

Report No: AUS0000454

# Middle East and North Africa

## Food Security in Yemen and Djibouti

Improving Food Availability and Access for Rural Households in Yemen and Djibouti

September 2018

AGR



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# Improving Food Availability and Access for Rural Households in Yemen

*FOOD SECURITY IN YEMEN AND DJIBOUTI (P166945)*



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Agriculture



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# **Acknowledgements**

*This presentation was prepared by a World Bank team led by Sandra Broka (Senior Agriculture Economist and co-TTL) and Mekbib Haile (Young Professional and co-TTL). The team is thankful for the research and background reports provided by Asa Giertz, Edinaldo Tebaldi, and Oleg Nivievskiyi (Consultant). We also acknowledge contributions and comments from Faiza Hesham Hael Ahmed and Rufiz Vakhid Chirag-Zade as well as from colleagues in other Global Practices, including Elizabeth Mziray (HNP), Sami A Sofan (FCI), and Benjamin Herzberg (FCI).*

*The team also greatly benefited from collaboration with the International Center for Agricultural Research in the Dry Areas (ICARDA), in particular with Chandrashekar Biradar.*

# ***Study Objectives***

**The overarching objective** is to contribute to the improvement of food security and livelihoods in Yemen.

## ***How is this done?***

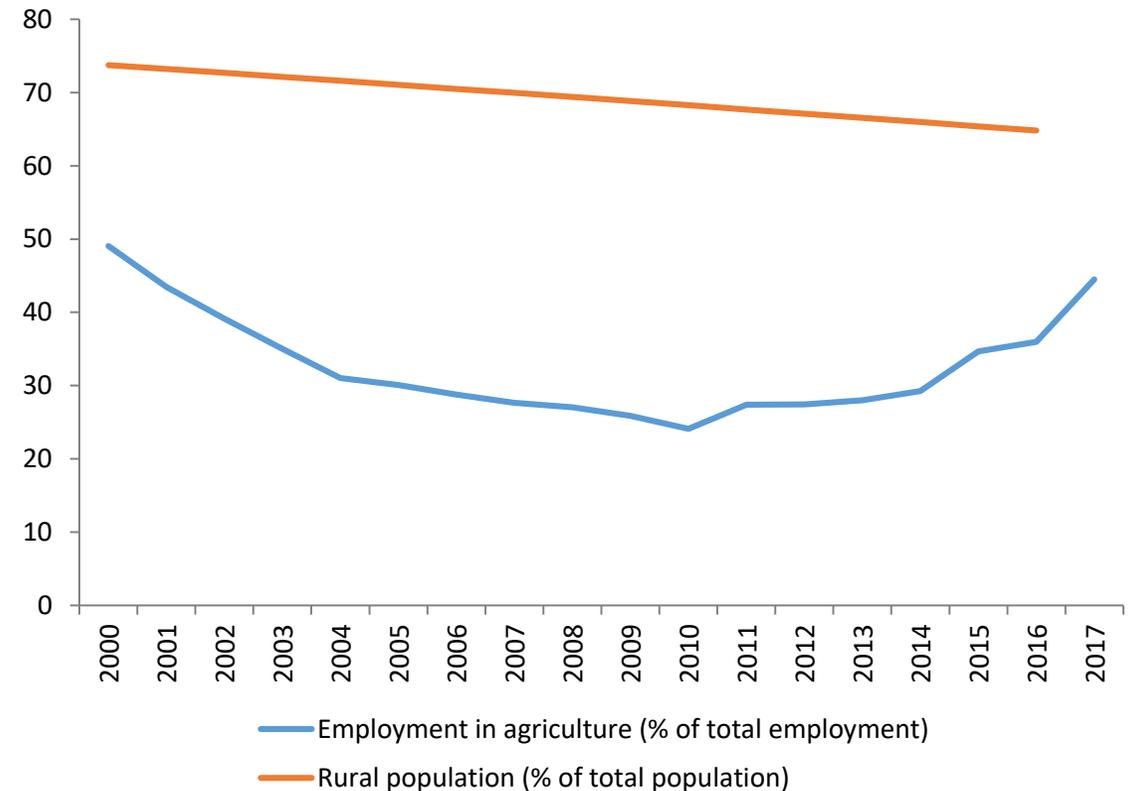
- 1) The study provides recommendations on operationalizing key supply chains (including fish, honey, and coffee) with high cash and/or nutritional values. These value chains are expected to generate better incomes and improve availability of nutritious food to rural households.
- 2) The study assesses availability of suitable water-saving technologies that can both allow production of nutritious food items (such as vegetables) as well create jobs among rural communities, in particular, for women.
- 3) The study develops a model for mapping and early monitoring of crop production that will assist in improving public decision making on food security and the overall agriculture sector development in Yemen.

*\*The work on alternative technologies draws on the World Bank's report, "Frontier Agriculture for Improving Refugee Livelihoods: Unleashing Climate-Smart & Water Saving Agriculture Technologies in MENA (Verner et. al. 2017)."*

# ***Agriculture is a key source of livelihood and can play a key role in enhancing food security in Yemen***

- Agriculture makes up about 17.5% of the Yemen's economy in 2017.
- The sector remains a key source of income to about 45% of Yemen's population (in 2016)
- Yet, agricultural productivity is low
- Farm supporting infrastructure is in a poor shape
  - *Insufficient availability of inputs*
  - *Post-harvest losses*
  - *Inadequate value addition and marketing systems*
  - *Low human resource capacity,*
  - *Poor infrastructure*
- Agri-Food export profile is quite limited, contributing just 11% to the total Yemeni exports

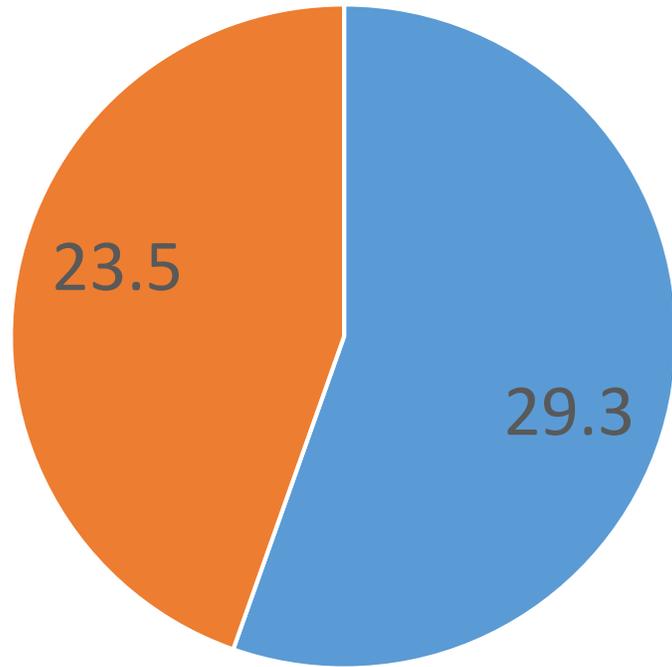
*Agriculture employed about 45% of Yemenis in 2016*



*Source:* World Development Indicators

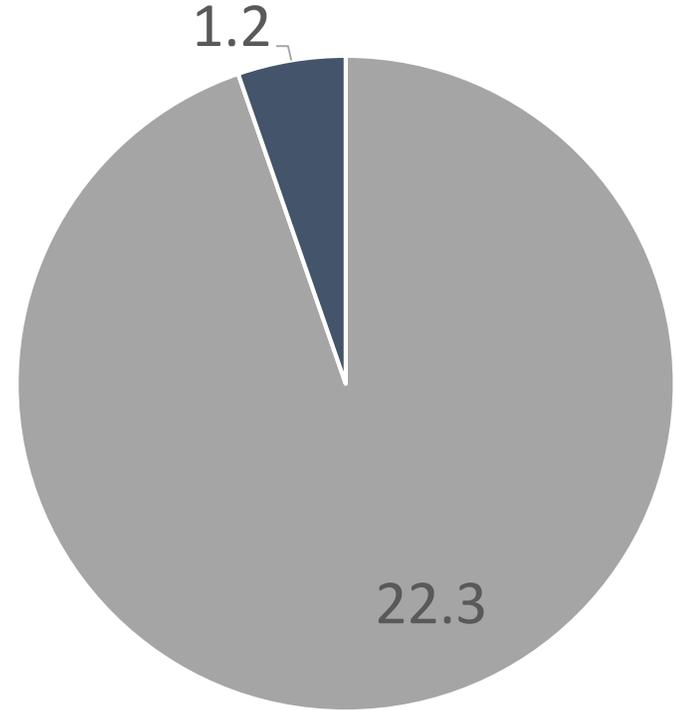
# However, only 5 percent of Yemeni's 24 million hectares of agricultural land is arable

Yemen has vast agricultural land (about 24 million hectares)



■ Non-Agricultural Land Area ■ Agricultural Land

Yet, only 5 percent of Yemen's agricultural land (1.2 million ha) is arable.

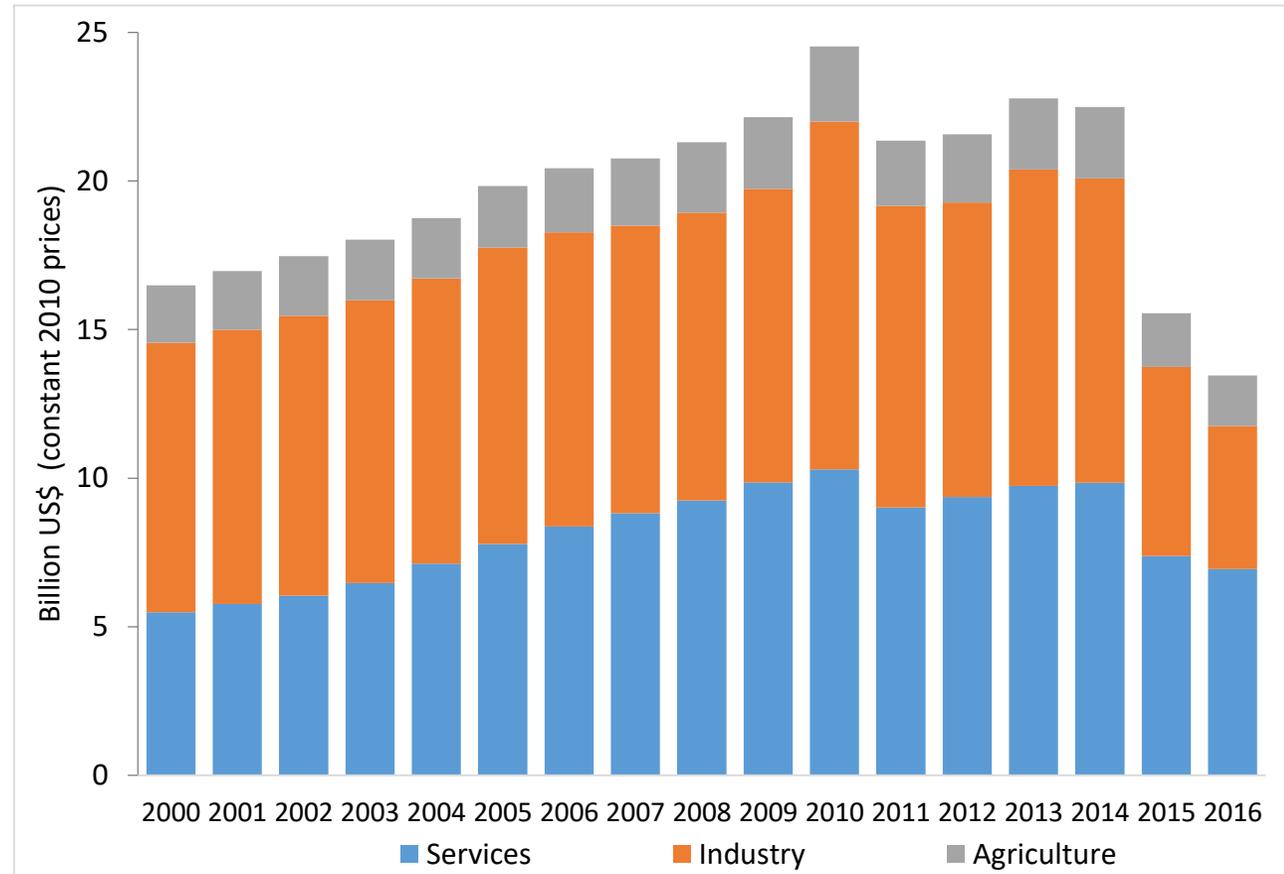


■ Other Agricultural Land ■ Arable Land

# ***The recent conflict has also severely affected Yemen's economy, including the Ag sector***

- The ongoing conflict has pushed millions of Yemenis to the brink of starvation
- The enduring civil conflict has led to a severe economic distress and increased costs of trading. For instance,
  - The country's GDP in 2016 was just 60% of what it was before conflict (in 2014)
  - Similarly, Yemen's real ag GDP in 2016 was worth only a third of its value in 2014
  - The conflicts has also detrimental impact on the country's logistics and physical infrastructure

*Yemen's economy has significantly suffered from the recent conflict; ag GDP has dropped from US\$2.4 billion in 2014 to US\$1.7 in 2016.*



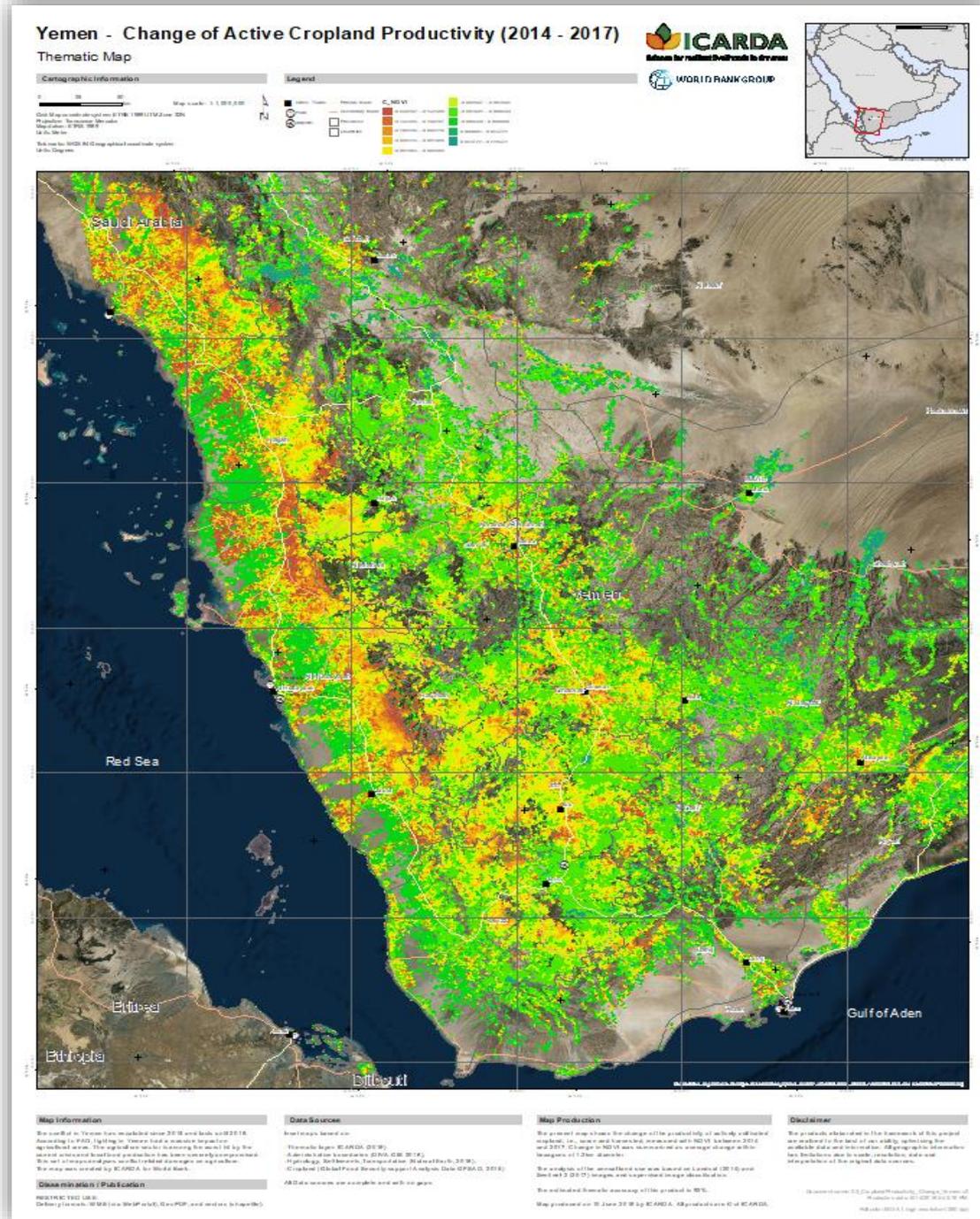
*Source:* World Development Indicators



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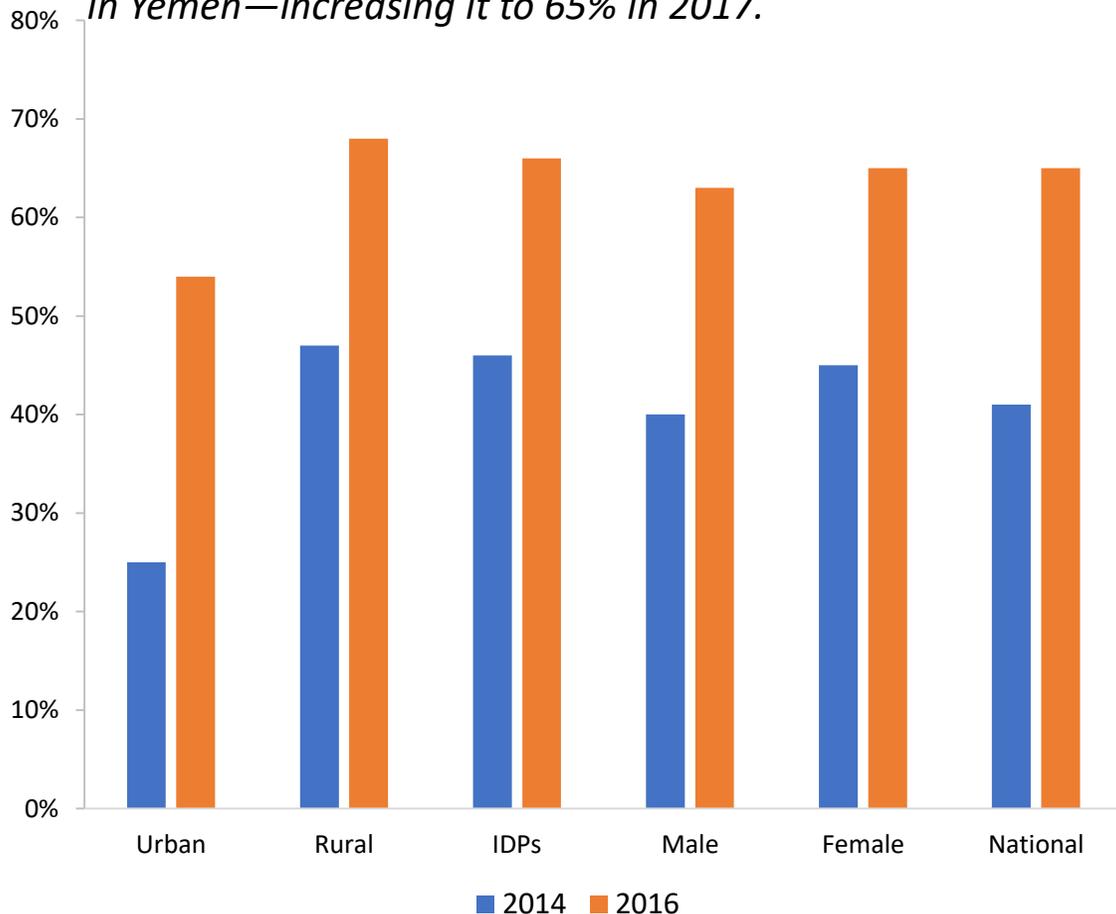
# *The conflict resulted in a productivity decline on two-thirds of the total cropland (between 2014 and 2017)*

