, education, housing, healthcare, and employment. It then embarked on a family-planning program to counter the mistakes of past government policy.

The national family-planning program has drawn international attention because of its innovative structure. The program started in 1989 with the goals of encouraging women to wait three to four years between pregnancies, discouraging childbearing for women younger than 18 or older than 35, and limiting family size to three children. In May 1993, a national family-planning law was passed that encouraged couples to have fewer children by restricting maternity leave benefits and withdrawing food coupons and social welfare subsidies after the third child. A nationwide campaign introduced contraceptives, including pills, condoms, intrauterine devices, implants, tubal ligations, and vasectomies. Moreover, the law called for several government ministries to incorporate information on population, family planning, and mother and child healthcare in curriculum materials. For example, university students are now required to take a two-credit course on population and family planning. The Ministry of Islamic Culture and Guidance was given the task of allowing the media to raise awareness on population issues and family-planning programs, and the Islamic Republic of Iran Broadcasting was entrusted with broadcasting such information. Money saved on reduced maternity leave was used for these educational programs. From 1986 to 2005, Iran's total fertility dropped from 7 to 2, which is replacement-level fertility.

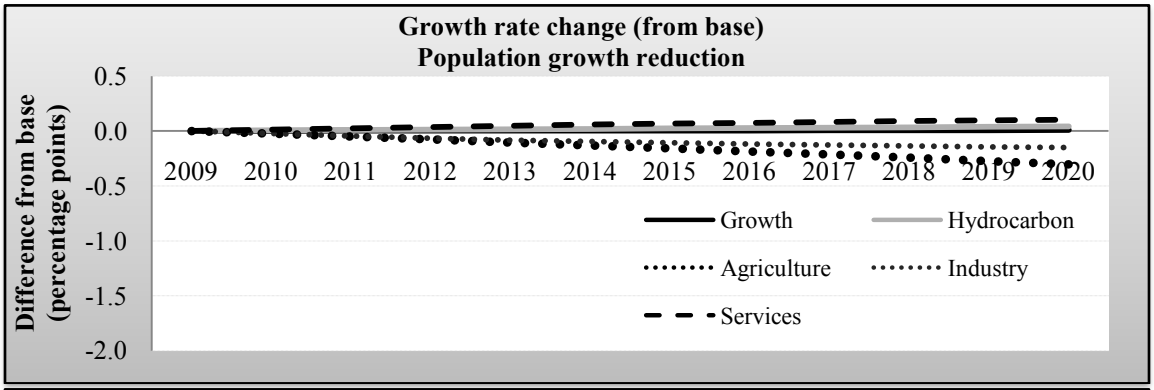
Family planning was also integrated with primary healthcare. A comprehensive health network, made up of mobile clinics and 15,000 "health houses," was established to provide family-planning and health services to rural people. Mobile teams were sent to remote parts of the country to offer free, modern contraceptive methods, including vasectomies and tubal ligations, to married couples. The government also had a strong information campaign, which was particularly effective because it was backed by Islamic clerics. In their weekly sermons, religious leaders have even cited having smaller families as a social responsibility and have issued fatwas (religious edicts with the strength of court orders) that permit and encourage the use of all types of contraception, including permanent male and female sterilization. Another unique aspect of Iran's family-planning program is the promotion of the involvement of men. Iran implements mandatory family-planning classes for men and women before they can receive a marriage license. Iran is the only country in the region that has a state-owned condom factory. Aside from the direct healthcare interventions, a broad-based effort was launched to raise female literacy, boosting it from 25 percent in 1970 to more than 70 percent in 2000.

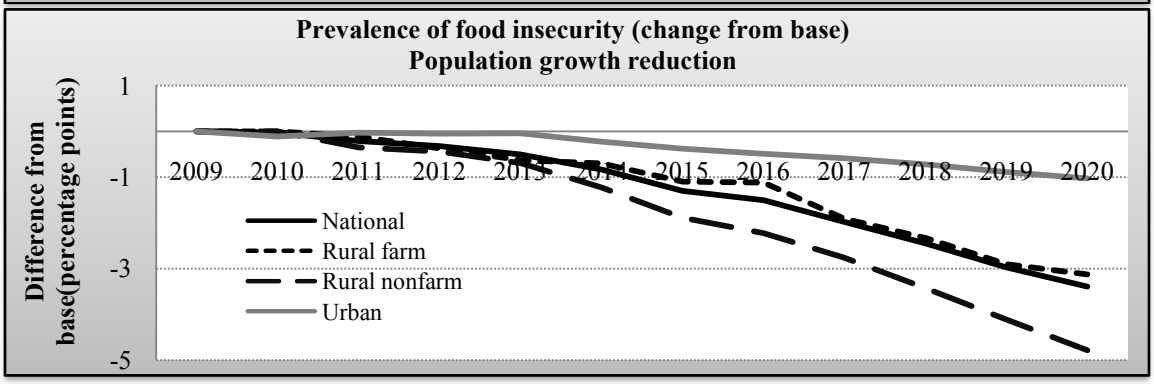
Population and health experts attribute the program's success to the government's information and education program and to a healthcare delivery system that was able to meet reproductive health needs. Moreover, the program has succeeded in addressing religion carefully and in a culturally sensitive manner. The following scenario assumes that Yemen will manage to follow the Iranian success story in reducing population growth by 0.125 percentage points between 2010 and 2020.

Results show that a reduction in population growth will make an important contribution to food security. Household food insecurity will drop steadily over the entire period, reaching 20.9 percent by 2020, a reduction of more than 3 percent as compared with the baseline (Figure 10). The main driver of this result is the fact that per capita food consumption will increase in all households. The positive effects will be largest for those households with the highest initial food insecurity and household size. Therefore, the food security of rural nonfarm households will improve most, followed by rural farm and urban households.

The per capita calorie gap will narrow from 348 to 319 kcal under the population-reduction scenario. Thus, to make all Yemenis food secure, a total increase of 319 kcal per capita is needed on average. Child malnutrition will also be reduced; however, as with previous scenarios, reducing child malnutrition will require additional programs that are well targeted to the children's needs.

Figure 10. Population growth reduction: Model results





Food security	2009	2015	2020
Household food insecurity (percent)	32.1	24.0	20.9
Number of food insecure people (in thousands)	7,483	6,504	6,225
Per capita calorie gap (wrt. 2009)	–480	–343	–262
Child malnutrition (percent)	59.4	57.9	57.1
Rural	63.5	62.0	61.3
Urban	47.7	45.9	44.8
Total exports/food imports	3.83	4.79	5.22
GDP (growth)	6.6	3.9	3.6
Hydrocarbon	4.3	–2.3	–2.3
Nonhydrocarbon	7.3	5.2	4.5

Source: Authors' calculations.

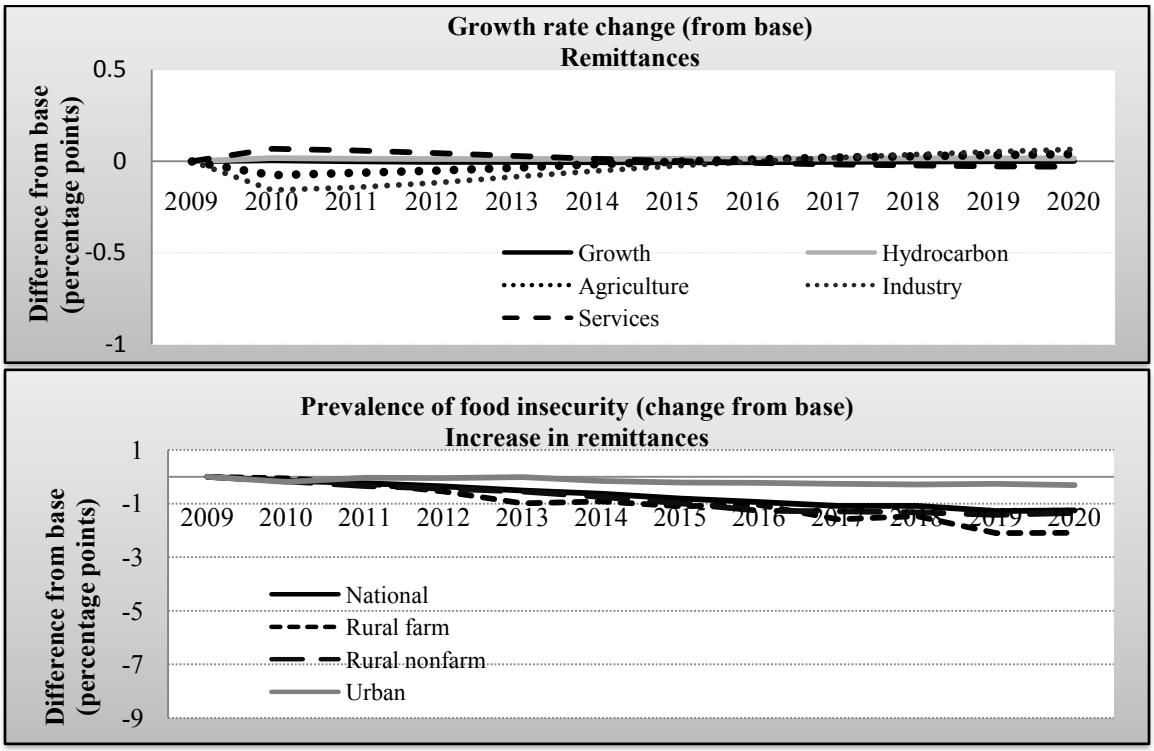
3.9. Stimulation of Remittances

Remittances are an important source of income for all groups, especially for rural food-insecure people. The average household receives about 8 percent of its annual per capita income from income transfers. The average shares among the rural population and the food-insecure population are slightly higher (9 percent each). Remittances make up 80.8 percent of the income transfers to the rural food insecure and 78.8 percent to the rural food secure. To the largest extent, these income transfers are coming from family relatives in the Gulf states. This indicates that further increasing remittances—for example, through education programs and worker exchange programs with neighboring countries—can play an important role in improving food security. To show the effects of such programs, the following scenario assumes that remittances will increase by 3 percent annually.

Raising household incomes by facilitating additional remittance flows will further reduce food security (Figure 11). If remittances received by Yemeni households increase by 3 percent annually, food

insecurity will be reduced by about 1.3 percentage points. However, it is important to note that the increase of inflows of foreign exchange can lead to an appreciation of the real exchange rate, which can negatively affect export sectors. The main beneficiary in terms of growth would be the service sector, whereas manufacturing and agriculture will see a slight decrease in output (relative to the base). This can be explained not only by the exchange rate effect but also by the fact that additional household income is spent on goods that are imported rather than produced domestically. For these imported goods, the main value added occurs in Yemen's transportation and trade sectors.

Figure 11. Stimulation of remittances: Model results



Food security	2009	2015	2020
Household food insecurity (percent)	32.1	24.5	23.1
Number of food insecure people (in thousands)	7,483	6,812	7,438
Per capita calorie gap	–480	–352	–320
Child malnutrition (percent)	59.4	58.0	57.6
Rural	63.5	62.1	61.8
Urban	47.7	46.1	45.6
Total exports/food imports	3.83	4.48	4.57
GDP (growth)	6.6	3.9	3.6
Hydrocarbon	4.3	–2.3	–2.3
Nonhydrocarbon	7.3	5.2	4.5

Source: Authors' calculations.

3.10. Water Sector Reform

Water sector reform is critical for improving food security and sustaining accelerated development overall. Availability of and access to water are rapidly deteriorating in Yemen. The share of water used by the agricultural sector is projected to decline to about 60 percent of total water due to the rapid depletion

of groundwater as well as the need for more shares to supply the growing population with drinking water and to satisfy the water demand from economic growth in promising sectors, such as tourism, mining, and manufacturing.[23] Water tables are falling by about 2 meters in Sana'a City and other parts of the country. Although there is little doubt about the severity of the situation, estimating and modeling the water system in Yemen is severely constrained by data.

Yemen has developed a National Water Sector Strategy and Investment Program (NWSSIP), which will complement the planned food security strategy and contribute to improving food security. The following summarizes the main point of that strategy.

The successful management of reducing overall groundwater use and the redistribution of water from agriculture to other economic activities and human consumption will play a decisive role in Yemen's future food security. Recognizing the importance and urgency of this issue, Yemen has developed a comprehensive water strategy. The following main pillars of this strategy relate to policy:

- Strengthen capacity for and implementation of integrated water resources management, including groundwater monitoring and control and water quality improvement
- Manage the environmental impact of effluent and waste water in partnership with the private sector
- Develop water resource and water use efficiency through the protection of user rights
- Deliver efficient, low-cost projects on a demand-driven basis by enhancing project implementation efficiency, improved coordination, and decentralization
- Strengthen institutions to play their role in promoting efficient water use
- Enhance resource sustainability and quality through improved watershed management

3.11. Comprehensive Food Security Policy Action (Combined Scenario)

Results from the nine food security scenarios show that none of the individual policy actions is able to reach Yemen's goals of achieving moderate food security and sharply reducing child malnutrition by 2020. Therefore, the following scenario combines all the actions to investigate how far food security can be improved.

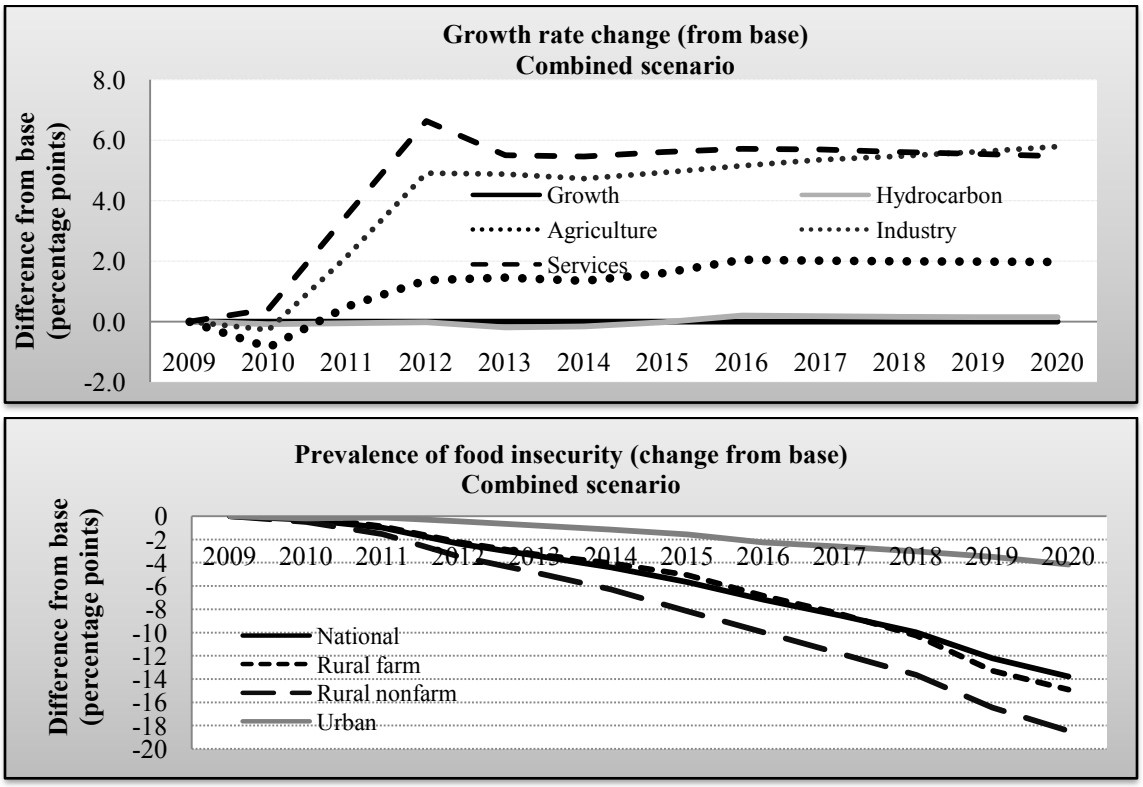
Under the combined scenario, economic growth will accelerate to 8.4 percent by 2015 and to 8.8 percent by 2020 (Figure 12). This is about 5 percentage points higher when compared with the baseline (that is, when compared with a situation without any policy action). Growth of about 10 percent in nonhydrocarbon sectors will compensate for the continuing decline in the hydrocarbon sector. As a consequence, the hydrocarbon sector will sharply lose its significance to the Yemeni economy, with the share of the sector falling from 23.4 percent of GDP in 2009 to 8.2 percent in 2020. Growth in nonhydrocarbon sectors will rise sharply starting in 2011, as driven by growth in industry (especially construction) and services. After this initial spike, promising sectors in mining and manufacturing will drive and sustain growth at high levels throughout 2020. Agricultural growth levels will remain much lower due to the sectors' serious natural resource constraints.

Macrolevel food security will improve from 3.8 to 6.2 points, indicating that instead of using 26 percent of its export earnings to import food, only 16 percent of export earnings will be needed to import food by 2020. The improvement in macrolevel food security will mainly be driven by a strong growth in exports, mainly from the promising sectors and tourism. At the same time, the reduction of qat and the related increase in cereals production will increase domestic supply, while the reduction of population growth will slow domestic demand. These levels are close to the Middle East and North Africa (MENA) country averages. If complemented by appropriate measures for dealing with emergencies, such as global food price crises (see Section 3.6), food security on the macrolevel will be substantially improved under this scenario.

[23] Personal conversation with Abdul Malik Althawr (deputy minister for agricultural production), March 16, 2010.

On the household level, Yemen will reach its goal of cutting food security by one-third by 2015 and will have about 90 percent of the population food secure by 2020. Food security will dramatically and steadily fall, driven by sharp increases in income across all household groups. Although the per capita calorie gap will be eliminated, food security will still exist due to unequal food distribution across the population. Compared with the baseline, food insecurity will be 16 percentage points lower in 2020, bringing the food insecurity rate down to almost 10 percent. The rate for the most food-insecure group, the rural nonfarm households, will drop the most, followed by farm households. This result is a clear indication that the policies suggested here are prorural and pro–food secure. Despite this strong improvement, however, food insecurity will continue to be a rural problem. The total number of food-insecure people will be more than halved, leaving 3.1 million in food security, with most of those in rural areas.

Figure 12. Combined scenario: Model results



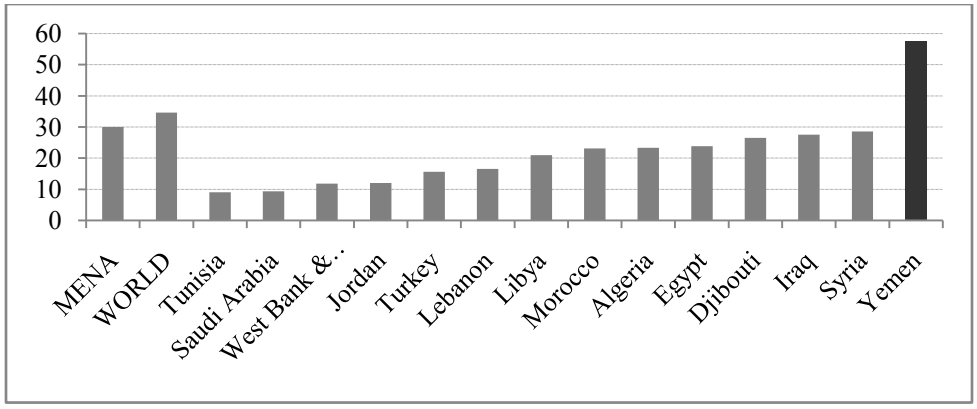
Food security	2009	2015	2020
Household food insecurity (percent)	32.1	19.6	10.5
Number of food insecure people (in thousands)	7,483	5,325	3,134
Per capita calorie gap (wrt. 2009)	–480	–223	176
Child malnutrition (percent)	59.4	56.8	53.5
Rural	63.5	61.0	57.8
Urban	47.7	44.8	41.2
Total exports/food imports	3.83	5.23	6.24
GDP (growth)	6.7	8.4	8.8
Hydrocarbon	4.2	–2.4	–2.1
Nonhydrocarbon	7.4	10.4	9.9

Source: Authors' calculations.