- **Agricultural damage assessment shows a decline in productivity of active cropland in Yemen**
  - Satellite analysis revealed that **76%** of the observed area experienced a **decrease** in active cropland productivity (2014 – 2017), as approximated with NDVI
  - **In contrast, only 5%** of the observed area experienced an **increase** in active cropland productivity (2014 – 2017)



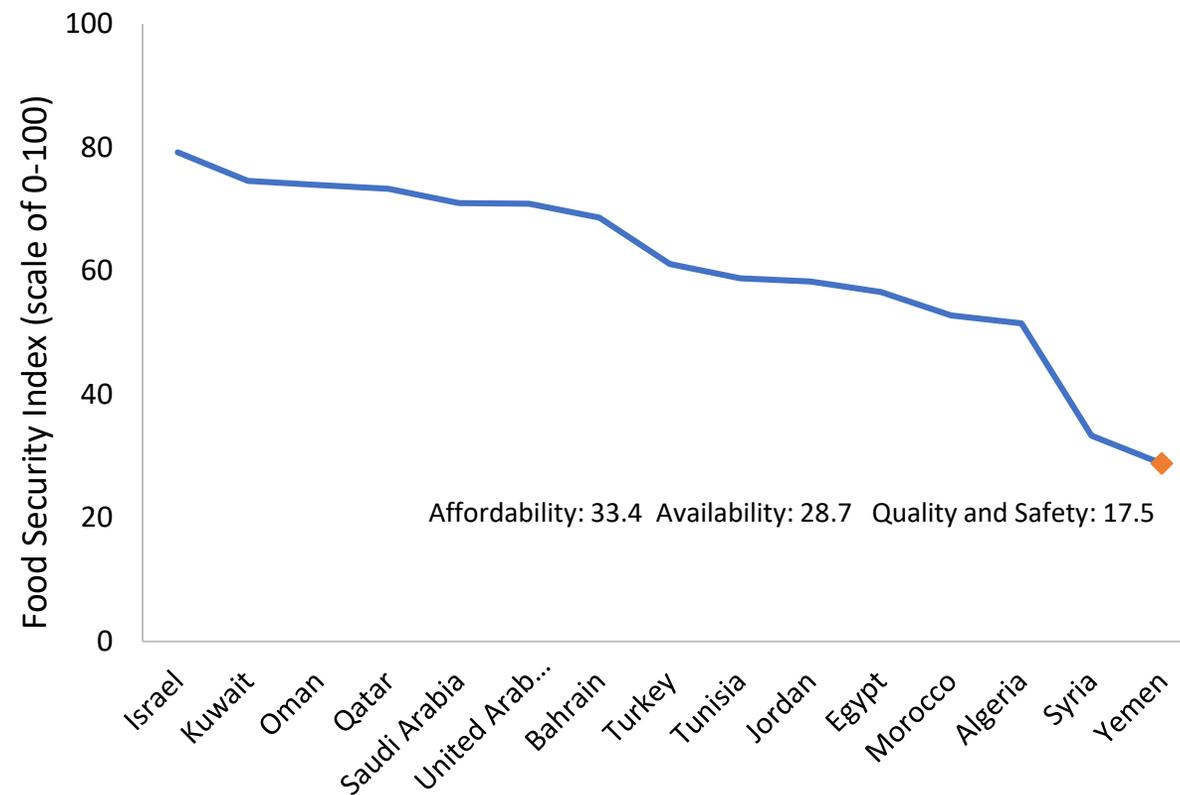
# The conflict resulted in even higher level of food insecurity in the country

The ongoing crisis has worsened the prevalence of food insecurity in Yemen—increasing it to 65% in 2017.



Source: Based on data from WFP 2014 and from the Emergency Food Security and Nutrition Assessment (EFSNA), 2017

Yemen has an overall Food Security Index of just 28.8 (max score = 100), ranking 108 out of 113 countries (in 2017).



Source: The Global Food Security Index

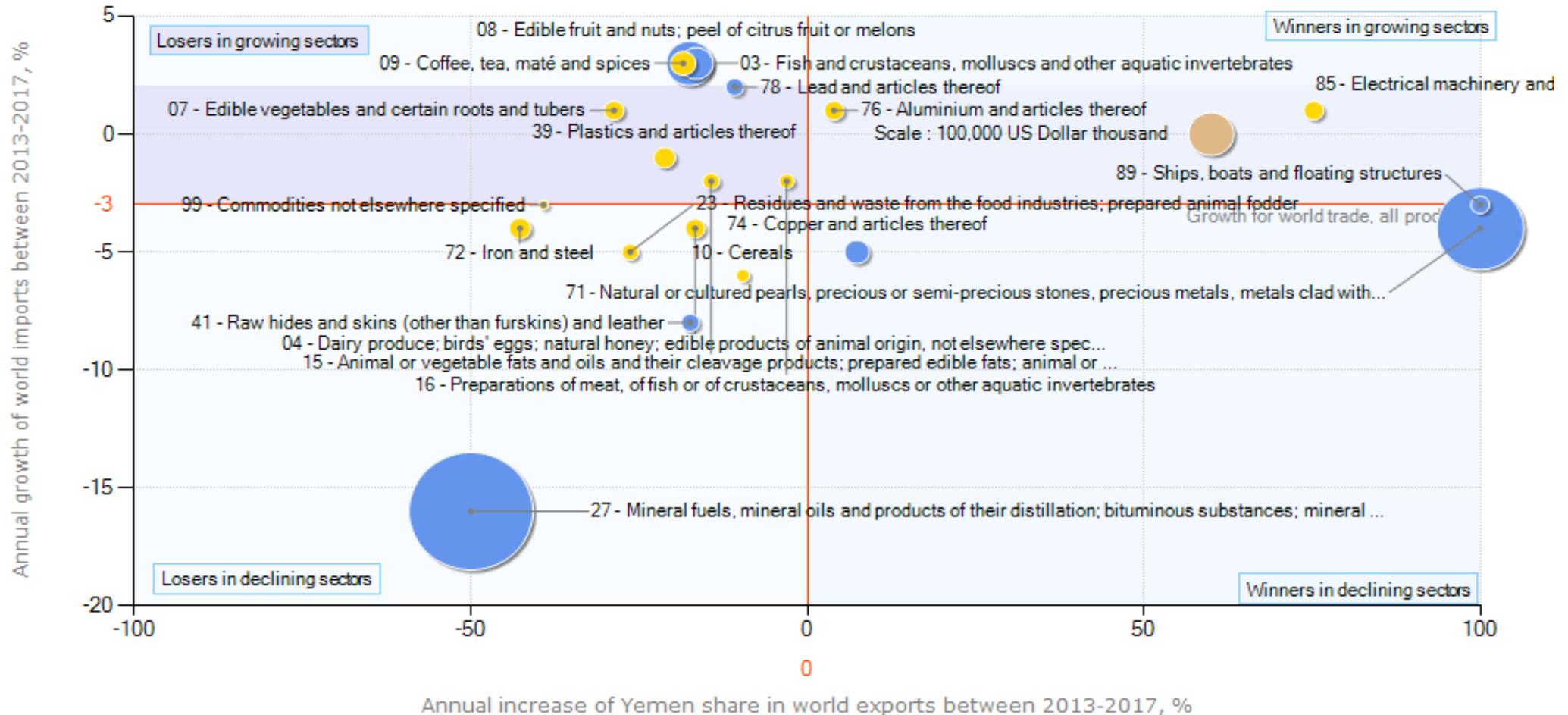
Note: The average overall score for MENA is 60.8

## ***Arable land and water scarcity exacerbate the food and nutrition security challenge in Yemen***

- **High food insecurity and malnutrition:**
  - Above 18 million Yemenis were reported as food insecure in 2018
  - About 42.5% of children under 5 years old were stunted (2013)
  - Above a third of children under five were wasted (i.e., were too thin for their age (2013)).
- **The water deficit:** annual renewable water sources are estimated to 86 cubic meter per person.
- **Limited land for food production:** arable land in Yemen is less than 3% of total land; 38% of irrigated land is used for qat production.



# As a result, Yemen is a net importer of most of the agricultural and food products



● Yemen is a net importer for this product

● Yemen is a net exporter for this product

● Reference bubble

The bubble size is proportional to export value



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# ***The Ag and food sector can still be a crucial sector to improve food security and for job creation, especially after conflict***

## ***The Agri-food sector is important for job creation***

- Agriculture is a labor intensive sector
  - *In the post-conflict situation agriculture could rapidly absorb large amounts of labor and rebuild household economies*
- Agriculture has strong backward and forward linkages, with jobs created at each stage of the value chain
  - *Jobs are created in upstream (input supply & primary production), midstream (handling, processing), and downstream (distribution, marketing)*
- Agriculture creates jobs for vulnerable population, including women and IDPs
  - *Women make up a large proportion of the agricultural work force*

## ***The Agri-food sector is attractive to the private sector***

- The agri-food sector has relatively low barriers to entry for the private sector
- Yemen has a large entrepreneurial potential in its young population that can generate incomes along the food value chain
- Importing food is costly in post conflict situation, creating a positive domestic agricultural supply response



# What is the proposed way forward?

- 1) **Developing key high-value supply chains with large potential to generate income and create jobs**
  - *Fish, coffee, and honey value chains play a key role in food and nutrition security and to generate income.*
  - *These value chains create several jobs along the value chain*
- 2) **Investing in alternative agricultural production technologies to improve food security and to create income opportunities**
  - *Besides the selected value chains, water-saving technologies can overcome the problems of water scarcity while also improving income and food security in Yemen*
- 2) **Developing Earth Observation for agricultural monitoring in Yemen to improve public decision making on food security and the overall agriculture sector development**
  - *This enables accessing timely information in case of adverse weather events and harvest failures*

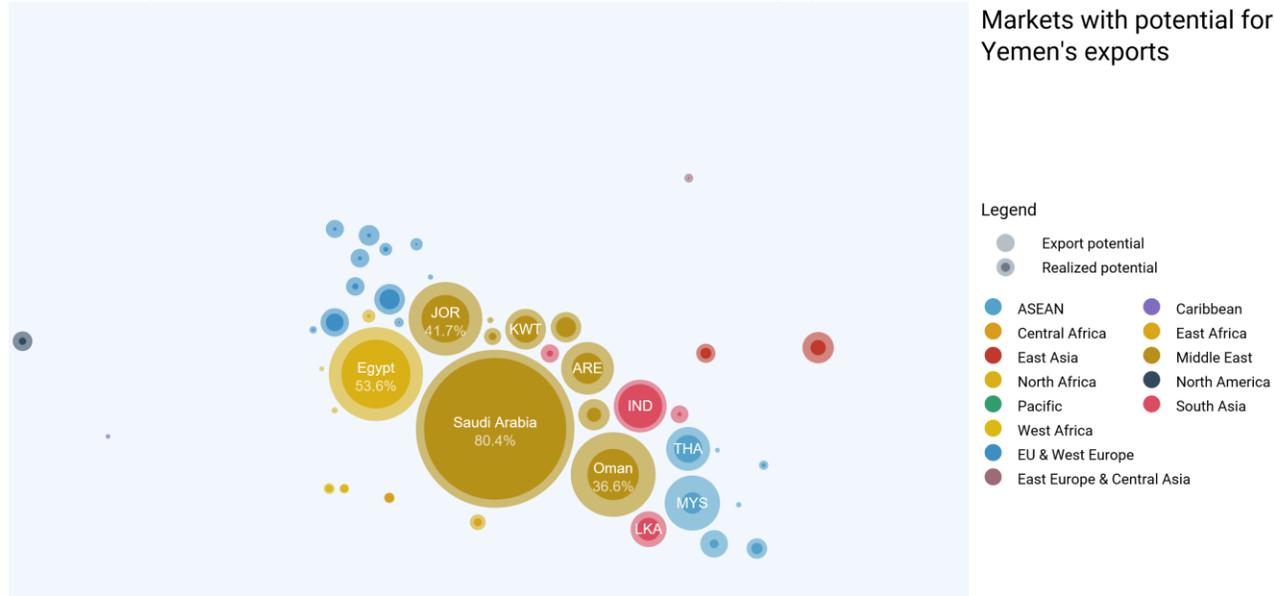
# **1) High-Value Supply Chain Development for Generation of Income and Jobs in Yemen**

# Identification of ag value chains in Yemen

Yemen has some competitive advantages in the following ag products:

- *guavas and mangoes,*
- *fresh and frozen fish\**
- *Coffee\**
- *onions,*
- *watermelons,*
- *strawberries,*
- *Honey\**

Main export markets include Saudi Arabia, Egypt, and Oman



Yemen has quite limited agriculture and food export profile

Code	Product label	Exported value (Million US\$)	Share in total export
<b>YEMEN</b>			
'TOTAL	All products	1676.47	100.0%
'27	Mineral fuels, mineral oils and products of their distillation;	868.19	51.8%
'71	Natural or cultured pearls, precious or semi-precious stones, precious metals	426.98	25.5%
'03	<b>Fish</b> and crustaceans, molluscs and other aquatic invertebrates	110.20	6.6%
'08	Edible fruit and nuts; peel of citrus fruit or melons	53.03	3.2%
'74	Copper and articles thereof	27.04	1.6%
'09	<b>Coffee</b> , tea, maté and spices	24.85	1.5%
'39	Plastics and articles thereof	16.74	1.0%
'72	Iron and steel	16.37	1.0%
'76	Aluminium and articles thereof	15.83	0.9%
'04	Dairy produce; birds' eggs; <b>natural honey</b> ; edible products of animal origin	14.62	0.9%

# ***Jobs creation potential, income generating opportunities, and export potential were the key criteria in selecting value chains***

## ***1) Fish value chain***

- Developing the fish value chain improves food and nutrition security in the country (main objective of the study)
- Yemen has achieved only 60% of its fish and shellfish export potential, implying an untapped export potential of at least US\$ 60 million in 2016.
- It is currently source of livelihood for about million Yemenis and has large potential to generate jobs in post-harvest processing, marketing, and value addition.

## ***2) Honey value chain***

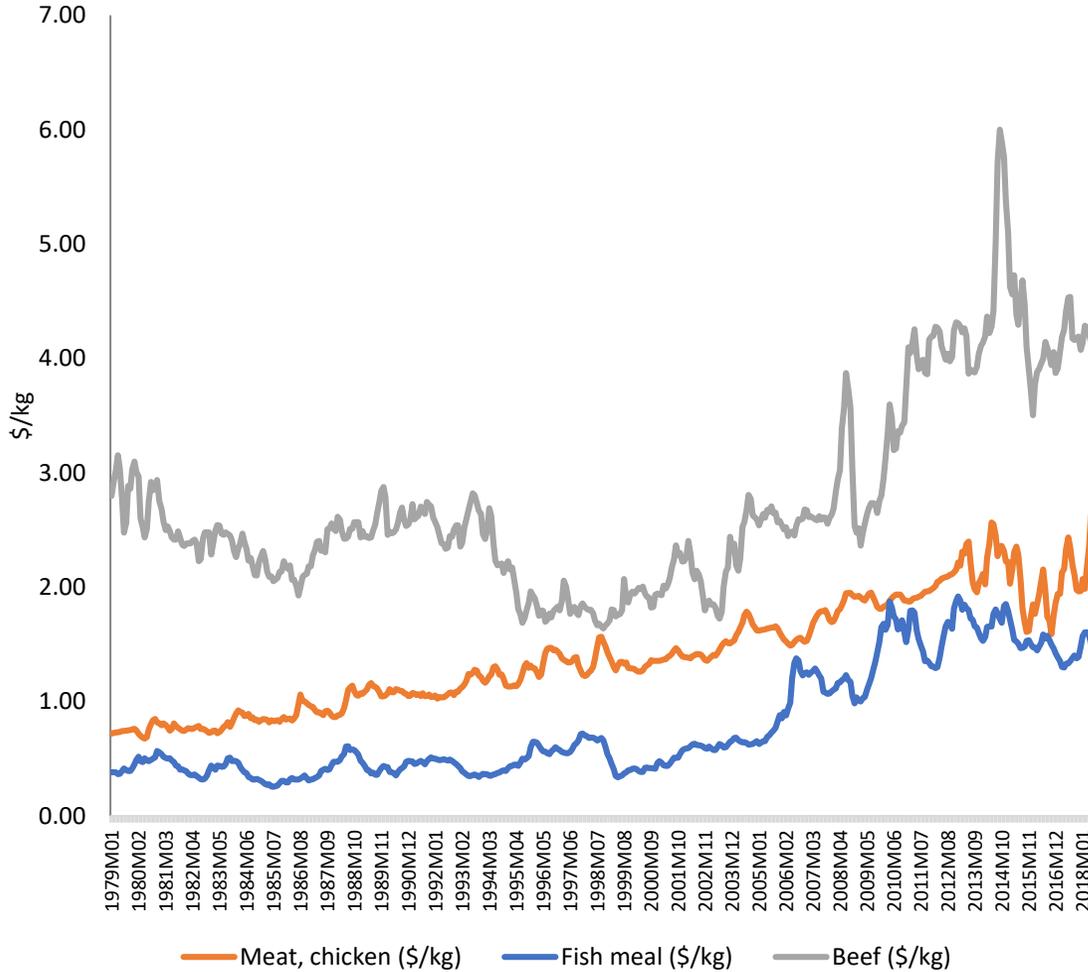
- Yemen has comparative advantage in that it has a reputation of high quality honey
- Yemen's honey can generate its quality premium thereby improving incomes and hence food security
- Yemen's actual honey export is only half of its export potential

## ***3) Coffee value chain***

- Coffee grows in 80 percent of the country's governorates, giving Yemen comparative advantage
- Yemen has comparative advantage in its coffee quality
- Estimates show that Yemen's untapped export potential in coffee is as high as 60% of the total export potential