4. INVESTMENTS AND PROGRAMS FOR IMPROVING FOOD SECURITY

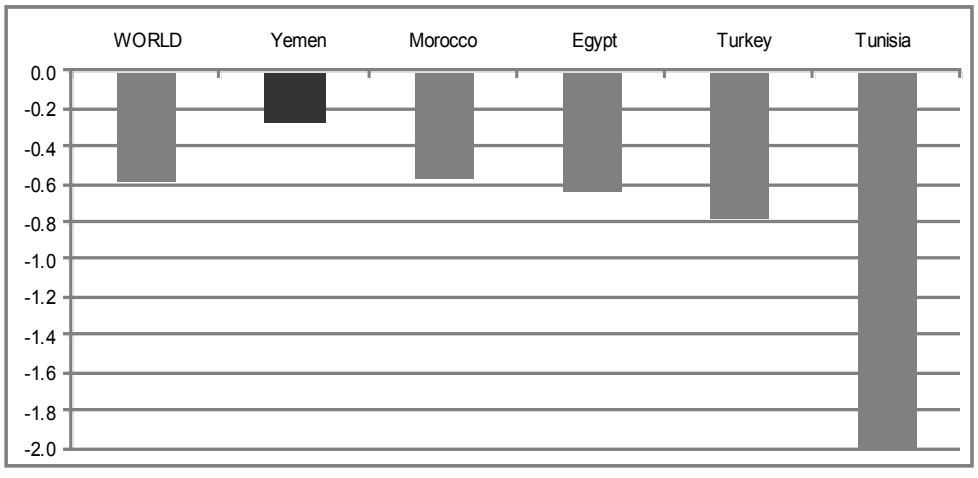
Not all food security goals can be reached by policies without additional actions; in particular, under all the proposed scenarios, the prevalence rate of child malnutrition remains unacceptably high. Section 3 showed that the proposed policies, both as single and combined options, are insufficient to fully reach the food security goals and, in particular, to sharply reduce child malnutrition (stunting). Figure 13 shows that Yemen has, by far, the highest prevalence of child malnutrition among all MENA countries. The annual reduction rate, which is equivalent to –0.27 percentage points, is less than half of the world's average (Figure 14). For a significant reduction in child malnutrition and an improvement of the overall nutrition situation, Yemen should strive for an annual reduction in the prevalence of stunting (as measured by children's height-for-age z-scores [HAZ], which is a long-term nutrition indicator) of more than 1 percentage point over the next 10 years. In addition to investments that improve people's economic and physical access to food and basic public services, targeted nutrition and health programs are required for achieving this objective.

Figure 13. Prevalence of child malnutrition (stunting among children under 5 years) in MENA countries



Source: World Bank 2010b.
Note: Latest estimates (2000–2006).

Figure 14. Average annual reduction in child malnutrition (stunting) in selected MENA countries

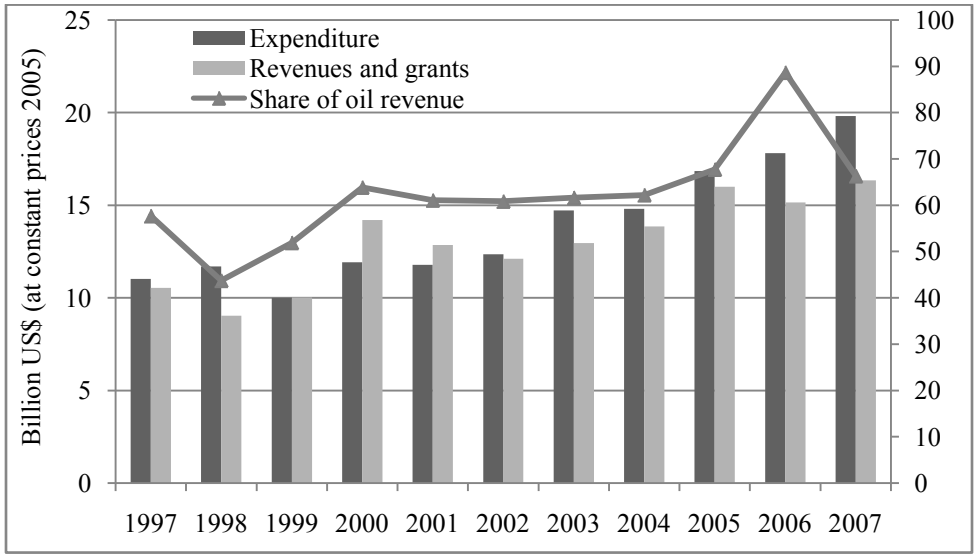


Source: World Bank 2010b.

4.1. Public Spending Overview

Yemen's government spending has increased at an average annual rate of 6.3 percent, significantly above economic growth. Expenditures increased from US$11 billion (in constant international dollar terms) in 1997 to US$20 billion in 2008 (Figure 15).[24] During the same period, total government revenues and grants grew at 5.3 percent per year. The high expenditure over revenue resulted in government-debt ratios hovering above 10 percent of total expenditures. Moreover, the government's reliance on oil revenues grew between 1997 and 2005. Declining oil revenues will require significant government finance reforms on the income and expenditure sides. The most important reform is the fuel subsidy reform (Section 3.2).

Figure 15. Government revenue and expenditure (1997–2007)

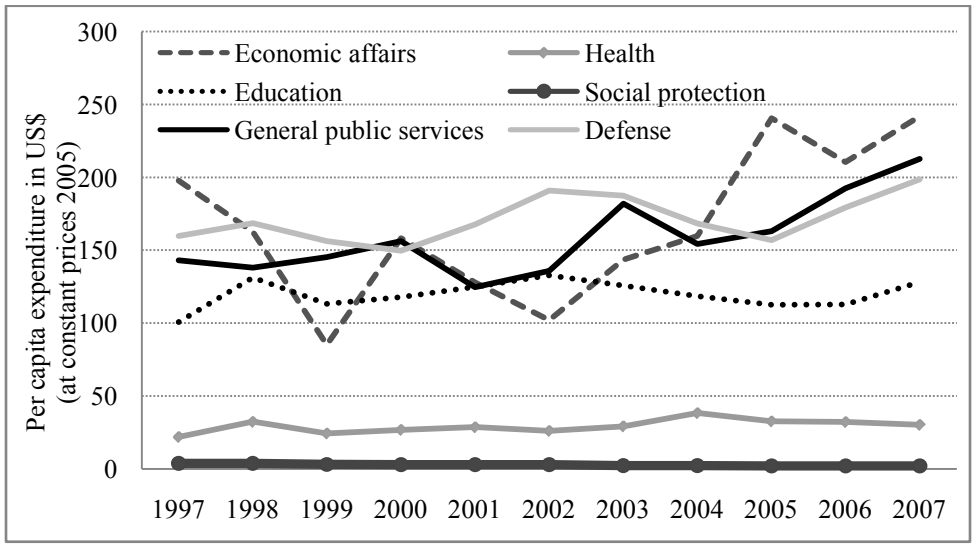


Source: Authors' calculations based on CSO 2010.

The top three expenditure items in recent years were economic affairs, general public services, and defense, accounting for 30.2, 22.6, and 21.4 percent of the government's budget, respectively. Economic affairs were the largest category in terms of spending, with expenditure reaching US$242 per capita in 2007, growing at 6.5 percent per year (Figure 16). The government allocated a substantial amount of resources to education (13.7 percent) and spent US$128 per person in 2007. On the other hand, government spending on public health remained low, with only 3.4 percent of total public expenditures allocated to health-related activities. Social protection is extremely weak in Yemen. In 2007, only 0.2 percent of total government spending was used for policies and programs designed to reduce poverty and vulnerability. Per capita social protection spending was only US$2 in 2007, which was merely 1.1 percent of defense spending and 1.7 percent of education spending.

[24] To capture the temporal change of government expenditure allocation, expenditures were first deflated from current local currency expenditures to constant 2005 international dollars using an implicit GDP deflator.

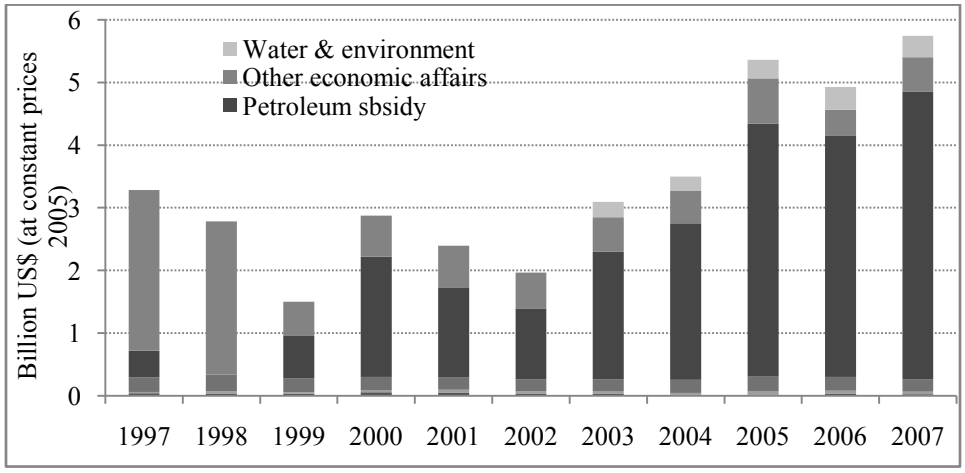
Figure 16. Government spending by sector



Source: Authors' calculations based on CSO 2010.