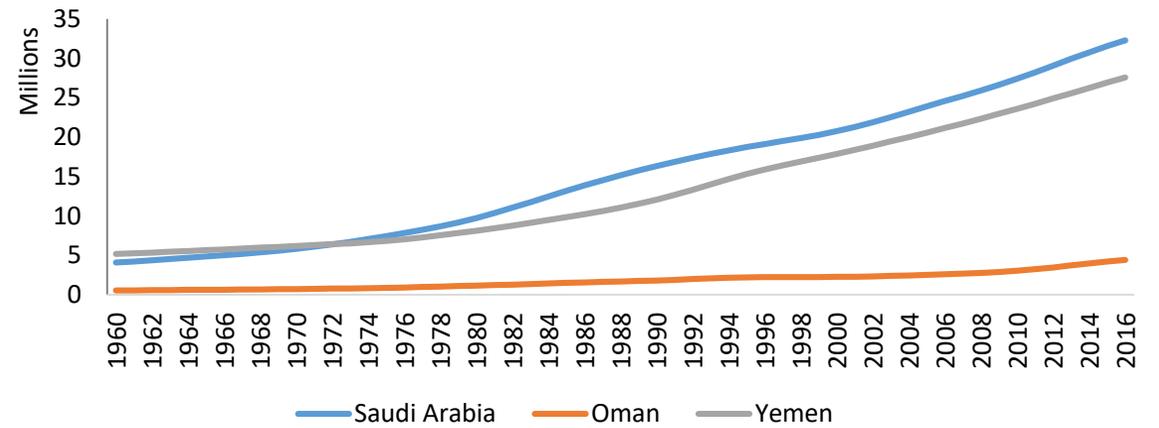
# 1) The Fish Value Chain - demand for fish and international fish prices are on the rise but Yemen's export is declining

International fish prices have shown consistent increase

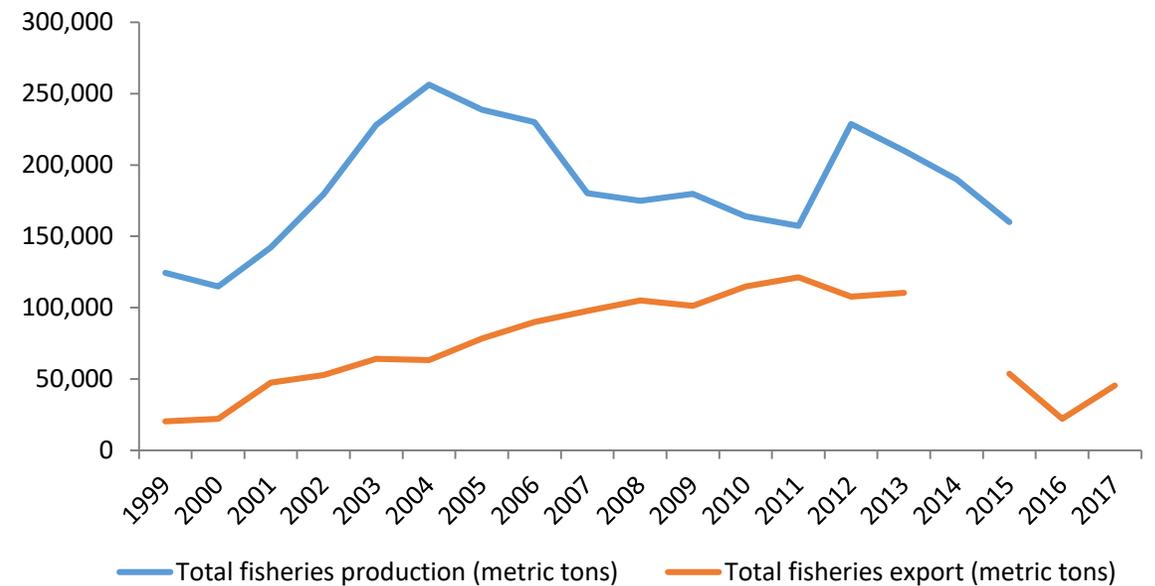


Source: WB Commodity Price Database

Population in Yemen and in its neighboring and main trading countries is rapidly growing



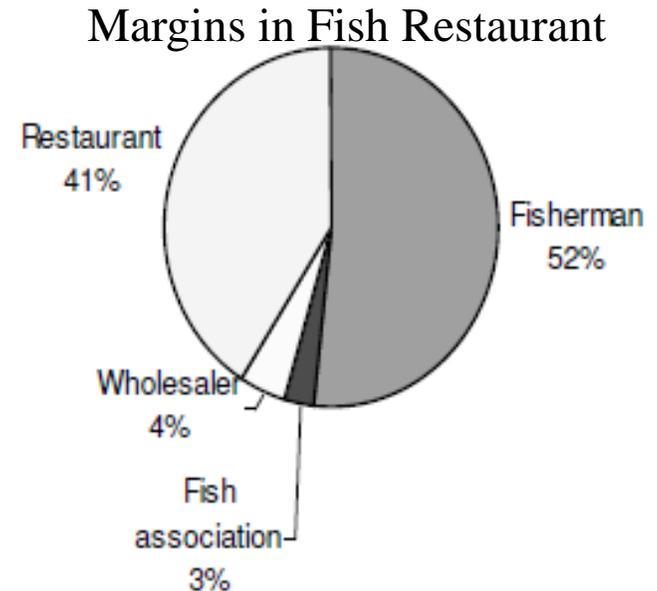
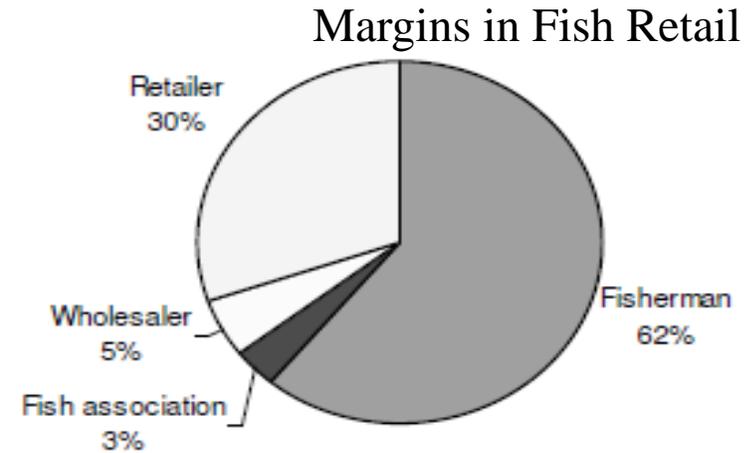
However, Yemen's fish production and export have large variations and are declining recently



Source: WB WDI, UN Comtrade and FAO (2009)

## ***The fishermen and the retailer/restaurant possess a large share of the value addition in the fish value chain***

- In terms of turnover, fishermen associations are the dominant players in the fish value chain.
  - *They perform fish marketing and provide fishery facilities on the landing side (e.g. ice, auction hall, cold storage, fuel station, fishing tools shop, engine spare parts, etc)*
- However, the largest share of the total value added goes to the fishermen and the retailer/restaurant



# ***Building capacity of fishermen association can enhance efficiency of fish value chain, which is fragmented and characterized by small-scale fish supply***

## ***Challenges in the fish value chain***

- The fish value chain is fragmented and characterized by small-scale fish supply
- Largest source of livelihoods for coastal communities
  - About a total of about 700,000 people rely in fishery for their livelihoods
- Effectively unregulated fishing has led to overfishing in the country
- Fish export is growing and this has resulted in shortages for domestic consumption

## ***Proposed solutions/interventions***

- Fishermen associations can be key starting point for intervention in the value chain. In particular, fishermen associations could be assisted with:
  - *developing market information system*
  - *developing capacities of associations to follow and react on domestic and export markets developments and demands; assisting in opening new premium export markets*
- Establishing and enforcing an appropriate fishery governance system that would reduce overfishing and ensure a sustainable resource base for the sector;
- Supporting value chain financing mechanism to improve productivity and fish supply
- Establishing and enforcing private standards, that would reflect domestic and export market preferences



# ***Investing in value chain supporting infrastructure and financing can improve fishery export potential***

## ***Challenges in the fish value chain***

- Proper Market Information System lacks in the value chain
  - *Lack of information on supply and demand parameters (such as on quantity, quality, packaging).*
- Lack of pre-financing among the chain actors
- Limited formal bank financing
  - *Bank financing is limited to fishermen associations and for export related businesses*
- quality and food safety infrastructure is virtually absent; Traceability is not of any concern to the chain actors.
  - *Exporters fail to comply with the food safety and quality standards of developed countries;*
- The typical fish value chain is short and has poor infrastructure

## ***Proposed solutions/interventions***

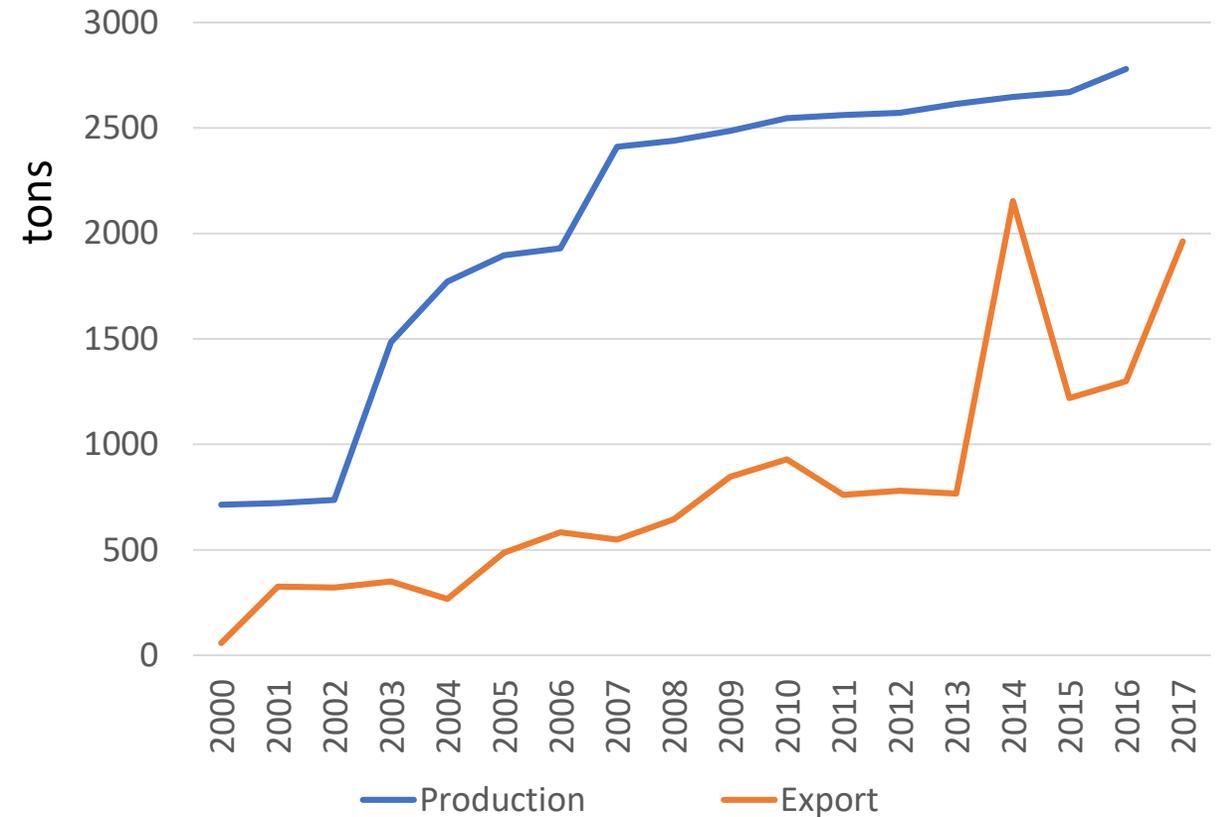
- Investing in digital (ICT) platforms to increase Market Information System
- Support and develop value chain financing mechanisms
- Government can play a key role in supporting development of logistics and cold warehousing nodes
- Private sector and digital developers can also play critical role in improving logistics and access through digital transportation solutions
- Establishing a food safety system in the sector



## 2) The Honey Value Chain – honey production and export has been increasing

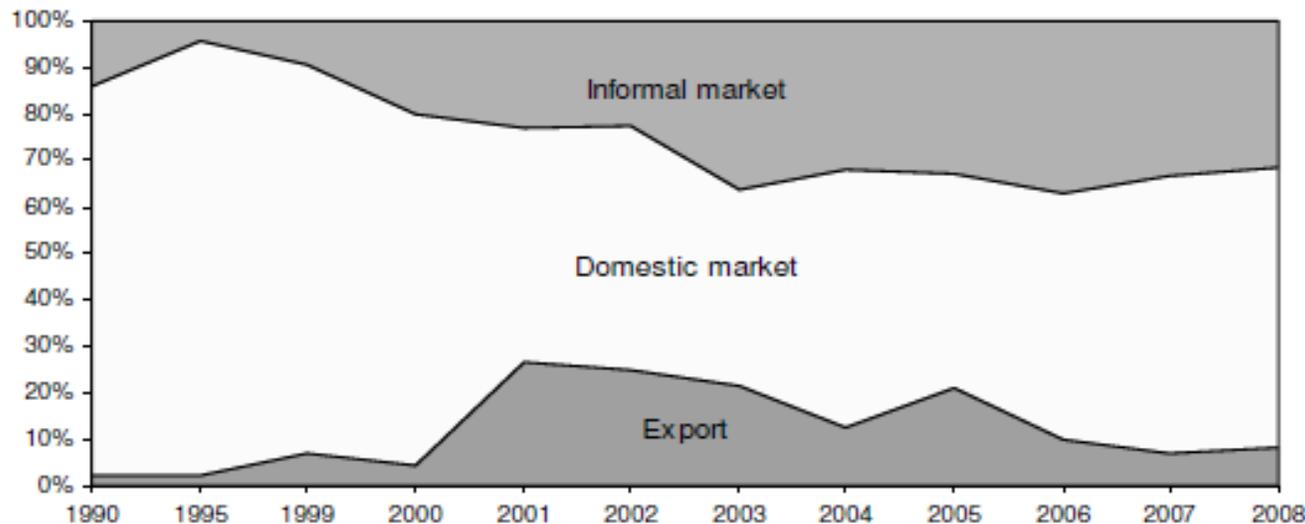
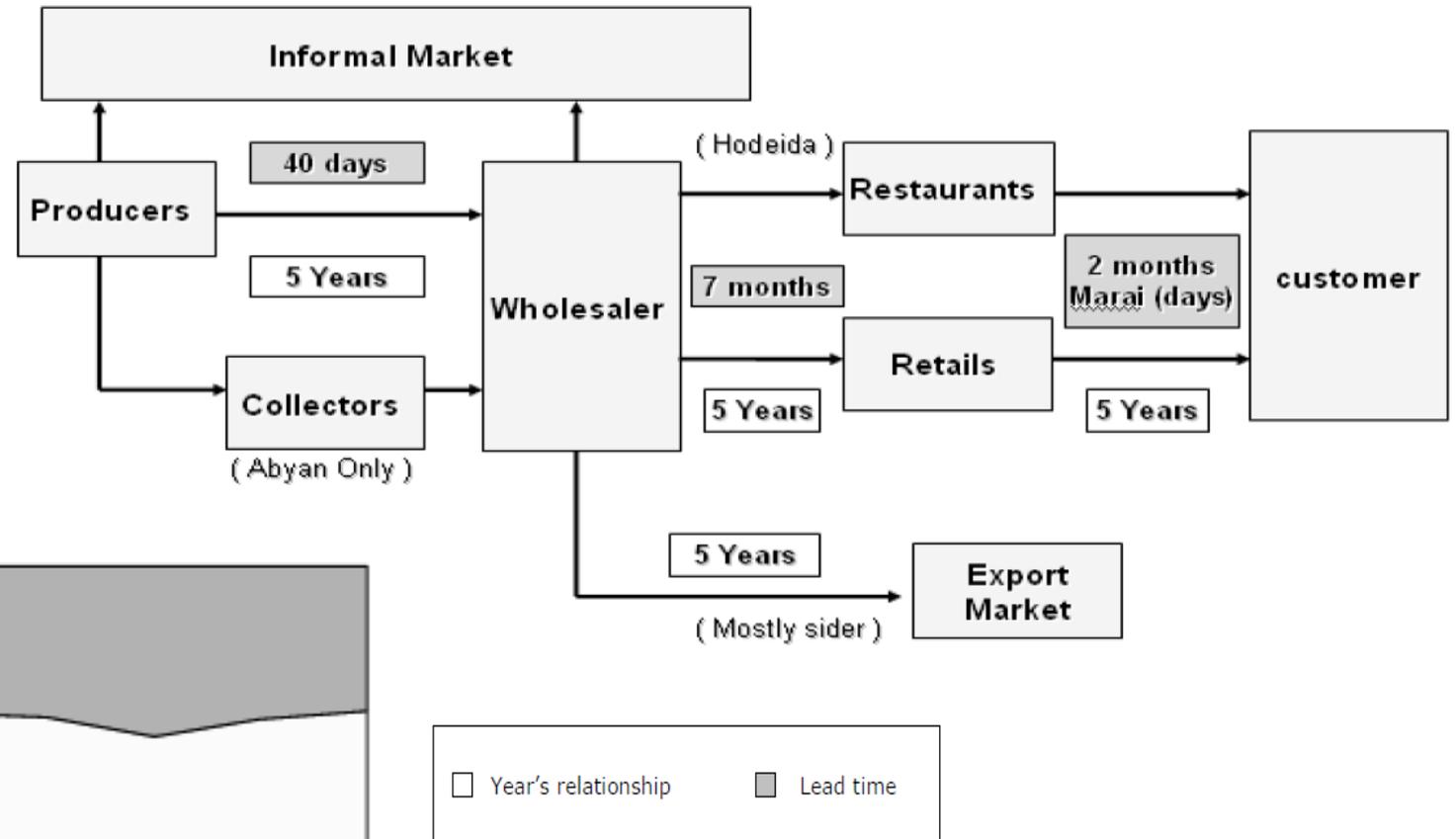
- **Yemen has a long history and a reputation for high-quality honey**
  - Yemen is known for Sidr honey, one of the most valuable honey variety in the world
- The sector is expanding in Yemen, albeit at a lower space over the last decade

*Honey production and exports have been increasing*



# The honey value chain is short and characterized by informality

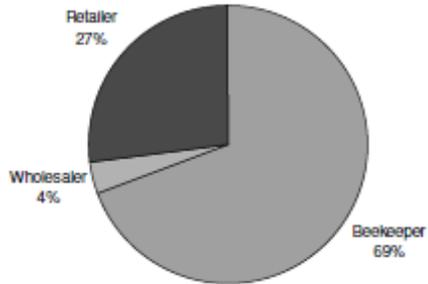
- **Short chain:** producers typically deal with wholesalers directly
- **Specialized value chain:** beekeepers derive their incomes mainly from honey, while retailers wholesalers are fully specialized in honey trading
- **Limited export market**
- **Large informal market**



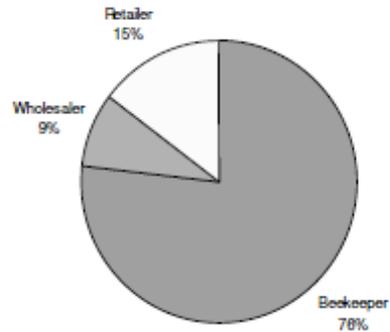
# ***Beekeepers are the dominant players in the honey value chain***

- Beekeepers take 70-80% of the total honey value in both domestic and export markets
- The share of retailers ranges between 15 and 33% of the total value in the domestic honey market

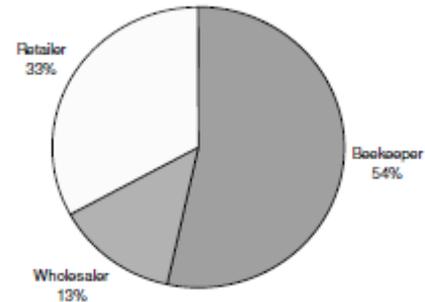
Value share honey average domestic market



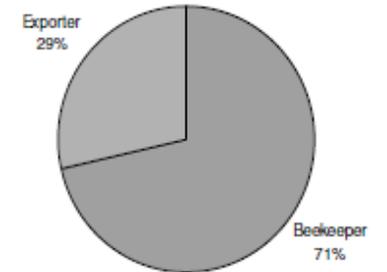
Value share Maryland honey domestic



Value shares Summer honey domestic market



Value shares Seder honey export



# ***The honey value chain faces several constraints that seek attention***

- 1) Non-compliance to the honey grading system in the country
  - Declining consumer confidence in honey quality is eroding producers premiums and incomes.
  - Honey value chain actors report about cheating via adulteration of good quality honey with lower quality varieties
  - There is also poor packaging and problems with obtaining necessary export certificates
- 2) Formal bank financing is limited to wholesalers, while value chain financing is available especially between beekeepers and traders.
- 3) Lack of cooperation between beekeepers
- 4) Underdeveloped or nonexistent market information system that would link smallholders to markets and improve their awareness of quality, demand, and prices
- 5) Poor processing and packaging
- 6) Lack of research supportive system and extension services



## ***The is a large scope for intervention in the honey value chain to overcome prevailing value chain challenges***

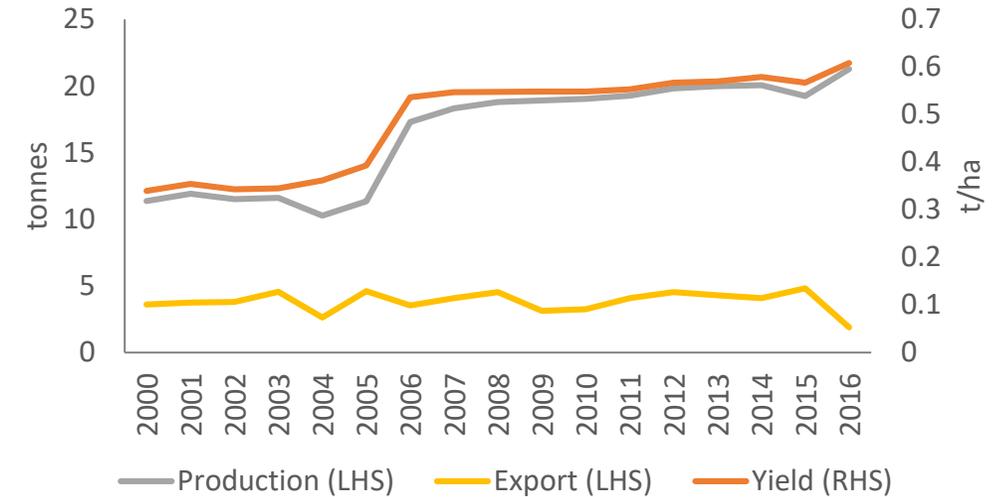
- Improving enforcement of the honey grading system
  - Support value-chain actors to ensure the quality of honey, thereby rebuilding consumers' trust and restoring a premium segment for Yemen's honey.
  - This could be achieved via supporting quality certification system along the value chain, ensuring traceability, active promotion (including by the government) of the system domestically and abroad
- Promoting value chain financing of partnerships between wholesalers and beekeepers or beekeeper groups.
  - Additionally, promoting various instruments of microfinance, including mobile banking in rural areas.
- Supporting development and implementation of a market information system (using mobile phones, for example) to link small beekeepers to the markets.
- Supporting the private sector in capacity building and technological transfers (via extension and R&D support).



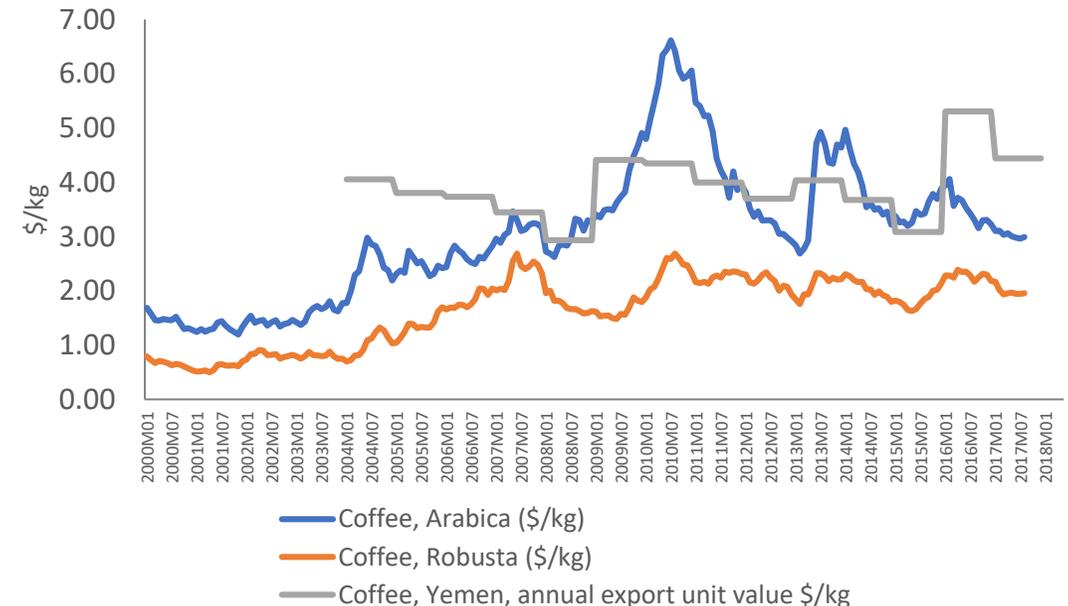
### 3) The Coffee Value Chain – Coffee production and export is dominated by smallholders

- Coffee is an important source of livelihood for Yemen's economy and particularly to the rural population
  - About a quarter of total coffee output is exported
- Yemen's coffee export price is on average higher than the international average price, reflecting its quality premium.
- Due to low productivity; however, this has not translated into high incomes

Increasing coffee production but export has been stable

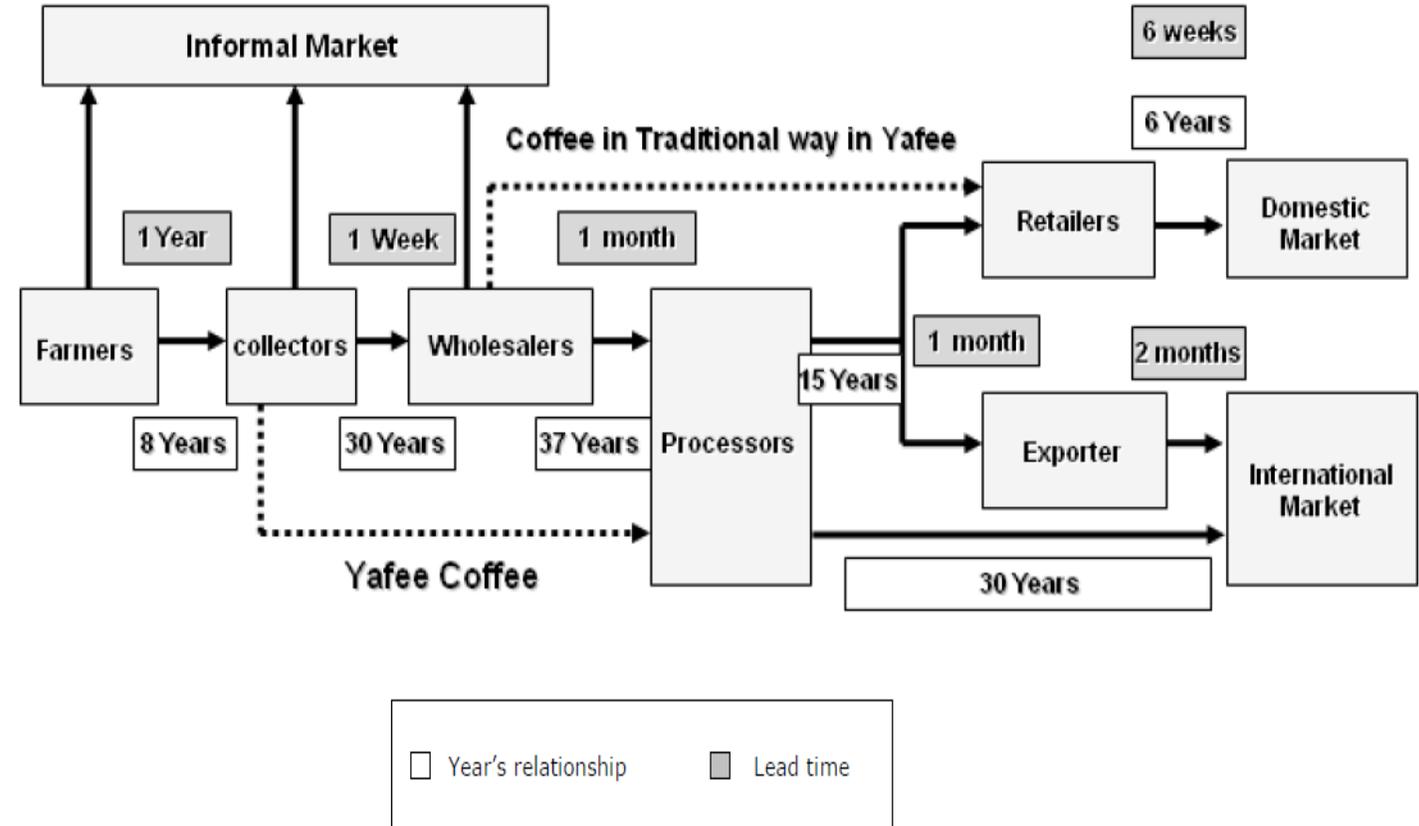


Yemen's coffee enjoy higher prices



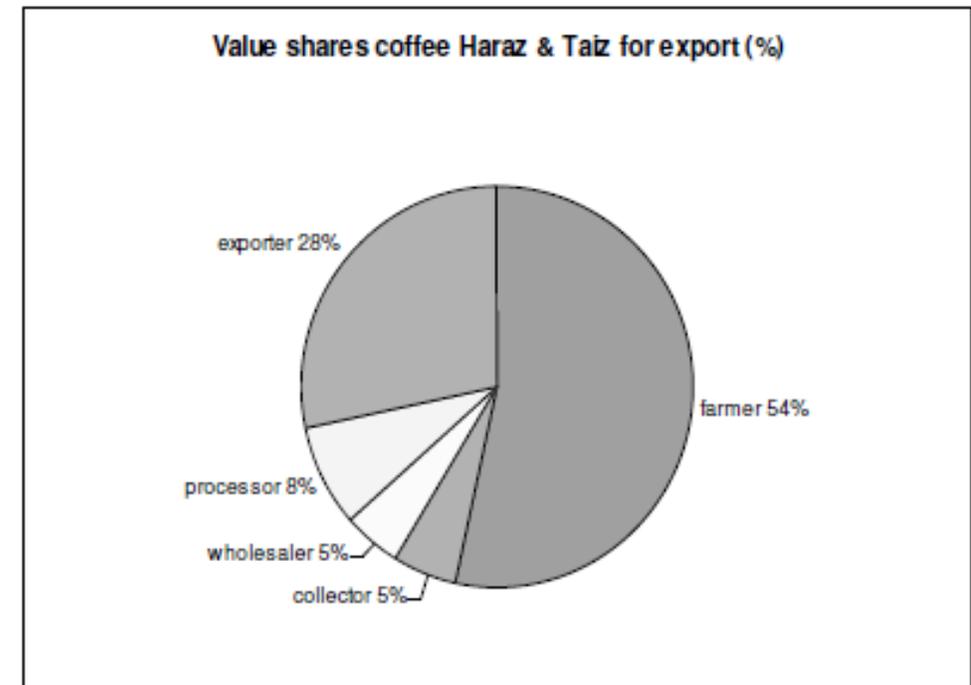
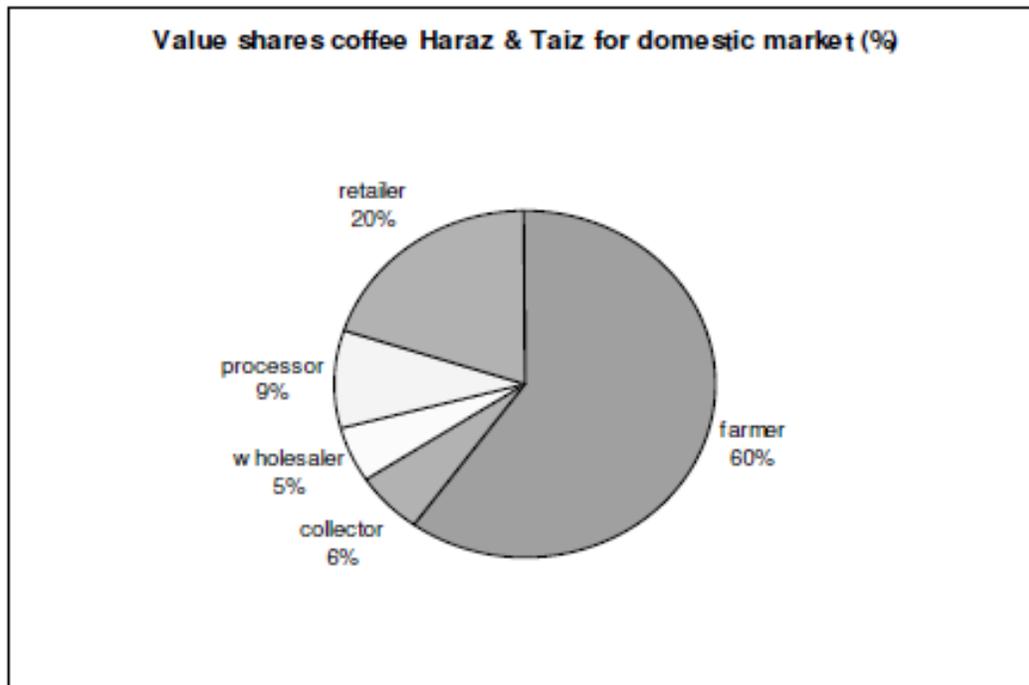
# The coffee value chain lacks sophistication and quality processing

- Small-holder coffee farmers (up to 1 ha) dominate the chain in terms of the value share
  - About 50-60% (in some cases even 80% for export markets) of the final value is retained at a farm level
  - This is mainly due to little value addition along the coffee value chain
- Farmers face several challenges in coffee production and marketing



## ***Farmers obtain above half of the coffee value added in both domestic and export coffee market***

- Although farmers produce small quantities and sell individually, they receive 54% to 60% of the total product value
- Midstream chain actors (collectors, wholesalers and processors) have low value shares, ranging from 5 to 10 percent in both the domestic and export markets
- The midstream value chain actors work at low operating margins



# ***The coffee value chain faces several constraints***

- **Low productivity at the farm level**

- Coffee production suffers from shortage of water, pests and diseases, costs of fertilizers and wages
- There is water and land competition from qat
- Farmers are not organized and not well integrated to markets
- Poor production technologies and knowledge on quality standards

- **The value chain supporting infrastructure is largely undeveloped**

- There is no appropriate cross-cutting quality grading system, certification and traceability along the value chain that ensures farmers to benefit from quality premium of Yemen's unique coffee variety
- Lack of market information system that would link farmers to the market/consumer preferences, price information and quality requirements;
- Lack of cooperation among the small farmers to benefit on a scale from input purchases and water management;
- Malfunctioning research and extension system
- Formal bank lending is absent for farmers, and has very limited coverage of processors and exporters

# *The coffee value chain can benefit from the following interventions*

- Implementing and ensuring effective and consistent systems for quality grading/certification and traceability
- Supporting development and implementation of a market information system (using digital platforms, for example) to link small holders to other value-chain participants and to the markets, to new technologies and other types of necessary information
- Promoting value chain financing of partnerships between the aggregators/processors and smallholders or coffee farmer groups
- Developing alternative microfinancing instruments (such as mobile money payments) seem highly relevant in this case (digital solutions to microfinance should be more explored)
  - New mobile banking regulations were issued by the central bank of Yemen (CBY) in 2014, providing the enabling environment for banks and mobile network operators to work together to improve financial inclusion
- Strengthening plant health protection in the country (against pests and diseases)
- Facilitating research and extension infrastructure in the country to ease farmer's access to new technologies and knowledge transfer



# ***Promoting gender responsiveness in high value food value chains is critical***

## **The way forward for better participation of women and equitable benefits from the fish value chain includes:**

- Strengthen women's role in fish cooperative unions, including through enhancing the formation of fish women associations
- Raise awareness on gender-based occupational segregation, thereby changing attitudes and social norms
- Ensure wage equality between the genders for work of similar value
- Addressing gender norms to improve limiting women's mobility and women's roles in value chains
- Train women in technical and leadership/supervisory skills
- Increasing women access to credit & business development skills
- Improve women control over inputs, knowledge, social networks, and key assets
- Enhancing women governance and power through the economic empowerment of women in fish value chains.

## **The way forward for better participation of women and equitable benefits from the honey value chain includes:**

- Introduce modern beekeeping technology that addresses the cultural constraints that hindered women from participating in enterprises dominated by men
- Assess the challenges hindering women participation in beekeeping value chain
- Build skills and knowledge to eliminate the limitations to effective management and realization of the technologies potential among women
- Conduct technical training to increased productivity for beekeeping enterprises and to boost local honey production of rural women
- Formulation of policies that allow development agencies to target the rural poor, especially the rural poor women, will be vital in improving food security.



## 2) Alternative agricultural production technologies to improve food security and to create income opportunities

- *Besides the above value chains – fish, coffee, and honey– fruits and vegetables are critical for nutrition security in Yemen.*
- *Alternative agricultural production technologies, such as hydroponics, can therefore have large potential in improve food and nutrition security as well as creating income opportunities*



# Yemen has potential to benefit from adoption of frontier agricultural technologies

- Hydroponics/aquaponics can produce 7/8 out of 10 food groups essential for adequate dietary diversity and nutrition
- In the right markets, these technologies are viable for commercial production and can provide employment without necessitating advanced skills
- These technologies are water and land efficient
  - For instance, hydroponics can use as little as 10 percent of water use of traditional agriculture
  - They do not depend on land conditions and can be placed on rooftops or in basements
- Some technologies are mobile and can be moved if necessary, making them suitable investments for non-permanent communities.