Within economic affairs, spending has been focused on the fuel subsidy rather than on investments to enhance productivity and food security. The fuel subsidy accounted for about 45 percent of total economic affairs expenditures in 1999, though this ratio quickly jumped to above 80 percent in 2006/07 (Figure 17). In absolute numbers, the average petroleum subsidy received per person swelled from US$25 to US$205 (at constant 2005 value) in 11 years, or about 20 percent per year. All other economic activities were dwarfed by the fuel subsidy. The share of agriculture and fisheries in economic affairs declined steadily from 8–9 percent in the early 2000s to 3.7 percent in 2007. Taking population growth into account, per capita spending on agriculture and fisheries dropped by 4.3 percent annually. Investment in infrastructure, including transportation and telecommunication, was a tiny fraction of the subsidies. Between 2005 and 2007, less than 1 percent of the economic affairs budget was allocated for infrastructure construction. Government expenditure in industry and trade also shrank by half from 2000 to 2007. Spending on water and the environment did not pick up until 2003. Since then, it grew rapidly from US$247 million in 2003 to US$342 in 2007, or 11.5 percent per year.

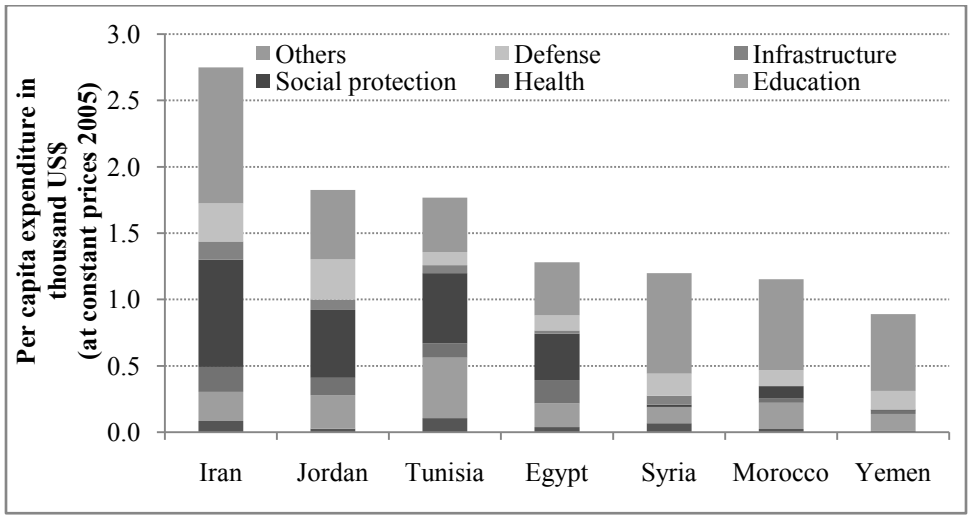
Figure 17. Government spending by economic affairs



Source: Authors' calculations based on CSO 2010.

Compared with other MENA countries, Yemen spends less on infrastructure, agriculture, and health. When compared with neighboring MENA countries, Yemen exhibits a different pattern in terms of budget allocation. Yemen ranks the lowest in agriculture spending, which, on average, accounts for 1 percent of the total government budget (Figure 18). Although social protection plays an important role in helping the vulnerable groups in the society, only 0.02 percent of the Yemeni budget is used for this purpose. About 0.5 percent of total expenditures was used for infrastructure in 2007, which is extremely low as compared with the MENA country average of 3.3 percent. Health spending is far from sufficient to cover the population in Yemen. In other MENA countries, budget allocations for health expenditures were 6.2 percent, whereas Yemen only reached half this percentage. Education spending in Yemen is comparable with other countries in the region, where it accounts for 14.5 percent of total government expenditure on average. As this education figure highlights, budget allocation and execution are misaligned with food security goals, and policy interventions are urgently needed to ensure that resources are used to achieve growth and food security.

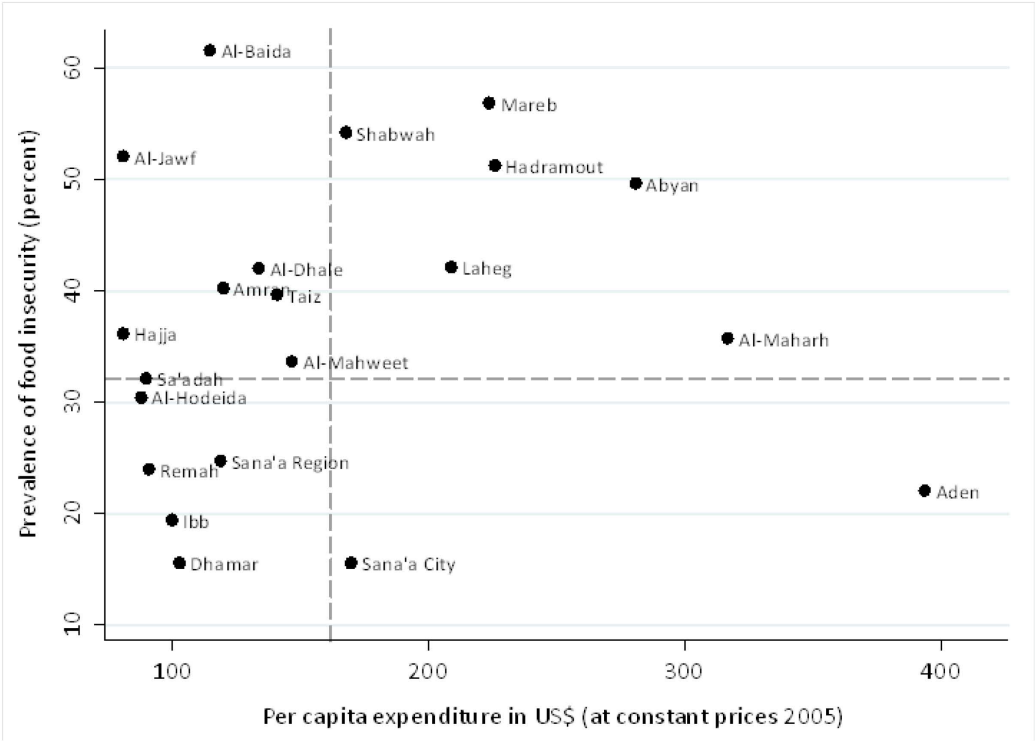
Figure 18. Structure of public spending in selected MENA countries



Source: Authors' calculations based on CSO 2010.

Public spending across governorates does not seem to be aligned with food security levels, indicating low efficiency and targeting toward food security. Figure 19 compares the food security situation with per capita government expenditure at the governorate level. The horizontal dash line indicates the national average food security rate of 32.1 percent, and the average per capita expenditure is indicated by the vertical dash line. Governorates with low per capita government expenditure and high food security are presented in the lower left quadrant, which includes Al-Hodeida, Dhamar, Ibb, Remah, and Sana'a. The upper left quadrant includes governorates that are food insecure with low government spending—namely, Al-Baida, Al-Jawf, Al-Mahweet, Al-Shale, Amran, Hajja, Sa'adah, and Taiz. Low spending could contribute to the food security issue in these regions. Governorates with high food insecurity and high public spending are positioned in the upper right quadrant. These governorates are worthy of special attention, as additional resource allocation did not generate expected outcomes of food security improvement. Governorates in this category include Abyan, Al-Maharh, Hadramount, Laheg, Mareb, and Shabwah. Sana'a City and Aden, located in the lower right quadrant, are characterized by low food security and high government spending. Aden stands out for its high expenditure figures—on average, $394 was spent on each Aden resident in 2007.

Figure 19. Relation of public spending and food security by governorate



Source: Authors' calculations based on CSO 2010.

However, it is not only the size and sector targeting of public spending that determines food security outcomes; the quality of spending also matters. There is a great deal of scope for improving spending, which may be at least as important as scaling up spending. For example, in the past, MOAI put much emphasis on irrigation and maximizing agricultural production. However, there is now an indication that the construction of upstream dams has benefited the richer farmers and has contributed to the impoverishment of poorer downstream farmers. Realizing these effects, MOAI should focus more on sustainable agricultural production that increases food security. Similarly, service provision in health centers is often not satisfactory. For example, interviews in health centers near Al-Hodeida showed that although physical infrastructure for midwifes exists, service provision was irregular. A more detailed study on service-provision quality and investment efficiency in all sectors will be needed for better outcomes.

4.2. Investments in Infrastructure and Basic Public Services

Reallocating and prioritizing public spending toward food security outcomes will be critical; however, which sectors and programs should be targeted? This section looks at investments in physical infrastructure and public services and compares their impact on food security. The analysis of investments that primarily increase household food security through an improved access to marketed food is based on the food security microsimulation model (Section 4.2.1). The child nutrition microsimulation model underlies the analysis of factors that improve the nutritional status of individuals—and children, in particular—through the link between individual health and nutrition (Sections 4.2.2–4.2.4). Thus, investments that improve people's access to drinking water, basic health, and basic education can directly contribute to a reduction of malnutrition.

4.2.1 Investing to Upgrade Existing Road Networks

Road density, especially of asphalted roads, is generally low, so that the average travel time by district to the nearest urban center exceeds three hours (Table 17). Food-insecure households generally need to travel 10 to 20 minutes longer to reach the nearest local market or urban center. Accordingly, results from the food security microsimulation model clearly suggest that investments in the road network system will improve food security in rural and urban areas. Expansion and upgrading of existing roads will reduce travel time for consumers and farmers to local markets, where they buy and sell food, and will see a subsequent reduction in transportation costs. Improvements of road infrastructure will also ease people's access to public service facilities, such as hospitals, schools, and administration offices, and will have positive spillover effects on development and commercialization in rural areas.