*Several nutritious food crops can be produced with alternative hydroponic systems*

Food Group	Foods that can be produced in hydroponics
White roots and tubers	White potatoes, yams, and beets
Vitamin A rich vegetables and tubers	Sweet potatoes, vitamin A rich yams, beets, carrots, bell peppers
Dark green leafy vegetables	Leafy greens, kale, swiss chard, arugula, micro-greens
Other vegetables	Radishes, celery, cucumbers, peppers, wheatgrass, onions, leeks, parsnips, squash, corn, bok choy, watercress, chives, broccoli, cauliflower, cabbage, radishes,
Other Fruit (non-vitamin A rich)	Tomatoes, watermelon, cantaloupe, strawberries, blackberries, raspberries, blueberries, grapes, dwarf citrus trees (lemons, limes, oranges), dwarf pomegranate tree, bananas
Legumes, nuts, and seeds	Beans, peas
Herbs / spices and condiments	Chives, oregano, mint, basil, sage, rosemary
Grains	Rice, barley
Fish and seafood	Pacu, prawns, carp, catfish, barramundi, goldfish, salmon, trout, mussels, crayfish, murray cod, koi, white bass, sardines, carp, sunfish, shrimp, silver perch, blue gill, tilapia
Sweets	Honey



# *What are Yemen's advantages to benefit from investments in frontier technologies?*

- Yemen has excellent conditions for using solar power
- The agriculture sector is mainstay of the economy.
  - About 73% of Yemenis relying on agriculture and fisheries for food and incomes, and 29% of the labor force being employed in agriculture.
- High costs of inputs for conventional production, such as diesel for irrigation and the real cost of water makes resource-efficient technologies more competitive in Yemen.
- Yemen has some experience with hydroponics through projects with 'Agricultural Research and Extension Authority (AREA)



# Which technology options are more suitable for Yemen?

Technology	Food	Water Use <sup>+</sup>	Energy Use	Technological Complexity	Maintenance	Start-Up Cost	Financially self-sustaining	Mobility	Suitability for Yemen
<b>Bio-intensive farming methods</b>	Crops	Medium	None	Simple	Low-medium	Low	Medium-High	Low-Medium	*****
<b>Wick Systems</b>	Crops	Low	None	Simple	High	Low	High	Low-High	****
<b>Deep Water Culture</b>	Crops	Low	Medium	Medium	Low	Medium-High	Medium	Low	***
<b>Ebb &amp; Flow</b>	Crop	Low	Low-High	Complex	High	Medium-High	Low	Low	*
<b>Drip Method</b>	Crop	Low	High	Complex	Low	Med-High	Low	Low	*
<b>Nutrient Film Technique</b>	Crops	Low	High	Complex	Med-High	High	Medium	Low	*
<b>Aquaponics</b>	Crops & Fish	Low	Low-High <sup>**</sup>	Complex	High	Medium-High	Low	Low	**
<b>Aeroponics</b>	Crops	Low	High <sup>***</sup>	Complex	High	High	High	Low	*

Source: Adapted from Verner et. al., 2017

<sup>+</sup> Open systems recirculate water closed systems do not recirculate water

<sup>\*\*</sup>Based on international farm-budgets, not specific for Yemen.

<sup>\*\*\*</sup>Depending on pump size and heating requirements. Aquaponics require a constant electrical source or backup energy (battery, generator).

# ***Access to finance, inputs, and skills will be necessary to unleash new technologies in Yemen***

## ***Different approaches will be needed to target entrepreneurs vs. small-scale subsistence producers***

- ***Finance for start-up costs:*** equipment, solar panels, simple building-structures.
- ***Inputs and equipment:*** mobilize input providers for easily accessible liquid mineral fertilizers or salt blends for hydroponics; filters and spare-parts with domestic distributors for more advanced technologies.
- ***Skills:*** Specially trained extension staff or formal collaboration with NGOs or commercial off-takers to provide skills and support services. Options for advisory services via mobile phones, e.g. cost-free phone-services, or building on already established mobile MIS services.
- ***Alternative service providers:*** Skills for technologies targeting household subsistence farming that are mainly for increasing dietary diversity may be disseminated via NGO's (e.g. Care Int.) or women's health centers, where traditional extension services are not present.



## ***Investing in frontier technologies is a commercially viable option in Yemen***

- Investing in the more traditional and easier systems, such as supporting commercially based farms using the deep-water culture hydroponic or household level investments in wick systems, will have large potential to reduce food insecurity in the short run.
- Our estimates show that more sophisticated and commercially based systems are also economically viable and can have large food and nutrition security implications.
- Initial public support to these systems will be critical.
- *Yet, detailed business plans are recommended for private and public investments in frontier ag technologies*

**Revenue & Costs estimates of operating a typical deep-water culture farm hydroponic greenhouse system using a 285 sq meter greenhouse in Yemen yields an annual financial return of above US\$1000**

Revenue		
	% Space Utilized	90%
	Crop Harvest per Turn	6,220
	Packout	95%
	Marketable Heads per Harvest	5,909
	No. Turns per Year	8
	Marketable Heads per Year	42,272
	Unit Price	\$0.40
<b>Total Revenue/Year</b>		18,909
Costs		
	Total Production Supplies cost	3,675
	Total Production Labor	1,874
	Total Packaging Costs	3,675
	Total Utilities and Water Costs	6,866
<b>Total variable costs</b>		16,090
<b>Gross Return</b>	US\$/year	2,819
	% of total revenue	15%
	Greenhouse Cost	3,500
	NFT system + support + fertilizer mixing pump (156% of Greenhouse cost)	5,460
<b>Fixed Cost</b>	Total greenhouse structure costs	8,960
	Total Annual Greenhouse Structure Costs (Annual costs of owning the greenhouse at 20% depreciation rate)	1,792
Net return		
	US\$/year	1,027
	% of total revenue	5%

### 3) Earth Observation for agricultural monitoring: satellite based agricultural monitoring tool for Yemen

- *Agricultural monitoring and early warning systems can inform mid-and downstream value chain actors about production/supply possibilities*
- *It can also provide estimates for timely dynamic and needs assessments of production failures due to conflicts or adverse weather events*



# ***Why is Satellite based agricultural monitoring tool important for Yemen?***

## ***The problem: Information for decision making in agriculture***

- Reoccurring precipitation shortage, the incidence of droughts, or desert locust outbreaks have frequently affected agricultural production in the country.
- The recent conflict poses an additional threat to agricultural production in the country.
- Policy and decision makers in Yemen need timely and reliable spatial information about the status and changes of the agricultural system to be able to take appropriate action.
- Field surveys can become prohibitively expensive (if not impossible) and existing statistics might be outdated.
- It is thus of utmost importance to build and/or strengthen agricultural information systems and to consequently enhance agricultural production and productivity.

## ***Satellite agricultural monitoring***

- A monitoring tool based on satellite remote sensing and geographical information systems (GIS) would answer to most various information demands, including:
  - Detecting and quantifying spatial extent of cultivated cropland and assessing crop productivity (crop yield), and
  - Identifying potential crop failure within the growing season.
- This tool can support monitoring agricultural production in a timely manner
- It provides spatial information on cropland area and crop yield in digital maps and interactive database for several applications

## ***What is the added value of such agricultural monitoring tool to traditional tools?***

- **Timeliness:** It delivers up-to-date, accurate maps that contain information about land use dynamics
- **Comprehensiveness and objectivity:** Each field can be monitored with objective spatial data, without limitations (view from space, regardless of access on ground)
- **Accuracy:** It is a scientifically sound and accurate methodology, which can produce reliable and accurate maps for an accurate monitoring
- **Cost-effectiveness:** Landsat and Sentinel satellite images are free: considerable cost savings compared to comprehensive and regular in-situ ground control by traditional survey teams
- **Flexibility and continuity:** The tool can be extended to other fields of application or other spatial planning contexts (for instance, war damage mapping, pest (locust) hazard monitoring, drought early warning, and yield forecasting).

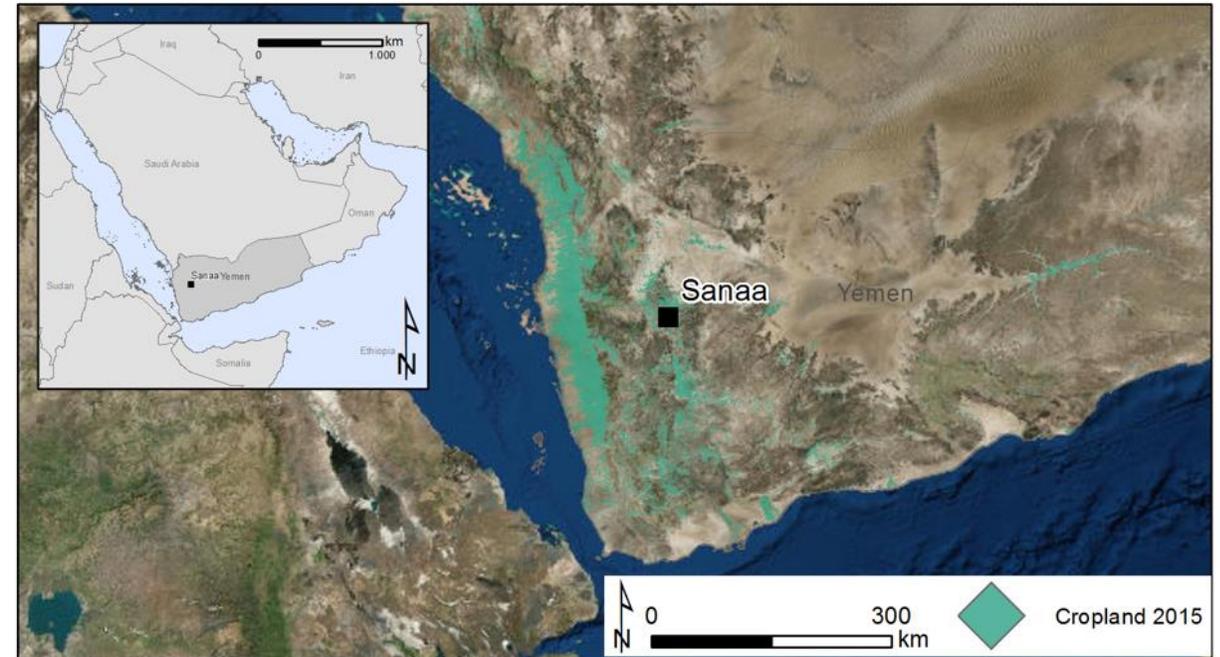
# A) EO Agricultural damage assessment in Yemen between 2014 and 2017

## Aims and scope:

- Satellite based assessment of changes in agricultural production between 2014 and 2017
- Focus: (i) active agricultural land (i.e., sown and harvested), and (ii) active cropland productivity
- 2014 was assumed “pre-conflict” period, 2017 (“post”)-conflict period
- Results provided via web-mapping application

## General approach

- Assessment of satellite images in 2014 and 2017
- Creation of cropland and crop productivity maps



# How is EO used for Agricultural damage assessment?

## EOS Data sets used:

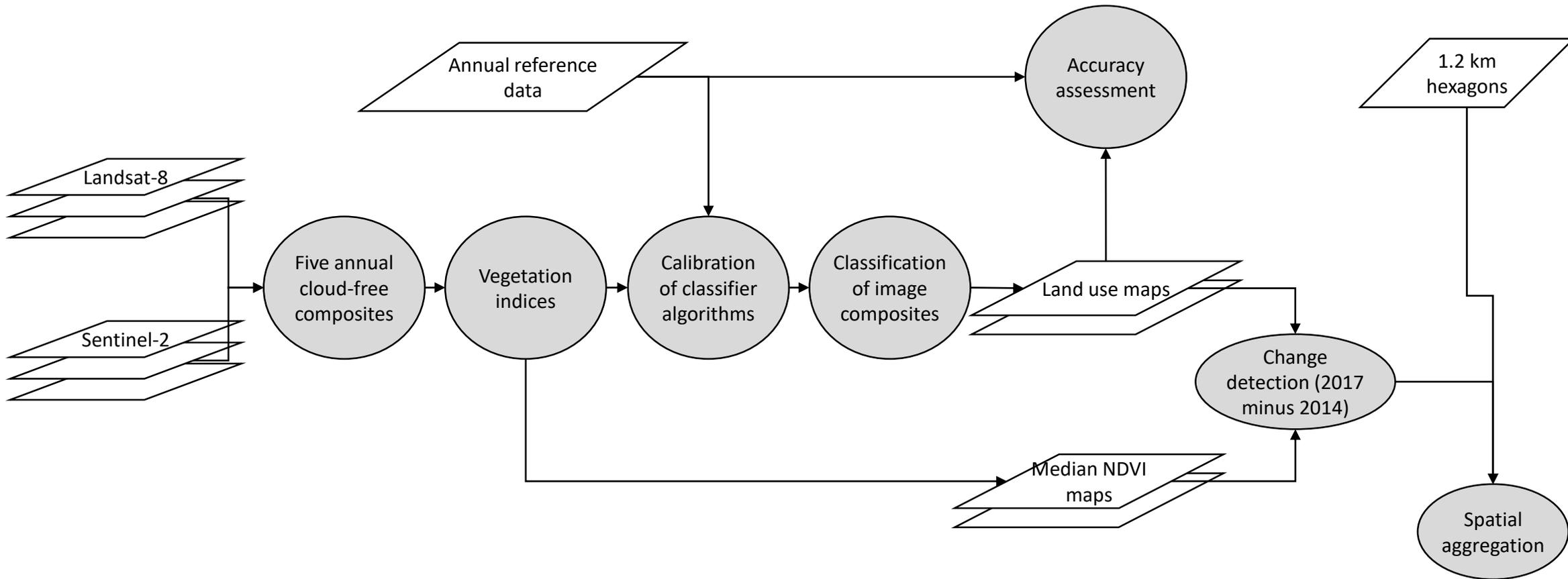
- Freely available satellite images: Landsat-8 and Sentinel-2
  - 30x30m and 10x10 m, respectively pixel size
- Existing cropland mask to limit analysis to cropland
  - Global Food Security-support Analysis Data (GFSAD): Cropland Extent 30 m V001 for nominal Year 2015 (GFSAD30CE V001)
  - <https://croplands.org/gfsadce30info>
  - Study area encompasses 236.020 sqkm cropland, according to GFSAD30CE
- Reference samples (polygons) from two land use classes (active vs. fallow cropland)

## Methods applied

- Computation of cloud-free image composites, covering main agricultural areas in the western coastal plains and highlands of Yemen
- Computation of various vegetation indices (NDVI, NDWI, EVI, spectral bands)
- Calibration of Random Forest and Support Vector Machines classifier algorithms



# Agricultural damage assessment using EO – the workflow



# Agricultural damage assessment – Results

- Thematic maps active vs. fallow cropland (> 92% classification accuracy)
- Using internationally recognized map layout from emergency management services
  - Two maps showing active cropland (2014, 2017)
  - Two maps showing productivity of active cropland (2014, 2017)
  - One map illustrating change of active cropland (2014 - 2017)
  - One map illustrating change of productivity of active cropland (2014 - 2017)
- Statistics and comprehensive reports
- Web-GIS tool for data visualization



# Yemen - Change of Active Cropland Area (2014 - 2017)

Thematic Map



## Cartographic information

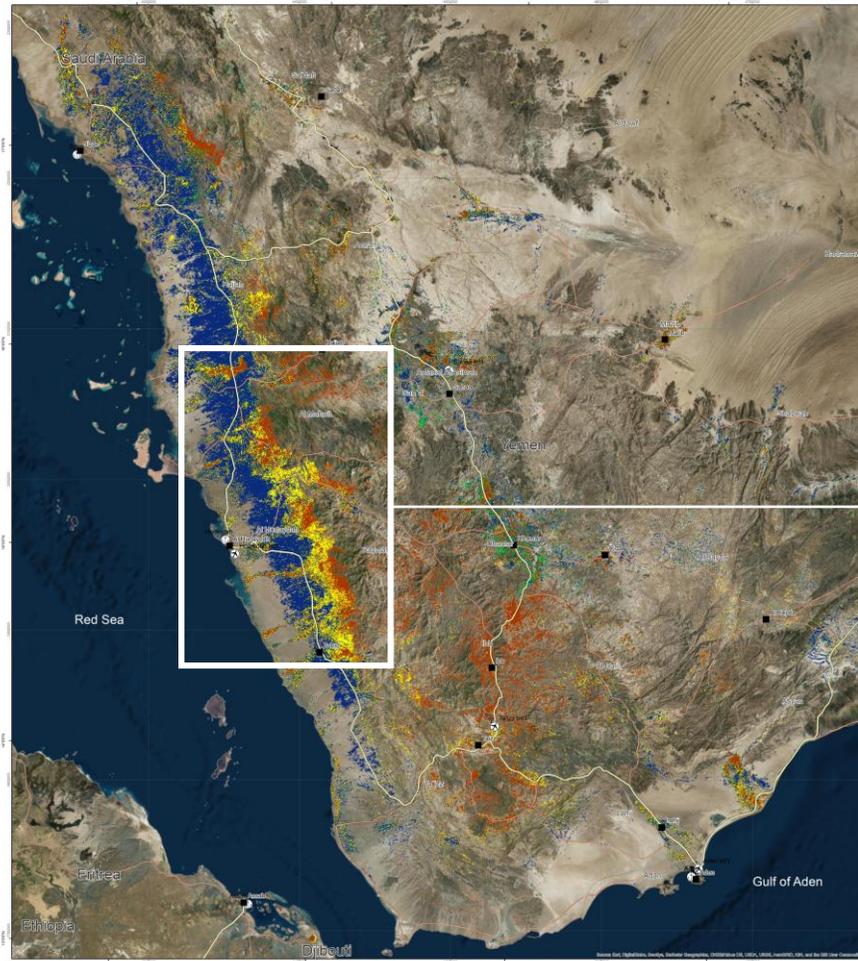
Scale: 1:1,000,000  
 Map scale: 1:1,000,000  
 UTM Zone 32N  
 UTM Zone 32N  
 UTM Zone 32N  
 UTM Zone 32N

## Legend

- Cities, Towns
- Ports
- Airports
- Primary roads
- Secondary roads
- Administrative boundaries
- Countries

## Change in croplands and fallow lands from 2014 to 2017

- Active cropland to active cropland
- Active cropland to Fallow lands
- Fallow lands to active croplands
- Fallow lands to fallow lands



## Map Information

The conflict in Yemen has escalated since 2015 and lasts until 2018. According to FAO, fighting in Yemen had a massive impact on agricultural areas. The agriculture sector is among the worst hit by the current crisis and local food production has been severely compromised. The use of maps and satellite data to monitor agricultural areas is essential for assessing the impact of the conflict on food security. The map was created by ICARDA for World Bank.

## Dissemination / Publication

RESTRICTED USE  
 Delivery format: WMS (via WebPortal), GeoPDF, and vectors (shapefile).

## Data Sources

Inset maps based on:  
 Thematic layer: ICARDA (2018)  
 Administrative boundaries: DIVA-GIS (2018)  
 Hydrology, Settlements, Transportation: Natural Earth (2018)  
 Climate: Global Food Security Support Analysis Data (GFSSAD, 2015)

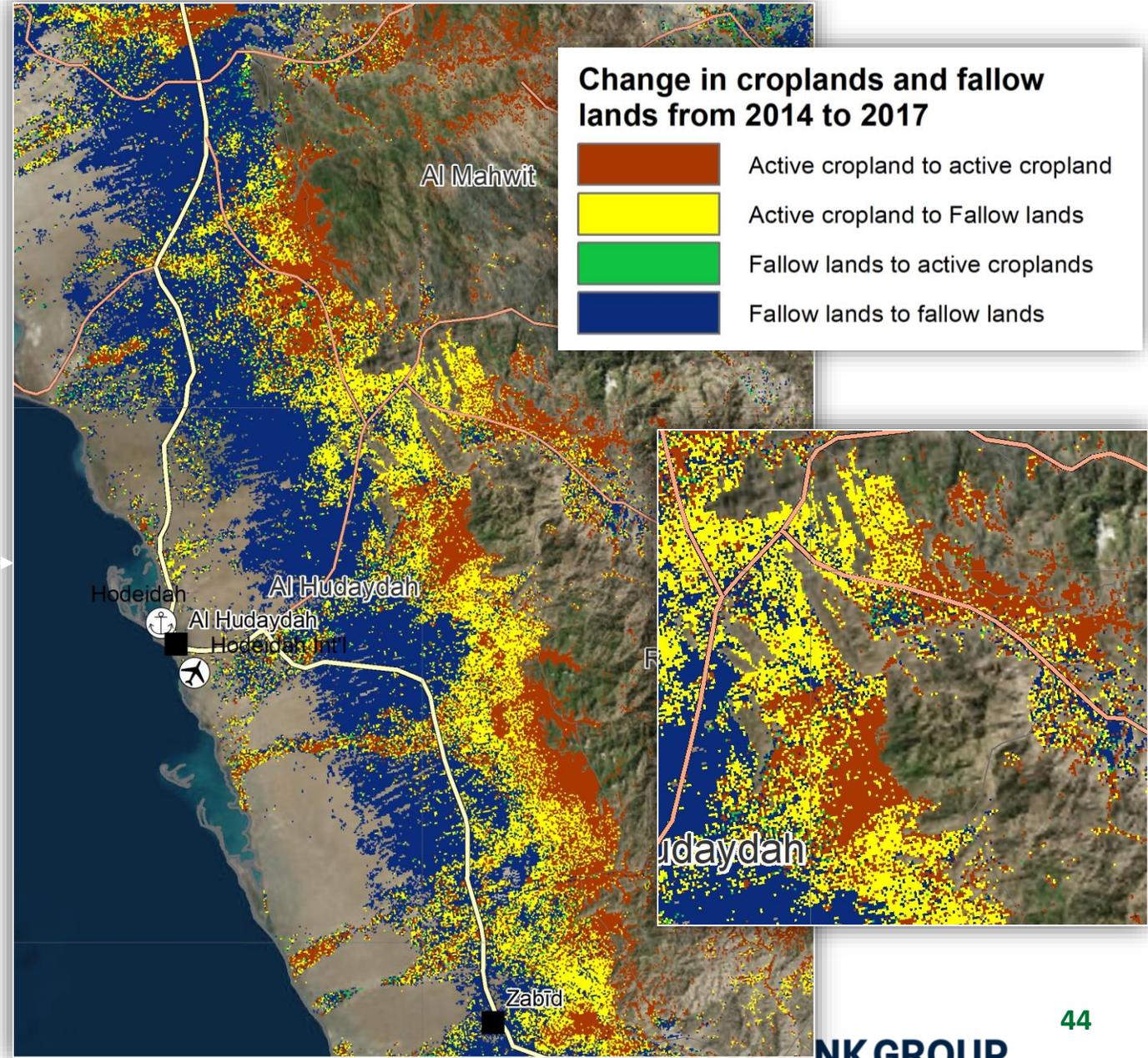
## Map Production

The present map shows the change of the area of cultivated agricultural land (i.e., sown and harvested) between 2014 and 2017. The annual area of actively cultivated agricultural land and fallow lands has changed. The analysis of the annual land use was based on Landsat (2014) and Sentinel-2 (2017) images and supervised image classification. The estimated thematic accuracy of this product is 80% or better. Map produced on 07. June 2018 by ICARDA. All products are © of ICARDA.

## Disclaimer

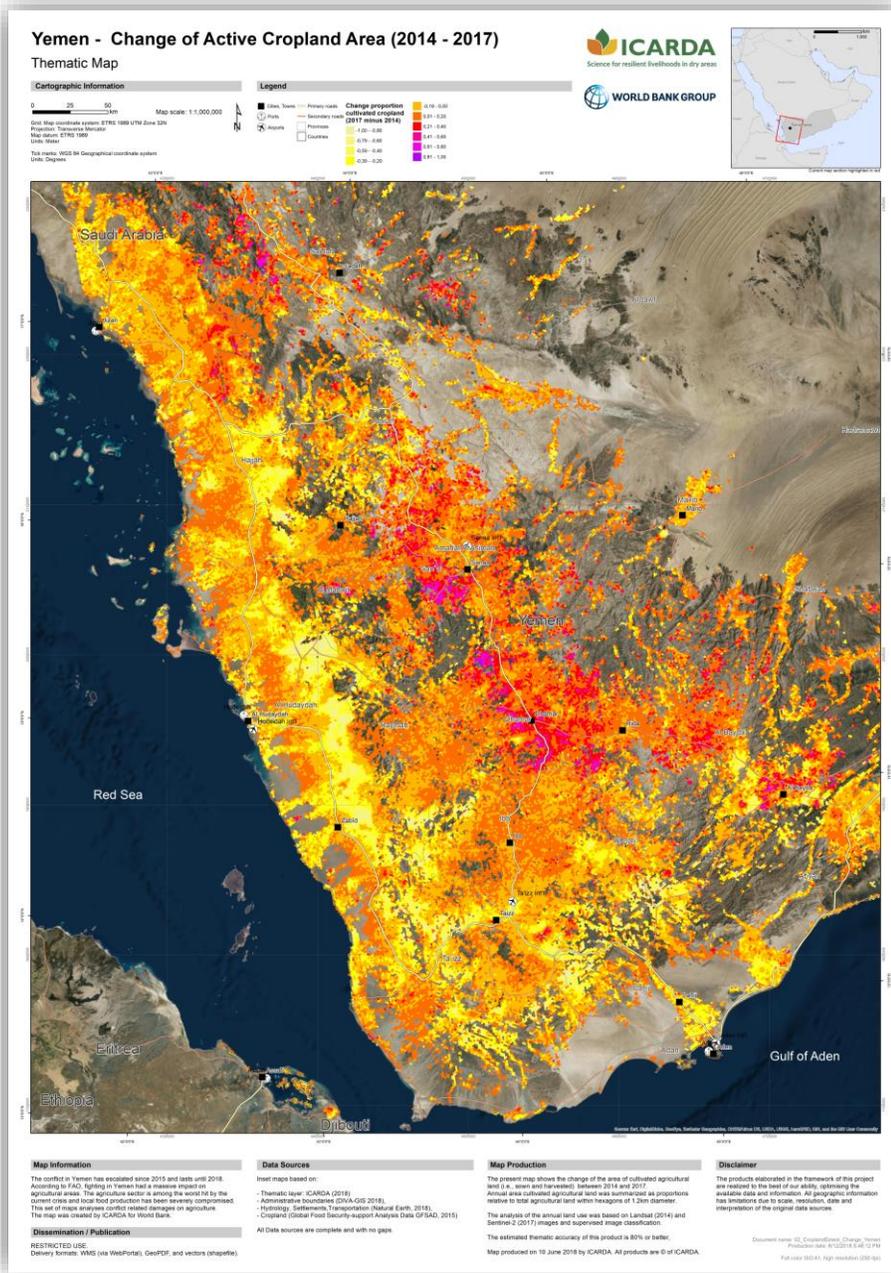
The products elaborated in the framework of this project are created to the best of our ability, utilizing the available data and information. All geographic information is not guaranteed to be accurate, complete, and up-to-date. The products are provided as a service and are not intended for use in any legal or other proceedings. The products are provided as a service and are not intended for use in any legal or other proceedings.

Document name: 02\_ChangeInLand\_Change\_How  
 Production date: 07/2018 12:46:12 PM  
 Full cover: 001-A1\_High-resolution (200 m)



## Change in croplands and fallow lands from 2014 to 2017

- Active cropland to active cropland
- Active cropland to Fallow lands
- Fallow lands to active croplands
- Fallow lands to fallow lands



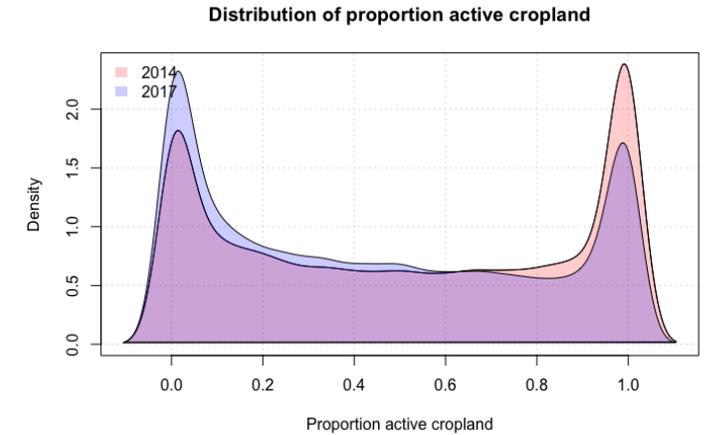
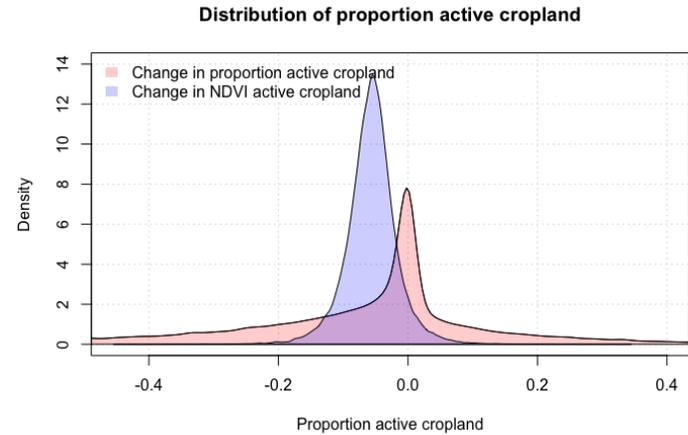
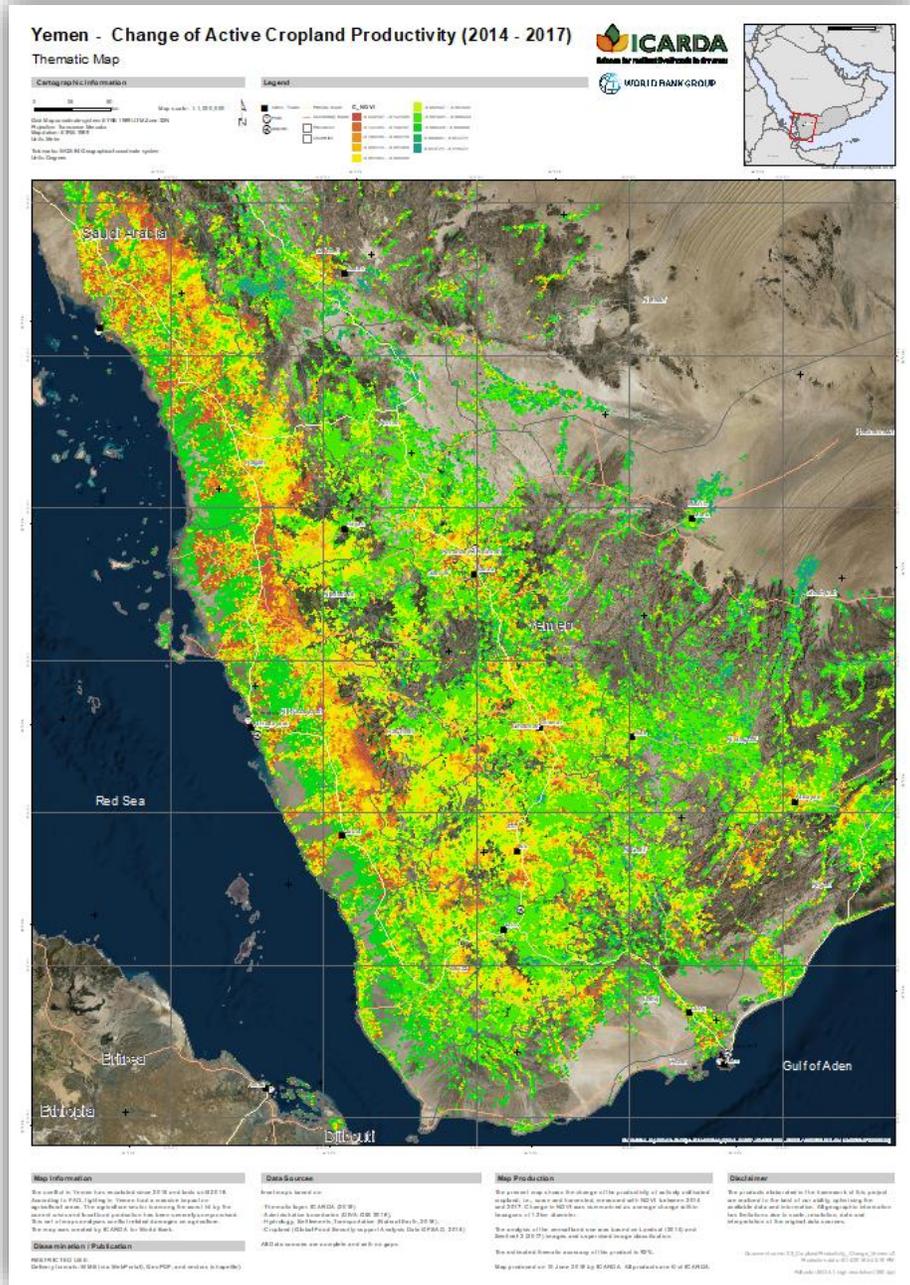
# Agricultural damage assessment- Results

## Results (Active Cropland Area):

- Satellite analysis revealed that **54%** of the observed area experienced a **decrease** in active cropland area (2014 – 2017)
  - 2014: 105,810 sqkm
  - 2017: 85,340 sqkm
- **5%** of the observed area were severely affected and experienced more than **50% decrease of cropland area**
- **Spatial hotspots** of abandonment were found near the mountains slopes between (from south to north) Taizz, Zabid, Bayt al Faqih, Al Hudaydah, Bajil, and Hajjah, and
- **25%** of the observed area experienced an **increase** in active cropland (2014 – 2017), but **only 1.1%** experienced an increase higher than 50%



# Agricultural damage assessment- Results



- Satellite analysis revealed that 76% of the observed area experienced a decrease in active cropland productivity (2014 – 2017), as approximated with NDVI
  - Only 5% of the observed area experienced an increase in active cropland productivity (2014 – 2017)
- ➔ *This information can be used as inputs for damage and needs assessment as well as for proper targeting of households/regions for reconstruction purposes.*

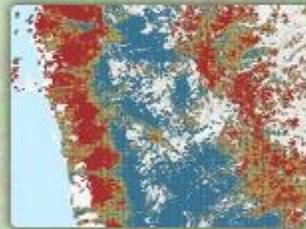
### Agricultural Monitoring in Yemen

Please select a product line

Go back to the portal



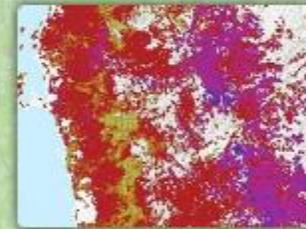
Croplands



Fallows



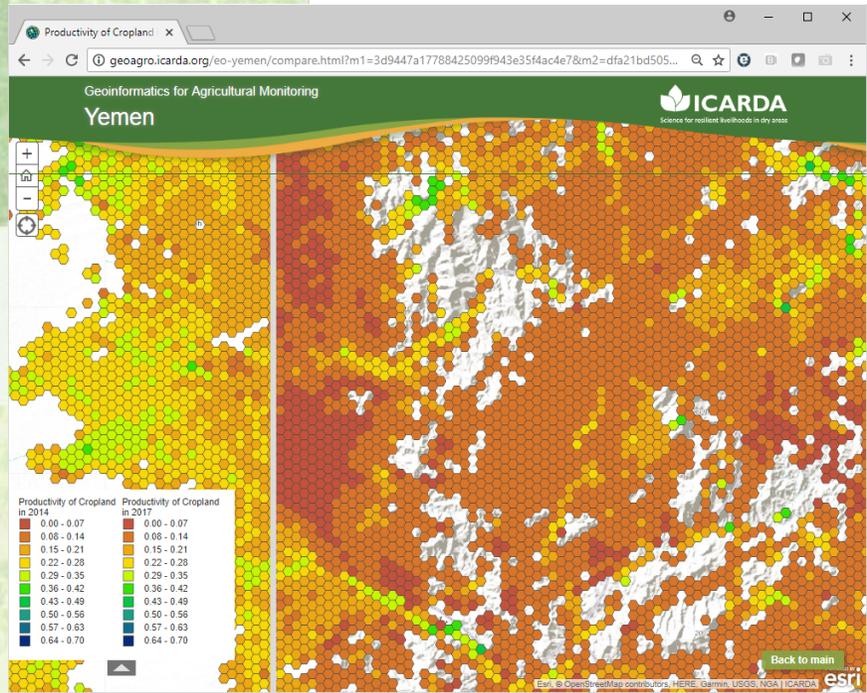
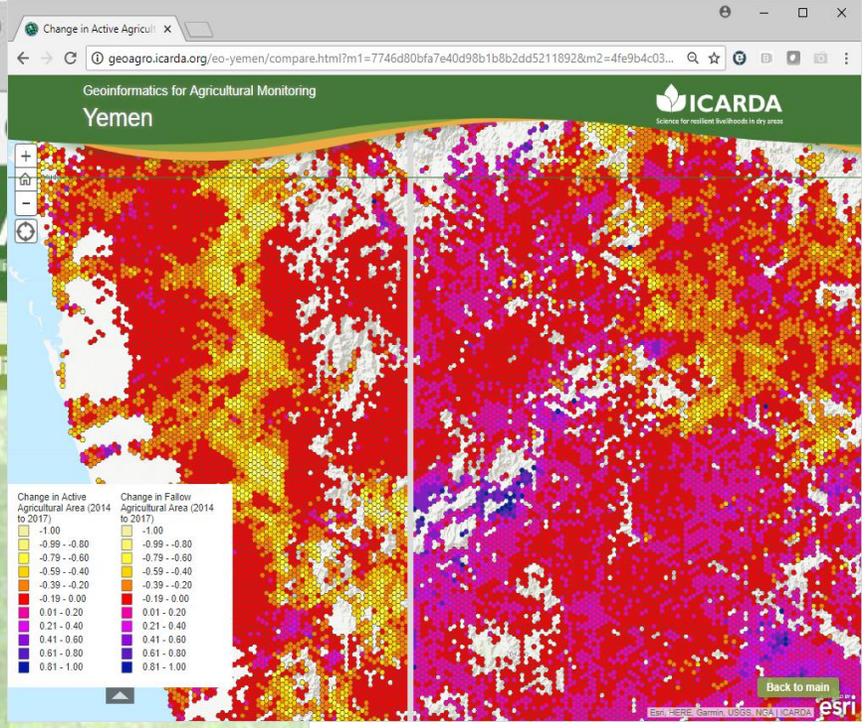
Productivity



Changes



<http://geoagro.icarda.org/eo-yemen/>



# ***B) Specification of an EO based Agricultural Monitoring Tool***

## **Background:**

- 230,000 km<sup>2</sup> (circa 43%) of land in Yemen constitute agricultural land (FAO 2017)
- War, reoccurring precipitation shortage, flooding, or desert locust outbreaks frequently disturb agricultural production
- 75 percent (22.2 million people) are in need of humanitarian assistance; this includes 17.8 million Yemenis food insecure