Table 17. Average road density and travel time by district

Average road density (m/km²)	
Asphalted roads	272
Asphalted and unpaved road	592
All (asphalted, unpaved, and unclassified) roads	614
Average travel time (min) to nearest	
Urban center	188
Settlement with more than 20,000 people	248
Settlement with more than 50,000 people	276
Settlement with more than 100,000 people	287

Source: Authors' calculation based on 2005/06 HBS data (CSO 2006).

Upgrading 20,000 kilometers of feeder roads in the most food-insecure districts and linking them to corridors, for example, will reduce more than half the travel time in these districts. More specifically, this upgrading, at an estimated cost of US$1 billion, will improve people's physical access to local markets (measured by a spatial access index) by about 124 percentage points. This translates into a reduction in the food insecurity rate of 1.6 percentage points. This drop includes only the direct effects resulting from an improved physical market access, but not the income effects. The positive spillover effects on economic growth and household incomes through income-earning opportunities and reductions in transportation cost are typically a multiple of the initial, direct effect. The resulting income growth in rural areas can be expected to significantly benefit the food insecure in rural areas. Empirical evidence also shows that investments in roads can be especially beneficial for women. For example, reduced travel time helps female school enrollment rates, in part by reducing the opportunity cost of schooling for girls. Similarly, increasing access to local healthcare facilities reduces the time women and girls need to spend on in-home care for sick family members.

Equally important are investments in basic water and energy infrastructure. In most settings, as in Yemen, collecting water and fuelwood is largely the responsibility of women and girls. In Ghana, Tanzania, and Zambia, for example, women spend between 5 and 28 percent of household time in water and fuel collection (World Bank 2001). Investments in time-saving infrastructure benefit all household members, and girls in particular. Low-cost childcare can also help both mothers and daughters. In Kenya, a 10 percent reduction in the price of out-of-home childcare increased the demand for such care and increased mothers' participation in the labor force. Low-cost childcare can also increase girls' school attendance: in rural and urban Kenya, a 10 percent decrease in the price of out-of-home care would be expected to result in a 5.1 percent increase in the enrollment rates of 8- to 16-year-old girls (after controlling for other factors), while having no effect on the enrollment rate of boys (Lokshin, Glinskaya, and Garcia 2000).

4.2.2 Investing to Expand Drinking Water Supply

Access to clean drinking water affects people's nutritional status, especially through its direct consumption and use for hygiene and food preparation. Lack of clean water access frequently results in diseases interfering with proper food digestion. Members of rural Yemeni households (especially women and children) with no direct water access spend an average of 42 minutes per day fetching water from wells or surface water sources. About one-half of the Yemeni population, and two-thirds in rural areas, do not have a water supply in their home (that is, a water network or their own well or tank) or at their door (water tank truck). Even in urban areas, more than 20 percent of households are not connected to a public, private, or cooperative water network, and the public network in many cities is inefficient and often short of water.[25]

The child nutrition microsimulation model provides clear statistical evidence that improved access to water would have a positive effect on the nutritional health of children (and other individuals) in both rural and urban areas. For example, reducing the average time of rural households to fetch water by 15 minutes would lead to a reduction in the prevalence of child malnutrition (stunting) by 1.4 percentage points. This might be explained by better hygiene and less diseases. Additional positive side effects can be expected from the saved time for fetching water; these effects are hard to quantify and are thus not taken into account in the model. Good water access can be associated with longer care times of mothers for their children, higher enrollment rates of pupils, increased income-generation activities, and lower workloads for women and children.

4.2.3 Investing in Food Security Risk Management

The ratio of total exports to total food imports (the macro food security indicator) remains below the international food security line, even in the combined scenario; therefore, additional measures must be considered. One option for enhancing the availability of cereals during crises is physical grain reserves. Strategic grain reserves can have several functions. The prime function is to help the country's vulnerable population better cope with food emergencies. Most commonly, strategic grain reserves are given a price-stabilization role, in addition to smoothing out local market price volatility. They can also function as providers of grain loans to recognized organizations and agencies—for example, as when those organizations experience delays in the arrival of their regular supplies (Lynton-Evans 1997). In countries that are highly dependent on grain imports and that have an oligopolistic importer structure, such as Yemen, strategic grain reserves can complement the private sector and correct the basic market failures of aggregate food markets. However, the appropriateness of establishing physical stocks as strategic grain reserves, especially functions that go beyond food emergency preparedness, need to be carefully assessed against the potential hazards associated with their management and operation.

For the emergency preparedness function of physical reserves, the target size for Yemen can be determined on the basis of the cereal requirements of the vulnerable population. *Lead time* is defined as the time required following the recognition of an imminent food emergency until additional supplies can be made available for distribution (Lynton-Evans 1997). Typically, the lead time is assumed to be three months. Based on food consumption data from the 2005/06 HBS and WHO/FAO minimum calorie requirements (see NFSSP Part I), the cereal (wheat) requirement of an average food-insecure person in Yemen is equivalent to 168 kilograms per year (providing 1,760 kcal/day).[26] Applying estimates of the number of food-insecure people in 2009 (7.481 million according to NFSSP Part I), the target size of the emergency grain reserve is about 314,000 tons, which is more than half of Yemen's current total annual production. However, a reserve of 314,000 tons is unlikely to be sufficient to function as a strategic

[25] Moreover, resulting from falling water tables, continuously deeper drilling for groundwater has led to an increase in fluorosis and other health impairments among children. These impairments likely result from drinking water contaminated with fluoride that is bounded in deep soil layers.

[26] It is assumed that additional calories needed for physical activities can be received from other sources. Thus, the grain reserve is calculated in such a way that it ensures only the minimum calorie needs for avoiding hunger, assuming that the minimum calories required can be obtained from wheat consumption only.

reserve for creating sufficient competition among importers, given a total cereal consumption of 3.2 million tons annually.

Physical reserves involve several challenges and limitations that must be carefully considered:

- Strategic grain reserves are not an appropriate instrument for solving chronic hunger, because the vast majority of hungry people lack the purchasing power to afford food. Thus, hunger is mainly a problem of poverty, rather than of food supply. However, strategic grain reserves can help reduce seasonal hunger by improving market functions in periods of local food shortages, so that the poor's vulnerability to hunger can be reduced during critical periods. Traders tend to underimport rather than overimport to avoid being left with high cost stocks at the end of a marketing year, which is when prices fall due to new harvests (Lynton-Evans 1997).
- The market distortions created by physical reserves need to be managed carefully. Market interventions have their own costs, including loss of efficiency and potential for mismanagement and outright corruption. Government reserves should be limited in order to avoid undermining the function of prices as a measure of scarcities and as a driver of allocations across geographical distances and time. The private sector works only by making profits, and price differentials are the key incentives. Typically, the private sector is more competitive, better informed, and thus more efficient (and often politically powerful) (Murphy 2009).[27] In fact, to increase competitiveness among the few (namely, five) notable grain importers and to reduce the disadvantages of the oligopoly for consumers in Yemen, laws and regulations to enforce competition may be a more effective tool for reducing consumer prices.
- The establishment, management, and operation of a grain reserve involve significant costs that can be a major burden for the national budget, especially if the reserve is used as a price policy instrument. The costs of establishing and maintaining the reserve are directly related to its physical size. Minimizing the costs of storage without jeopardizing its ability to cope adequately with initial stages of food crises can be achieved by adopting a policy of adjusting the storage size according to the prevailing circumstances, including the targeted population and the usual time of intervention (based on experience). A minimum stock should be kept to act as insurance against unforeseen circumstances (for example, keep the quantity required for one month of emergency relief). Additional costs for maintaining the reserve include the costs of recycling the reserve (on an annual basis), monitoring quality, and managing stock and pests (Lynton-Evans 1997).
- Well-functioning reserves require reliable, permanent information about real prices and quantities in local and international markets and their trends, as well as about the probability of a necessary intervention. In liberalized markets, such as in Yemen, the government is not fully aware of the quantity of grain marketed and the stocks of the private sector. It also does not have control over these quantities. A responsible government agency is required to collect price information and project prices of the coming marketing season (usually two or three months before the harvest) to decide when and how much to buy from the international market.
- Good management of reserves is critical to success and depends on transparent, accountable governance. Properly trained and paid staff is a prerequisite for the proper functioning of the reserve. Experience from other countries suggests that the risk of corrupt practices and abuse of the reserve is generally high (Murphy 2009).

[27] The lack of efficiency and the high operational costs were the main reasons for the government giving up its grain storage system in 2002.

In conclusion, physical grain storage facilities run by the state should only act in emergencies. Influencing market prices will require very large capacities, which are likely to be better handled by a competitive private sector. In January 2010, the Yemeni parliament approved the construction of one new silo near Al-Hodeidah that will have the capacity to store 100,000 tons of cereals. To serve as an effective tool for emergencies, the above simple analysis suggests that two more silos will be needed. A more detailed study is recommended, with a clear cost–benefit analysis. This study should also consider different management structures, as it is not clear that government's storage facilities are more cost effective than, for example, rents paid to the private sector. The private sector solution may thus be preferable to the public sector solution; however, to ensure that the private sector acts in a public interest, long-term contracts are required. For example, the success of Ethiopia's grain reserve program results from its smart design: The state agency responsible for management of the grain storages does not engage in buying and selling grain. However, it does serve as a custodian of the grain, with the responsibility of lending grain to government and international agencies and recognized nongovernmental organizations (NGOs), following official guidelines (Rashid and Lemma, 2010).

As an alternative to establishing state-owned grain storage facilities, other options should be considered. Many Arab countries face similar food security challenges due to their similarly high (or even higher) dependency on food imports. Thus, a regional grain facility solution might be a cost-efficient way to protect against future food price shocks. Hedging in international markets can be a smart way to avoid issues related to physical storage options. Comprehensive cost and risk analyses are needed to evaluate these options against one other, as a mix of options might be the preferred strategy.