## **Problem statement**

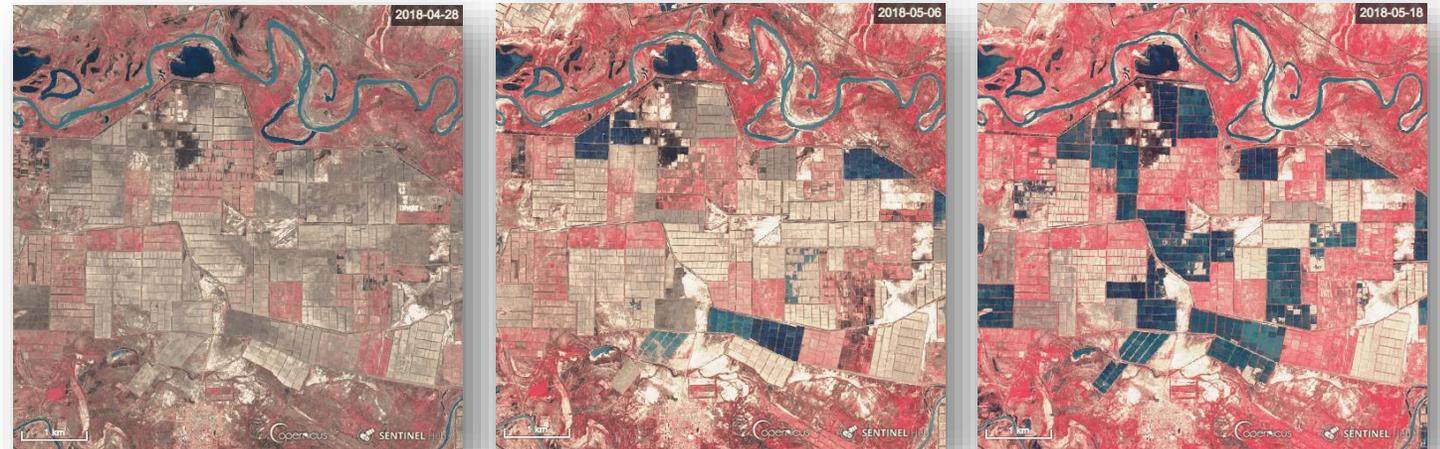
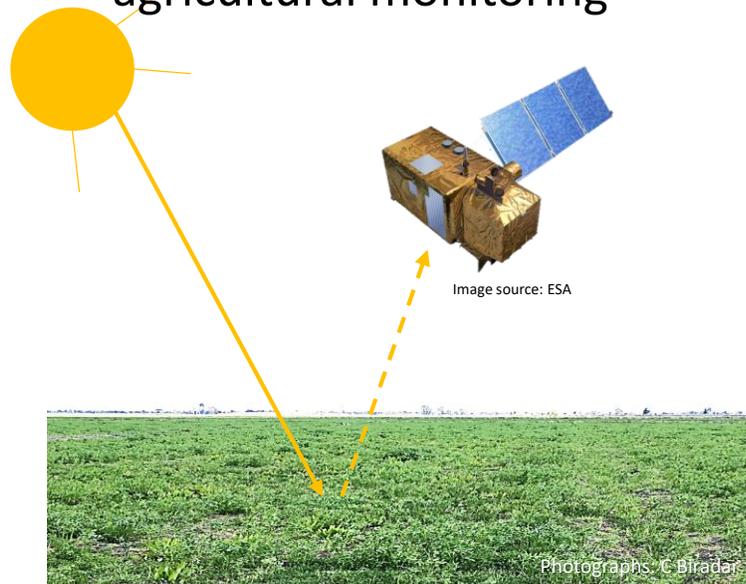
- Policy and decision makers in Yemen need to take several vital decisions against this backdrop
- Decisions require reliable information, planning & monitoring agricultural production have a strong spatial dimension
- Systematic & frequent (e.g. within growing season) information retrieval via field visits limited / prohibitively expensive (huge and inaccessible area)
- Existing statistics might be outdated or aggregated



# Proposed solution

## Satellite earth observation:

- Agricultural monitoring based on satellite remote sensing
- Technology that involves observing the Earth's surface by taking digital images from remote carrier platforms
- Resolve the spectral signal at individual crop parcel level and along the growing season -> key to agricultural monitoring

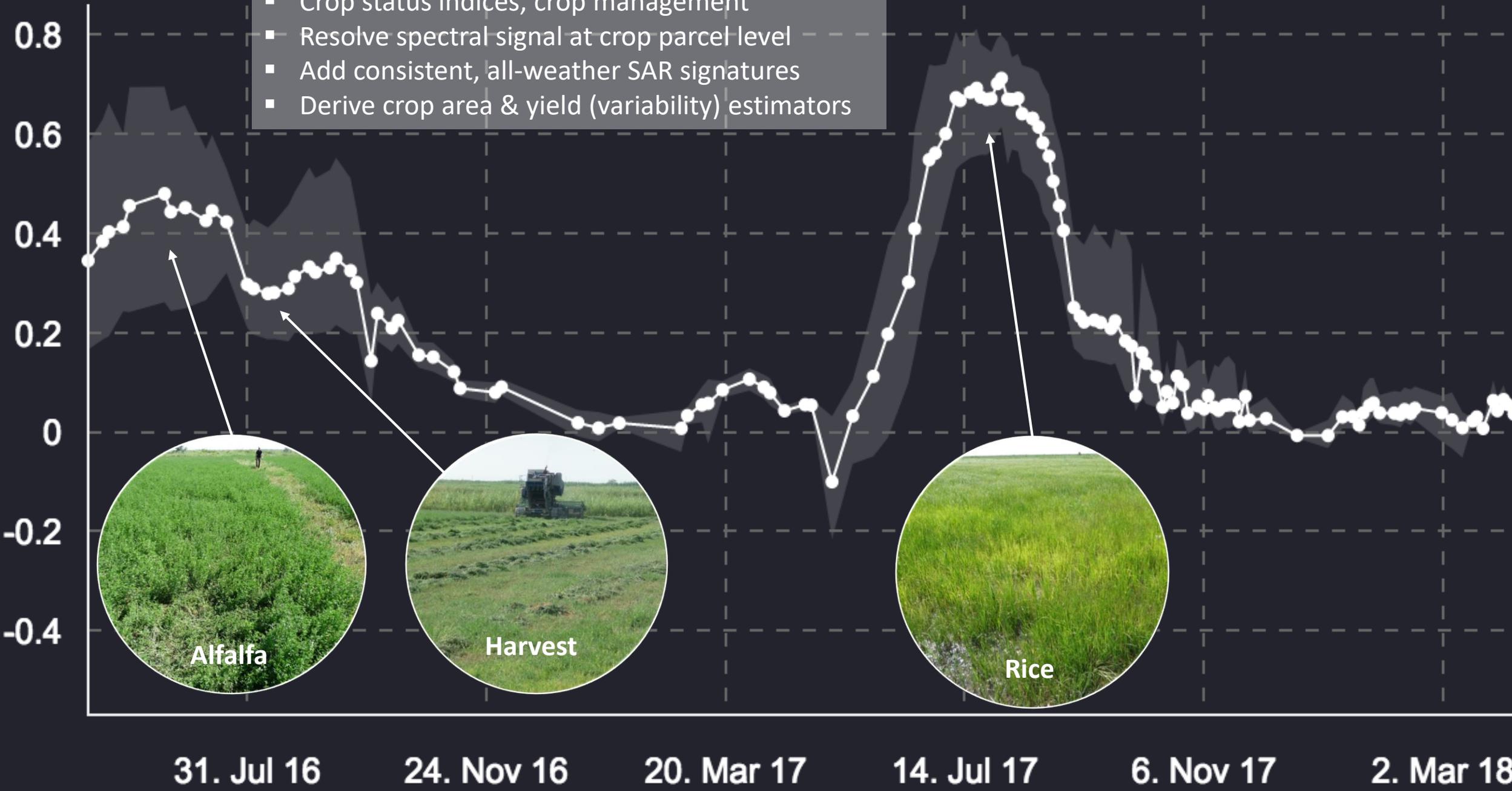


Mapping crop phenology



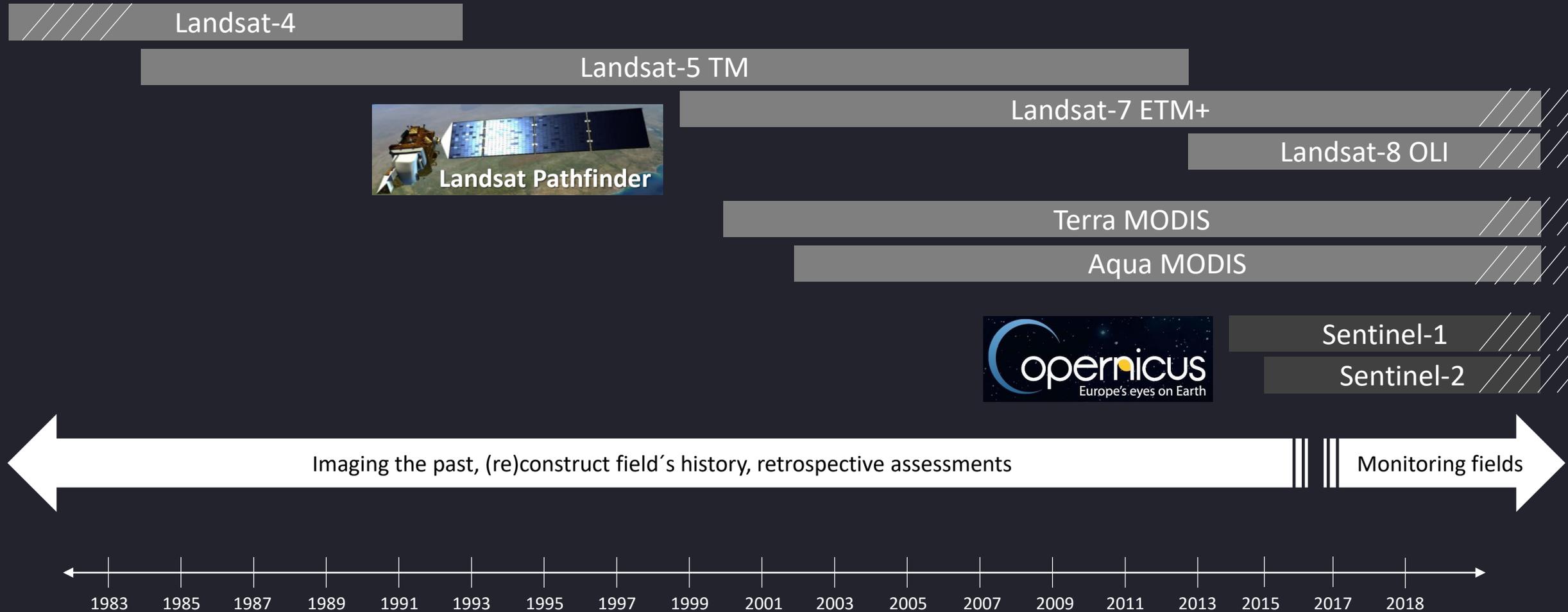
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- Crop status indices, crop management
- Resolve spectral signal at crop parcel level
- Add consistent, all-weather SAR signatures
- Derive crop area & yield (variability) estimators



## Baseline:

- Open and free satellite data
- NASA Landsat
- Copernicus Sentinels



# Potentials of “Sentinel” satellites

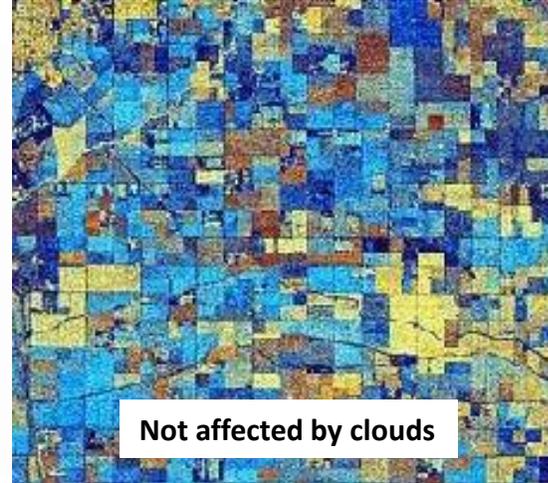
## Technical specification

- High resolution of Sentinel images (10+10m pixel size) enables monitoring single fields
- Full and systematic coverage of Yemen with Sentinel satellite data
- High revisit frequency (Sentinel-1: every 6 days, Sentinel-2: every 5 days) match dynamics of crop cycle, allows identifying different crop types very accurately

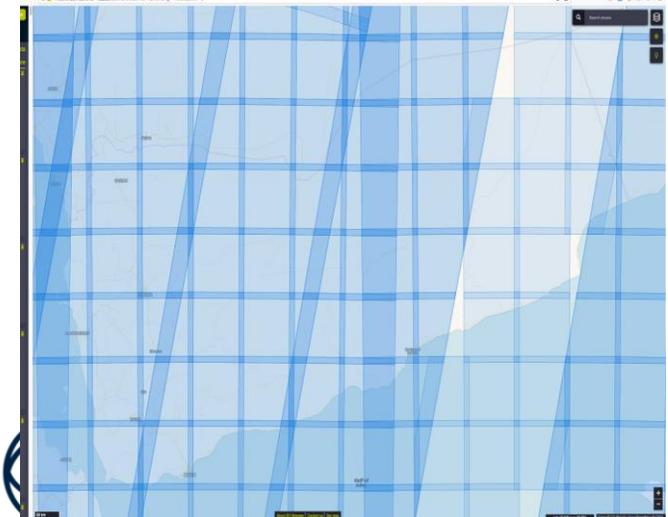
## Copernicus Earth Observation Programme

- Copernicus offers long term perspective suitable for agricultural monitoring (at least 2027 and beyond)
- Free and open access to Sentinel data (archive and recent imagery)

Sentinel-1 (since Oct 2014)



Sentinel-2 (since Jun 2015)



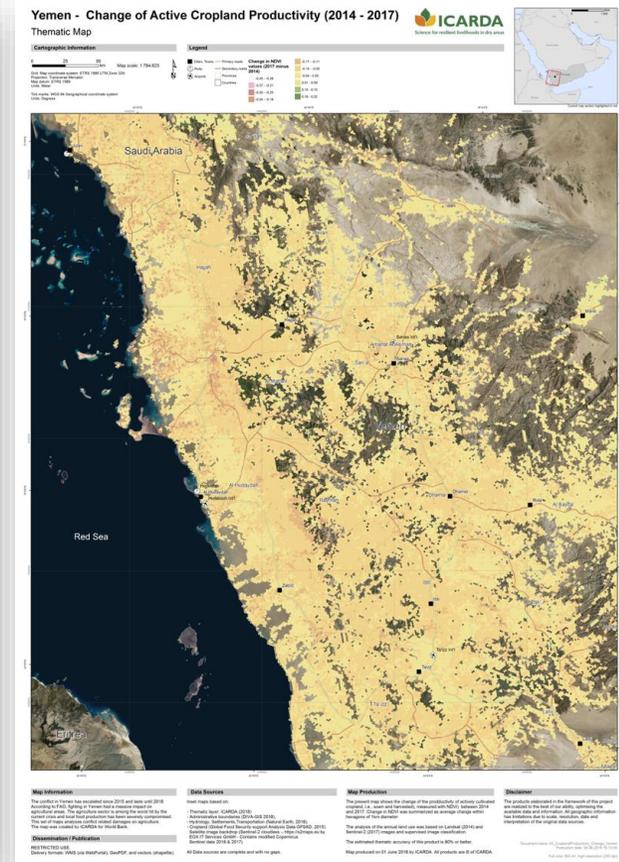
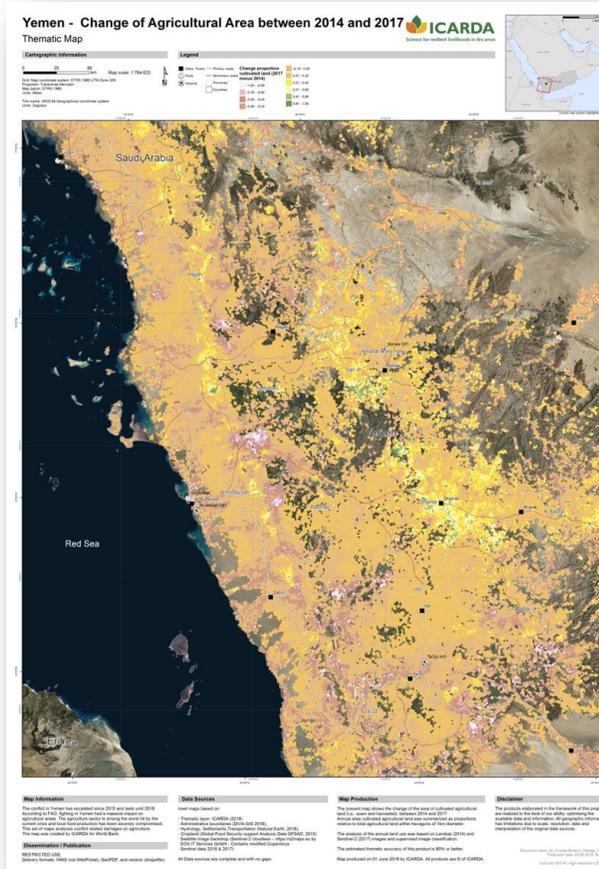
# Added value and benefits

- **Objectivity:** Satellites provide objective data
- **Comprehensiveness:** Each field in Yemen can be monitored, topics include crop type, crop stress, crop yield, floods, any many more...
- **Continuity:** Open access to Sentinel data support long-term (2027 and beyond) and regular (every 5-6 days) monitoring
- **Accuracy:** Reliable and accurate maps can be created, remote sensing is a scientifically proven method
- **Cost-effectiveness:** Considerable cost savings compared to ground control by survey teams



# Functionality

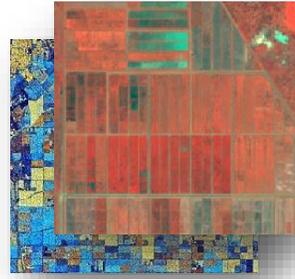
- Agricultural monitoring tool, based on remote sensing, delivers **MAPS** as baseline information for planning and decision making:
  - Detect and quantify spatial extent of cultivated cropland at least once a year, or within the growing season;
  - Assess crop productivity (crop yield) at least once a year, or within the growing season;
  - Additionally, extent the system to provide relevant data about factors that affect agricultural production and that allow for early estimation of hazards, such as floods, droughts, or conflict damage