The success of grain reserve programs can be increased by linking to other food security programs. Coordination between grain reserve and other food security programs, including NGO-run food aid, school feeding, and food-for-work programs, is critical for both the efficiency of the grain reserve and the overall functioning of all food security programs in a country (Rashid and Lemma 2010). A close coordination is particularly needed for efficiently targeting the most vulnerable people, as well as for continuously recycling the stored grain to maintain its quality (and thus to prevent health risks to the beneficiaries from spoiled grain in cases of emergency).

Lessons on disaster risk management from international partners, such as the World Bank and the World Food Program provide important lessons for the management of potential future crises.

Emphasis during Country-wide Shocks Must Be on Scaling up Existing Programs While Investing In Improvements over Time

For example, in Yemen the US $10 million grant from the Food Price Crisis Response Trust Fund has provided immediate support to two sets of complementary activities: (i) cash payment to the needy people to help them cope with the food price emergency through community-based labor-intensive work programs, using the Social Fund for Development (SDF) as a funding mechanism; and (ii) the implementation of support and capacity building measures for the Social Welfare Fund (SWF) to expand and improve the effectiveness of the national cash transfer safety net in order to further mitigate the adverse impact of high and more volatile prices on poverty. Through the implementation of this program and through the field observations, some important lessons were learned for future interventions. These include the following ones, inter alia.

Targeting Mechanisms Need Improvement and Simplification

Simplification and more efficient management of targeting, implementation, and monitoring processes is needed as existing processes have been found to be too labor and resource intensive. The SWF has prepared a set of criteria identifying the poor using proxy means testing. In the future, eligibility to work could be harmonized with the SWF criteria. Greater participation by women could be encouraged by designing interventions consistent with their physical ability and the culture of the community. Since a large number of women participate in salt production projects, such programs could be scaled up.

Risk Management Should Be Combined With Long-Term Development and Food Security Goals

Disaster management should become part of the overall economic development planning framework by recognizing the role of social transfers for building economic resilience among communities vulnerable to disasters, which are being implemented by the Social Welfare Fund, Social Fund for Development, Public Works Departments, international agencies and donors and include activities such direct transfers, cash-for-work programs, community asset building through public works, assistance to undertake micro-enterprises and other productive activities and nutrition and health programs. These institutions work at the field level and have to play a key role in providing immediate relief after disasters and assist in recovery and rehabilitation activities. Effectiveness of their role in the past disasters, for example 2008 floods, should be evaluated to estimate the needs for capacity building, funding and possible expansion of their role in disaster management.

Attention Is Needed To Ensure Sustainability of Infrastructure Created As Part of the Community-based Labor-intensive Works

Unlike regular SFD projects, due to the immediate response required in emergency interventions, community committees to maintain the infrastructure built or rehabilitated have not been established. However, there is recognition that the project cycle should be strengthened to ensure that infrastructure created/rehabilitated under the project is maintained. Some types of the works (e.g. road paving) have an opportunity to be combined with the development of skills for future job opportunities and this aspect also needs to be enhanced in future program design. Thus, the opportunities offered by intervention during emergencies should be utilized for initiating sustainable development.

Increased Occurrence and Intensity of Natural Disasters Is One of the Observed Impacts of Climate Change

This coupled with the fact that climate change also increases people's general vulnerability (by possible impacts on food, water, ecosystems, and livelihood) increases their risk of not being better prepared for disasters and reduces the authorities' ability to better protect the population from future disasters. In Yemen, there are synergies to be exploited when addressing disaster risk reduction and climate resilience. For example, linking climate modeling and forecasting with disasters' early warning systems is important to optimize data and forecasting tools in light of the resource and capacity constraints.

4.2.4 Investing in Basic Public Health

Access to basic public health services is poor nationwide, particularly in rural areas. Whereas the average urban person can reach a hospital in less than one hour and any health facility (hospitals, health centers, health units) in less than 30 minutes, the average rural person needs more than double the travel time in both cases. Nationwide, about 3,400 health facilities are operating (Ministry of Public Health and Population 2004), of which about 10 percent are hospitals, 40 percent are health centers, and 50 percent are health units (mainly located in rural areas).

However, the coverage of health facilities is not the major problem of the poor health supply to the population. Rather, it is the quality of the existing health facilities. Weaknesses include insufficient education of the workforce, especially in rural health centers and units; short operating hours of health centers and units; and inappropriate equipment. Consequences of the poor current health service's performance include mistrust of the health workforce in public health facilities (especially in rural areas), people's low willingness to pay for transportation to the health facilities, and a preference for costly health services provided by the private sector.

From a national food security and nutrition perspective, key areas of investment include programs related to breastfeeding education, nutrition education, hygiene awareness building, family planning, birth aftercare, and child growth-monitoring, in addition to the existing birth assistance and immunization services. Currently, only 31 percent of all health facilities provide education on breastfeeding practices and 29 percent on nutrition, and only 13 percent of all health facilities have a child growth-monitoring

program, reflecting a low coverage rate of these programs across the country and a long travel time to such specialized health facilities. On average, the travel time for these basic services exceeds one-and-a-half hours and is much higher in more remote districts. Thus, many households lack proper access (Table 18).

Table 18. Coverage of and access to basic health services

Average number of health facilities and specific health services by district	
All health facilities (hospitals, health centers, health units)	10.1
Hospitals	1.0
Health centers	2.9
Health units	6.2
Health facilities with	
Breastfeeding education program	3.3
Nutrition education program	3.0
Child growth-monitoring program	1.3
Density of health facilities and specific health services by population	
All health facilities per 1,000 people	0.173
Hospitals per 1,000 people	0.017
Health facilities with breastfeeding education program	
per 1,000 people	0.055
per 1,000 women (14–44 years)	0.282
Health facilities with nutrition education program	
per 1,000 people	0.050
per 1,000 women (14–44 years)	0.256
Health facilities with child growth-monitoring program	
per 1,000 people	0.022
per 1,000 children (0–59 months)	0.119
Average travel time (min) to nearest health facility and specific health service by district	
Health facility	44
Hospital or health center	74
Hospital	117
Health facility with	
Breastfeeding education program	91
Nutrition education program	103
Child growth-monitoring program	131

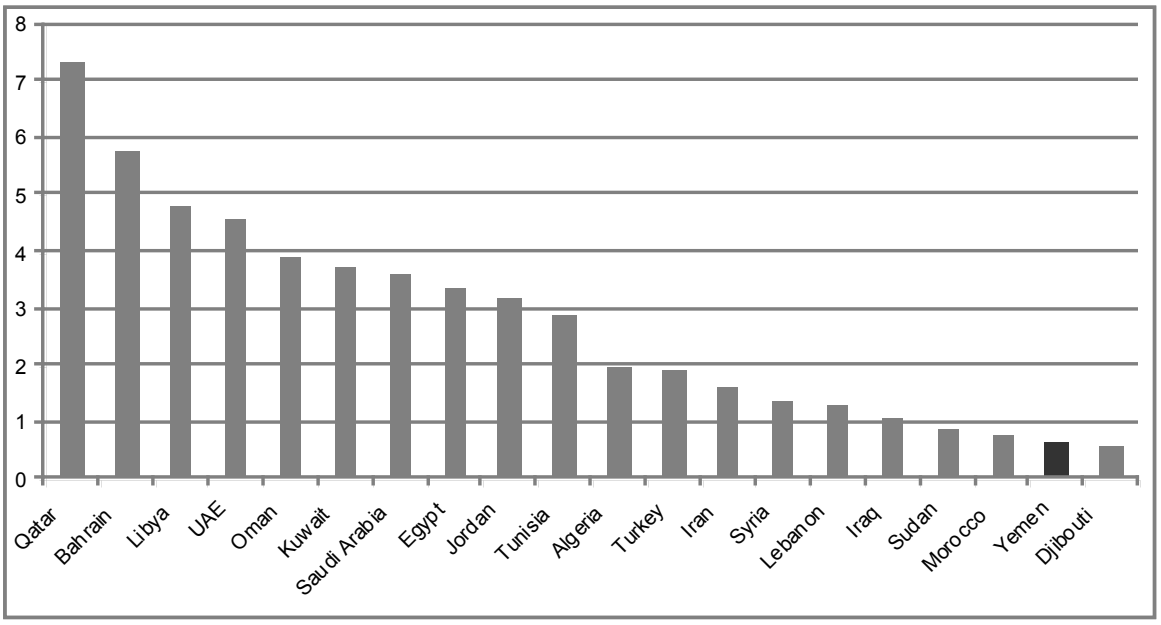
Source: Ministry of Public Health and Population 2004.
Note: Health facilities include facilities operated by the public sector (86 percent), private sector, and national and international nongovernmental organizations.

Therefore, priority in health sector investments should be given to upgrading existing health units and centers and expanding basic health programs, such as breastfeeding and nutrition education and child growth monitoring. Table 19 shows that, for instance, the expansion of breastfeeding education, nutrition education, and child growth-monitoring programs to all existing health facilities would lead to a reduction in child malnutrition (stunting) by 2.5, 2.4, and 3.0 percentage points, respectively.[28] In addition to the provision of adequate equipment and drugs, training of the health workforce and extending their numbers in rural areas are both urgently needed. Yemen, the same as Djibouti, has the lowest density of nursing and midwifery personnel in the MENA region (Figure 20). Achieving a density of two specialists per 1,000 people, or tripling their current number within the next decade (to reach the current level of Algeria and Turkey) should serve as a benchmark.

[28] It should be noted that these programs were only selected as indicators for basic health service provision.

International experience confirms these findings and underlines the importance of health services for food security, especially women's health. One strategy is to invest in women's health and nutrition throughout their life cycle and to empower women to seek better care for themselves and their children. Women's health and nutritional status are important for both the quality of their lives and the survival and healthy development of their children (Gillespie 2001). Because women's health and nutrition are life-cycle issues, interventions must attend to female malnutrition from adolescence through pregnancy and lactation to the promotion of growth of the newborn child and into the preschool years, school years, and adolescence. Direct actions to improve women's health and nutrition complement the struggle to achieve the long-term goals of gender equity and women's empowerment. Action must focus on both macronutrients and micronutrients, in particular iron, energy intake and energy expenditure, disease prevention, and above all, strengthening the capacity for and practice of caring for women and adolescent girls. Efforts are needed to space births in order to prevent maternal nutritional depletion, which is now widespread. Mothers need a recuperative interval of at least six months following cessation of breastfeeding. Accessible, good-quality prenatal and postnatal services run by supportive workers are vital to the early registration of pregnant women, counseling on nutrition and reproductive health, and access to contraception. Adolescent pregnancies need priority attention.

Figure 20. Density of nursing and midwifery personnel per 1,000 people



Source: WHO 2010.
Note: Latest estimates (2004–2008).

Perhaps the best-known example of interventions that directly aim to increase women's access to markets is the microfinance movement in Bangladesh. A number of NGOs in Bangladesh have attempted to improve women's status, as well as the well-being of children in their households, by directing credit to women. Microfinance programs have now been launched worldwide.

4.2.5 Investing in Basic Public Education

Lack of nutrition- and health-related knowledge and formal education is a major cause of Yemen's poor nutrition (as well as in other developing countries). For the nutritional status of children and the remaining household members, the educational status and nutritional knowledge of women and girls (who are typically responsible for meal preparation in the household) are critical. General knowledge and

awareness of nutrition, health, and hygiene-related issues usually increase with the years of schooling. Nationwide, the average Yemeni mother spends only two years in school (and does not achieve any educational certificate level), and 60 percent do not attend school at all. There is a large urban–rural disparity in formal education, albeit at a generally low level: the average number of years in school for mothers in urban areas is almost five times higher than that of rural mothers (Table 20).

Table 20. Effect of increasing the education of mothers and caregivers on child malnutrition (stunting)

	National	Rural	Urban
Average schooling years	*2.0*	*1.0*	*4.8*
Prevalence of food insecurity (percent)			
Status quo	58.7	63.0	46.2
Increase of average schooling years			
+1	57.9	62.3	45.3
+2	57.1	61.5	44.4
+3	56.1	60.4	43.7
+4	55.4	59.6	43.1
+5	54.7	59.0	42.4
+6	54.0	58.3	41.7
+7	53.4	57.7	41.1
+8	52.6	57.0	40.2
Compulsory school attendance for all			
Primary school (5 years)	55.7	59.7	44.5
Middle school (9 years)	53.2	57.0	42.4

Source: Child nutrition microsimulation based on 2005/06 HBS data (CSO 2006).

Formal education has a direct, positive, and statistically significant effect on child nutrition. For example, increasing the average number of years in school by five results in a reduction of child malnutrition (stunting) by 4 percentage points on average (Table 20). This effect captures only the benefit of generally improved education, but not the positive effects on women's income-earning opportunities and additional household income generation, not to mention other positive externalities of a higher-educated female population, including reduced population growth. Moreover, pupils' nutrition- and health-related knowledge can be improved by specific teaching programs and practical courses in school.

Thus, from a public nutrition and national food security perspective, compulsory school attendance and free basic education are beneficial and advisable. Making primary school (up to grade level of five successful schooling years) directly reduces child malnutrition by 3 percentage points nationwide (Table 20).

4.3. Educational Programs and Awareness-Building Campaigns

Information and awareness-building campaigns are particularly required in five essentially interlinked areas: (1) qat consumption, (2) breastfeeding practices, (3) family planning, (4) healthy nutrition, and (5) women's empowerment.

The child nutrition model underlying this paper gives clear statistical evidence that a higher household expenditure share for qat—and thus higher qat consumption—negatively affects the nutritional health status of young children. For example, in urban areas, an average reduction of qat expenditure by 5 percentage points leads to a reduction of child malnutrition (stunting) by 1 percentage point, without considering the positive effects resulting from the additional household income.[29] Therefore, issues related to qat consumption that need to be more strongly communicated include the following:

[29] The share of qat expenditure on total household expenditure equals 9 percent in urban and rural households, on average.

- High household expenses for qat consumption and the related underspending on children
- Reduction in people's productivity related to qat consumption
- Opportunity costs of buying and consuming qat
- Interfering effects between qat consumption and good nutritional health in individuals through loss of appetite
- Potential malabsorption of essential micronutrients, such as iron and zinc (which are particularly important for women)
- Negative impact on child development through reduced child attention and care
- Potentially inappropriate feeding practices of children if households' food consumption follows their adult (male) food needs

Promotion of adequate breastfeeding is critical for the healthy nutrition of infants and young children. Education is particularly needed regarding the benefits of breastfeeding for child development. There are widespread misconceptions related to breastfeeding and proper breastfeeding practices according to WHO recommendations (WHO 2009). Reference should also be made to the adverse effects of qat consumption during the breastfeeding period on child development.

Yemen's rapid population growth and its resulting negative effect on economic development and food security call for large-scale family planning campaigns. In addition to the traditional topics of family planning, campaigns should also amplify the economic challenges of raising many children. The child nutrition model reveals that children in households with high shares of dependent people (children and elderly) are significantly less well nourished, independent of the household's level of income. This might be a result of a lower attention and care than can be devoted to a single child. A reduction of the average household size by two dependent household members would reduce child malnutrition (stunting) by 3.1 percentage points on average, without taking the positive per capita income effect into account.[30] Considering Yemen's increasing under- and unemployment among youth, a significant reduction in the dependency ratio and in the economic burden of rapid population growth can only be achieved by reducing birthrates, especially in large families.

Nutritional education programs must cover a wide range of topics that devote attention to dietary diversity and micronutrient malnutrition. The lack of consuming diversified diets adequately enriched with vegetables, fruits, meat, and fish is the main cause of micronutrient deficiencies. The fact that diets are also poorly diversified in wealthy Yemeni households suggests that micronutrient malnutrition is not only a phenomenon of poverty (as in other developing countries); instead it is likely a consequence of poor nutritional knowledge. Similar to child malnutrition, micronutrient deficiencies are associated with high economic costs in the long term that can easily exceed 3 percent of the national GDP (Horton and Ross 2003, World Bank 2006).

The evidence clearly shows that in many countries, gender inequality goes hand in hand with hunger. Fortunately, this evidence also points to a clear avenue for reducing hunger by improving women's educational attainment, economic participation, health status, and political empowerment. Many successful interventions in these areas have already been initiated. Many more innovations will be needed, however, to unleash women's potential to make significant contributions to the food security and well-being of their families. Raising awareness for the importance of women for food security is important. For example, in Kenya, studies based on household survey data show that the attitudes and quality of teachers affect the demand for girls' schooling more than for boys (Mensch and Lloyd 1998). Changing attitudes among parents, teachers, and principals will require long-term efforts. To this end, training staff and reviewing and revising school curricula play important roles in ensuring that gender stereotypes are not perpetuated in the classroom. Schools also need to be safe places for children,

[30] The dependency ratio, defined as the number of children under 14 years of age and elderly aged 60 years and older divided by household size, equals 0.474 in rural areas and 0.401 in urban areas on average. The average household size is 7.65 in rural areas and 7.15 in urban areas.

especially girls, to learn. It is important to work at the policy level, with teachers and parents, to ensure that both the school and the route to school are free from violence in all its forms, so that girls can enroll in and complete a course of high-quality education while attaining the best possible grades.

Channeling knowledge and information to the population in need and training required staff can be achieved at relatively low costs. Experience from other countries shows that these investments have high rates of return. Close collaboration between government agencies and national and international NGOs can help reduce public expenditure and allow for buy-in of expertise. In addition to the usual way of reaching the most malnourished and food-insecure population (for example, sending out trained, local field workers), innovative channels need to be explored that achieve a high coverage at moderate costs. In addition to media channels, such as television and radio,[31] religious leaders, and the Friday prayer in particular, are important channels to consider. The common interest of the religion and the governance for good public health might ensure a sustainable improvement of the current nutrition situation. In general, a constant flow of information and knowledge is mandatory for changing people's behavior. The population penetrated by information and awareness-building campaigns should go beyond the typical target population, which is usually women—namely, young mothers and girls. It is also important to involve men, especially the household heads, into campaigns because of their decisionmaking power in allocating household resources and their leading role in Yemen's male-dominated society.

[31] Television coverage is low due to the lack of electricity in many households. Coverage through battery-powered radios is significantly higher.

5. SUMMARY AND CONCLUSION

Yemen is the most food insecure country in the Arab world and among the 10 least food secure countries globally. In response to this alarming situation, the Government of Yemen, under the leadership of the Ministry of Planning and International Cooperation (MOPIC), developed a joint vision on food security: all Yemeni people should have access to sufficient and nutritious food at all times to live an active, productive and healthy life—i.e. food security for all Yemenis.

To translate this vision into action, the National Food Security Committee has formulated a set of concrete goals as a yardstick against which success in implementing the National Food Security Strategy can be measured. These goals are:

(1) To cut food insecurity by one-third by 2015

(2) To make 90 percent of the population food secure by 2020

(3) To reduce child malnutrition by at least one percentage point per year

If it does not take action, Yemen will almost certainly miss these goals and the absolute number of food insecure people is projected to increase. Therefore, in a consultative process involving major government agencies, civil society, and international partners, the Food Security Committee identified 18 priority areas for action. Drawing on these priority areas, and based on results from the Yemen Food Security model, a set of seven actions has been prioritized as the core for the implementation of the Strategy.

If this 7-Point Action Plan is implemented decisively, Yemen will reach all three of its food security goals and become a food secure country by 2020. The required actions are as follows:

1. Leverage the fuel subsidy reform to promote food security

The Government of Yemen made a first step to reform petroleum subsidies by increasing fuel prices in 2010. Continuing this reform process offers a great opportunity for improving food security, if the transition to higher fuel prices is designed properly to make it pro-food secure. Simply phasing out the fuel subsidy would increase food insecurity, as farmers and the urban food insecure are most affected by higher fuel prices. However, the budgetary savings from reform provide ample fiscal space for complimentary measures to improve food security. These savings should be used to finance a combination of direct transfers and productivity-enhancing investments. Scaling up direct transfers targeted to the food insecure will help alleviate negative effects during the initial years of reform, and the Social Welfare Fund with its new targeting system will be crucial for implementing income transfers. To foster sustainable food security in the medium to long run, however, direct transfer payments will have to be complemented by public investments. Public investments in infrastructure related to utilities, transport, trade and construction integrate economic spaces and create a platform for restructuring agricultural, industrial and service value chains, which could be exploited by enabling domestic and foreign private investment in the medium term.

2. Improve the business climate to foster pro-food secure private investments in promising sectors

Policymakers can make an important contribution to facilitate private sector-driven pro-food secure growth by improving the investment climate for both domestic and international investors. Improvements in the business climate are especially needed in access to credit, protection of investors, and the tax regime to unleash private sector-driven growth. While foreign direct investments are largely concentrated in the hydrocarbon sectors (oil and gas), it is important to attract investors in nonhydrocarbon sectors. These sectors usually have more linkages with the rest of economy, create more jobs, and employ more food insecure people. FDI inflows also come with new technology and fresh market opportunities to create a more productive labor force and enhance management skills. Investors should be especially encouraged to invest in rural areas. Many promising sectors such as mining, food processing, and tourism have the potential to generate employment in rural areas, thus helping the poorest escape food insecurity. However, the food insecure are often unable to participate in the labor market or do not possess the right

skills to reap the benefits of growth: important issues that will require additional programs as discussed under point 7.

3. Use qat reduction policies for fostering agricultural development

Agriculture can make an important contribution to rural development and food security, especially by generating income and jobs. The major constraint for agricultural growth, however, is water; thus sharply reducing qat consumption (which consumes 40-50 percent of the country's water resources) is vital for reaching nonqat agricultural growth and Yemen's food security goals. However, measures to reduce qat consumption may meet sharp resistance from the Yemeni people. Therefore policy measures will require a communication campaign to provide comprehensive information on their urgency and necessity. Policymakers must serve as good examples and abstain from consuming qat and should consider additional measures for discouraging qat consumption. The introduction of a consumption tax on qat could kill two birds with one stone. It discourages people from excessive consumption *and* generates additional revenues for the government. These tax revenues should be invested in agriculture and used for the promotion of alternatives to qat production, such as cereals and coffee production, and marketing. If this "qat reduction for agricultural development strategy" is implemented properly, farmers will be more than compensated for the loss of qat revenues, and Yemen's food security will improve.

4. Improve food security risk management

To reduce Yemen's vulnerability to global food price shocks and disasters, appropriate risk management mechanisms are necessary. First, effective risk management will require improvements in the food import regime and of existing mechanisms to protect the most vulnerable from shocks. The oligopolistic structure of the cereal import market, dominated by a small number of importers, increases local prices for cereals even during non-crisis years. Creating more competition among food importers by introducing appropriate laws and regulations will make an important contribution to improving food security. Second, the Government should consider building physical grain reserves for emergency situations, such as the 2007-08 global food crises. However, it is most important to note that physical reserves involve several key challenges that have to be considered very carefully, including potential market distortion, high management costs, and issues of bad governance. Regional grain facilities might be a cost-efficient alternative to protect against future food price shocks, and hedging in international markets can be a smart way to avoid issues related to physical storage options. For any type of price risk management, an effective market price monitoring system will be critical for effective decisionmaking. Third, the Government should use the political opportunities that arise from food price crises and disasters to increase long-term food security and development, by incorporating risk management into the overall economic development planning framework. Government should also recognize the role of social transfers for building economic resilience among vulnerable communities should be recognized, including activities such direct transfers, cash-for-work programs, community asset building through public works, assistance to undertake micro-enterprises and other productive activities and nutrition and health programs. Strong collaboration between agencies such as the Food Security Committee, the National Disaster Management Unit (NDMU) working under the Civil Defense Higher Council, and Yemen's international partners is absolutely essential for success.

5. Implement the water sector strategy decisively

Water sector reform is crucial for achieving Yemen's food security goals and sustaining accelerated development. The successful management of the reduction of overall groundwater use and its redistribution from agriculture to other economic activities and human consumption will play a decisive role for Yemen's future food security. Important pillars towards efficient and sustainable water management are: (1) to strengthen capacity and implementation for integrated water resources management, including capacity development, groundwater monitoring and control, and water quality improvement; (2) to manage environmental impacts, including environmental protection and partnership building with the private sector on effluent and waste water; (3) to develop water resource and water use efficiency by protecting user rights; (4) to deliver efficient, low cost projects on a demand-driven basis by

enhancing the efficiency of project implementation, improving coordination, and decentralizing; (5) to strengthen institutions to allow them to play their role in promoting efficient water use; and (6) to enhance resource sustainability and quality through improved watershed management.

6. Better target public investment and improve service provision, especially in rural areas
In recent years, Yemen has spent more on petroleum subsidies than on education, health, and social transfers combined, and, compared with other MENA countries, it under-spends on infrastructure, agriculture, and health. From a spatial perspective, public spending across governorates does not seem to be aligned with food security levels, indicating low efficiency and targeting. Better aligning public investments with Yemen's development objectives in general and food security strategy in particular across sectors and governorates will require a comprehensive public investment review. It is not only the size and sector targeting of public spending but also the quality of spending that determines food security outcomes. There is a lot of scope for improved spending, which may be at least as important as scaling up spending. Often, physical infrastructure exists but the services provided are not satisfactory. Evaluation and monitoring of service provision quality and investment efficiency in all sectors will be needed for better outcomes. However, additional investment is also required, particularly to upgrade the rural drinking water supply and rural roads. Key services to target include programs related to breastfeeding education, nutrition education, hygiene awareness building, family planning, birth after-care, and child growth monitoring, in addition to existing birth assistance and immunization services.

7. Launch high-level awareness campaigns for family planning, healthy nutrition, and women's empowerment
The Yemeni Government should launch three national campaigns at highest political level, for example, as "presidential campaigns." First, a national family planning program should be implemented, for which Iran's national family planning program can serve as a model in its design and implementation. Such a program should be strongly integrated with primary healthcare and should involve religious leaders. Second, a high-level campaign should be launched to address the lack of nutrition and health-related knowledge among Yemenis. This nutritional education program should cover a wide range of topics, including dietary diversity and micronutrient malnutrition. The third high-level campaign should focus on the acceleration of women's empowerment. The evidence clearly shows that gender inequality goes hand in hand with malnutrition. This points to a clear avenue for reducing malnutrition and speeding up economic development in Yemen: improving women's educational attainment, economic participation, health status, and political empowerment.

If this 7-Point Action plan is implemented, Yemen can reach its food security goals by 2015 and 2020, respectively. Given the NFSSP's comprehensive nature, this Strategy may become the "mother of all strategies" and make an important contribution to Yemen's development policies over the next decade. However, it is important that policymakers now quickly move from stating goals and defining actions to making the required policy reforms and designing the specific investment plans and programs to implement the 7-Point Action Plan. In addition, the implementation of the policies, investments, and programs proposed in this Strategy are likely to be most effective when conducted in a transparent and inclusive manner with effective follow-up, an evidence-based decisionmaking process, and appropriate monitoring and evaluation mechanisms. It will require an appropriate institutional design and significant efforts to strengthen capacities in all ministries involved. Perhaps most importantly, successful implementation will command decisive leadership and the commitment of all key ministries to collaborate toward making the food security vision for Yemen a reality.

APPENDIX A: PRIORITY AREAS AS IDENTIFIED BY THE YEMEN FOOD SECURITY COMMITTEE

A) Macroeconomics, growth, and income

1. Accelerate job creation and pro–food-secure growth in promising sectors
2. Foster growth in rural areas, for example through development of secondary cities
3. Encourage non-oil exports, remittances, and foreign direct investment (FDI)
4. Improve efficiency of social transfers to support the food insecure and review existing subsidies

B) Trade and transportation

5. Improve market access and infrastructure
6. Improve technology in food/fish processing using the private sector
7. Strategize the optimal level of physical storage for cereals
8. Foster trade agreements

C) Agriculture, water, and fisheries

9. Increase productivity in rainfed and irrigated agriculture
10. Limit cultivation of qat and promote alternatives
11. Increase rural and urban access to water
12. Promote sustainable water management
13. Increase productivity in the fishery sector to fully exploit its potential

D) Public health, nutrition, and education

14. Improve nutrition, especially for women and children
15. Improve health services, especially in rural areas
16. Reduce population growth through family planning
17. Achieve education for all, with emphasis on girls' education
18. Foster links among nutrition, health, and education

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IFPRI HEADQUARTERS

2033 K Street, NW
Washington, DC 20006-1002 USA
Tel.: +1-202-862-5600
Fax: +1-202-467-4439
Email: ifpri@cgiar.org

IFPRI ADDIS ABABA

P. O. Box 5689
Addis Ababa, Ethiopia
Tel.: +251 11 6463215
Fax: +251 11 6462927
Email: ifpri-addisababa@cgiar.org

IFPRI NEW DELHI

CG Block, NASC Complex, PUSA
New Delhi 110-012 India
Tel.: 91 11 2584-6565
Fax: 91 11 2584-8008 / 2584-6572
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