# How does it work?

➔ Satellite and auxiliary  
Data collection

Satellite image  
download



➔ Processing of the  
data sets & Data  
analysis and  
post-processing

Data pre-processing

Data analysis and  
interpretation



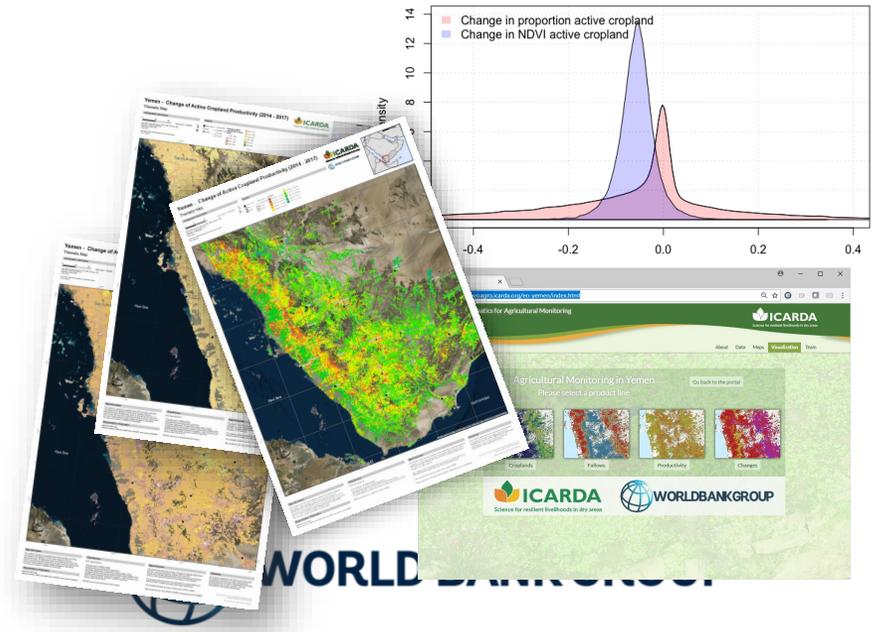
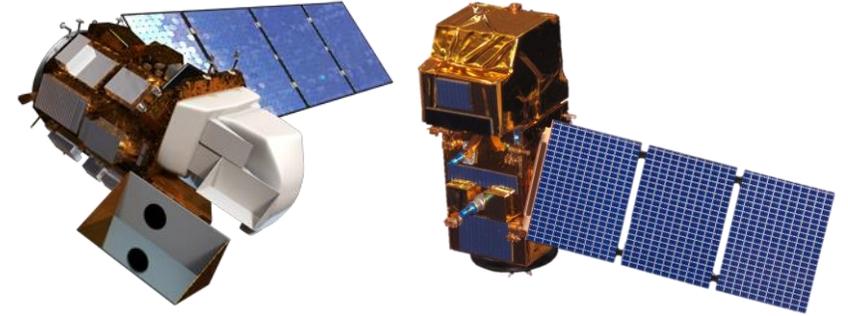
Validation & quality  
control

➔ Delivery to end-  
users and  
decision makers

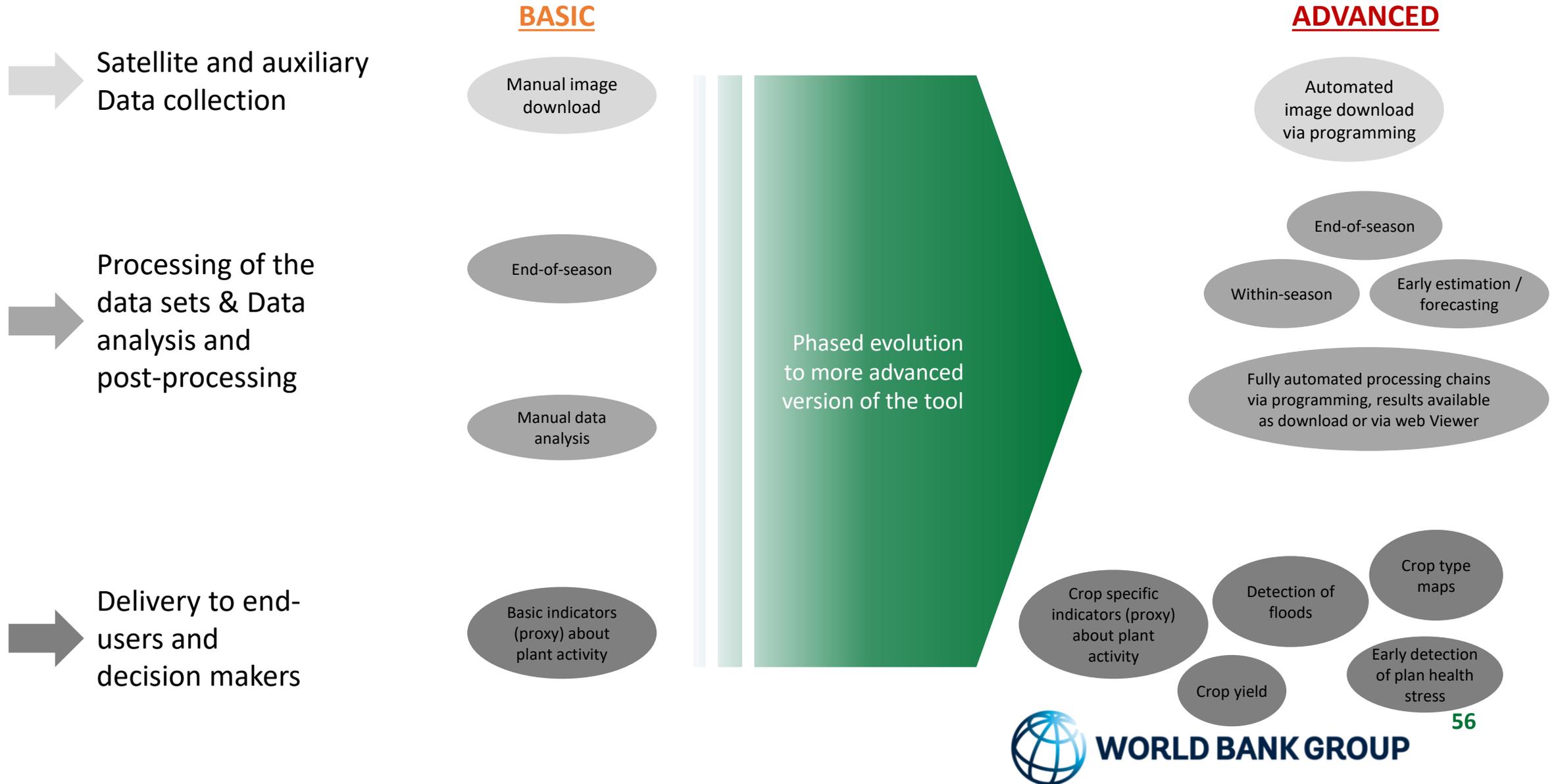
Data visualization:  
**Digital maps**

Reports,  
**Statistics**

Web tool  
**Interactive**



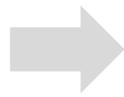
# Basic and advanced EO Tools



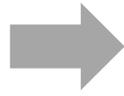
# Basic and advanced EO Tools

BASIC

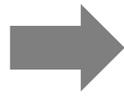
ADVANCED



Satellite and auxiliary  
Data collection



Processing of the  
data sets & Data  
analysis and  
post-processing



Delivery to end-  
users and  
decision makers

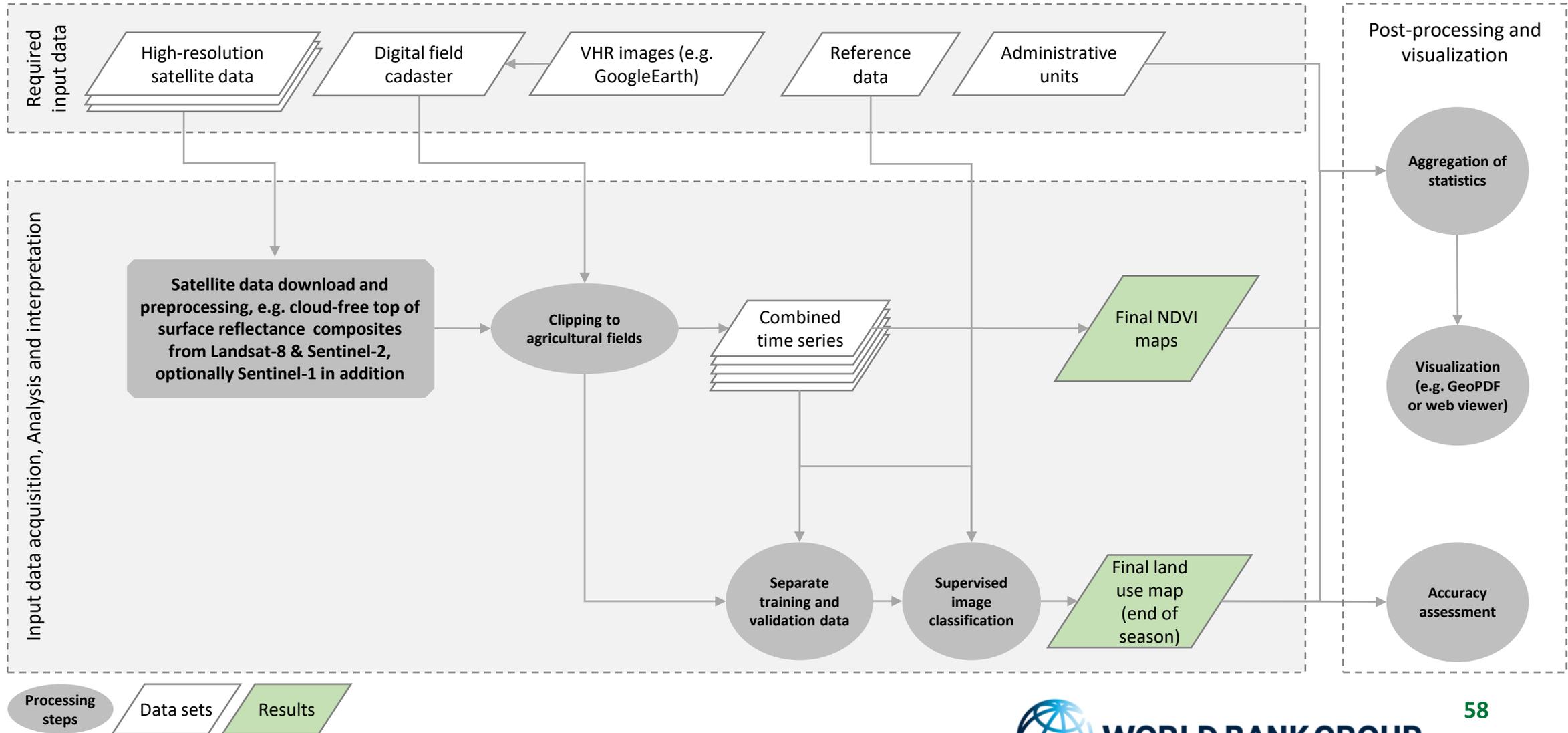


Note: All software and data (except for in-situ data) are free of charge

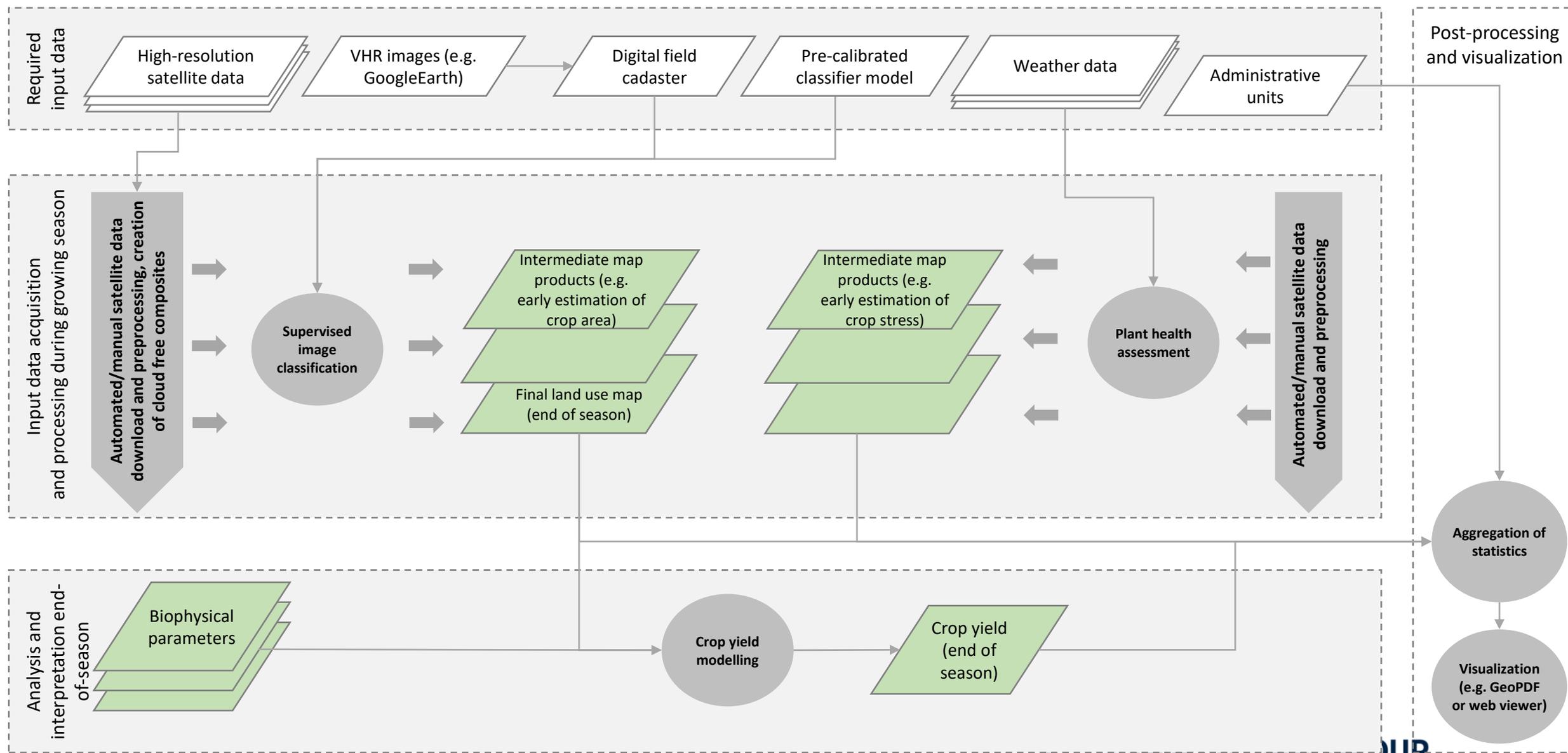


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# How does it work – Technical details (1)



# How does it work – Technical details (2)



## ***Key benefits of the agricultural monitoring tool: summary***

- Agricultural monitoring tool, based on remote sensing, delivers digital maps and database to retrieve about the status of agricultural area, crop health and production timely (within the season)
- Objective and reliable information as baseline information for planning and decision making
- Considerable cost savings compared to ground control by survey teams and a important option for conflict situation
- Open access to Sentinel data support long-term (2027 and beyond) and regular (every 5-6 days) monitoring, may help target specific planning, site specific intervention, forecasting and early warning
- Such information will be useful to different agricultural value chain actors to make market surplus assessments from different geographical areas
- Governments and other donor agencies can use this information for damage and needs assessment of conflict affected areas



# Key Policy Recommendations

Area	Key Actions to be Taken
<b>Value chain development</b>	<ul style="list-style-type: none"><li>• Address gender norms to improve limiting women’s mobility and women’s roles in value chains</li><li>• Support development of logistics and cold warehousing nodes</li><li>• Establishing a food safety system in the food sector, along the entire value chain</li><li>• Support organization and market integration of smallholders in each value chain</li><li>• Facilitate smallholder-driven value chain development through farmer cooperation, advisory service development, and market access measures</li></ul>
<b>Alternative frontier technologies</b>	<ul style="list-style-type: none"><li>• Capacity building and skill development</li><li>• Financing of start ups</li><li>• Alternative service providers: Skills for technologies targeting household subsistence farming that are mainly for increasing dietary diversity may be disseminated via NGO’s (e.g. Care Int.) or women’s health centers, where traditional extension services are not present.</li><li>• Developing nutrition awareness creation platform</li></ul>
<b>Satellite based agricultural monitoring tool</b>	<ul style="list-style-type: none"><li>• Build capacity of staff at Ministry of Agriculture and Irrigation</li><li>• Awareness creation on the Earth’s Observation Agricultural Monitoring tool and how it works</li><li>• Develop information system/map for investors: water resource availability, soil quality, ICT service and other support service availability</li><li>• Develop framework for water resource management in agriculture using ICT and precision technologies</li></ul>

# Improving Food Availability and Access for Rural Households in Djibouti

*FOOD SECURITY IN YEMEN AND DJIBOUTI (P166945)*



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Agriculture

# *Acknowledgements*

*This presentation was prepared by a World Bank team led by Sandra Broka (Senior Agriculture Economist and co-TTL) and Mekbib Haile (Young Professional and co-TTL). The team is thankful for the research and background reports provided by Asa Giertz, Edinaldo Tebaldi, and Oleg Nivievskiy (Consultant). We also acknowledge contributions and comments from Faiza Hesham Hael Ahmed and Rufiz Vakhid Chirag-Zade as well as from colleagues in other Global Practices, including Elizabeth Mziray (HNP), Sami A Sofan (FCI), and Benjamin Herzberg (FCI).*

# ***Study Objectives***

**The overarching objective** is to contribute to the improvement of food security and livelihoods in Djibouti.

## ***How is this done?***

- 1) The study provides recommendations on operationalizing key supply chains (including fish and livestock) with high cash and/or nutritional values. These value chains are expected to generate better incomes and improve availability of nutritious food to rural households.
- 2) The study assesses availability of suitable water-saving technologies that can both allow production of nutritious food items (such as vegetables) as well create jobs among rural communities, in particular, for women.

*\*The work on alternative technologies draws on the World Bank's report, "Frontier Agriculture for Improving Refugee Livelihoods: Unleashing Climate-Smart & Water Saving Agriculture Technologies in MENA (Verner et. al. 2017)."*

# ***Country Context***

- A small, fragile, and lower-middle income country which occupies a pivotal position for trade and security in the Horn of Africa and the Gulf of Aden.
  - Transportation and logistics services drive the economy
- Experienced fast economic growth ( ca. 7%) in recent years
  - The country engaged in mega-investments in port infrastructure development and railway construction to link Djibouti to Ethiopia
- About 41 percent of the growing population lives in poverty while 23 percent of the population lives in extreme poverty
- The presence of refugees and migrants has created additional pressure on infrastructure and further stretched the limited capacity to provide basic services.
- Imports about 90 percent of food consumption

## ***Food and nutrition insecurity remains unacceptably high in Djibouti***

- The prevalence of global chronic malnutrition is estimated at 29.7 percent while 40 percent of under-five deaths are linked to malnutrition.
- A third of children under five are chronically malnourished while 22 percent suffer from acute food malnutrition.
- The prevalence of malnutrition is much higher among rural households, reaching as high as 46 percent in some areas like Obock.
- The 2017 IFPRI's Global Hunger Index ranked Djibouti among the 20 hungriest countries in the world, with a GHI score of 31.4.
- Inequality, poverty and food insecurity lead to a multitude of challenges, with childhood malnutrition being particularly damaging.



# ***Land and water scarcity exacerbates the food and nutrition security challenge in Djibouti***

- **High food insecurity and malnutrition:** 75% of rural and 20% of urban Djiboutians are food insecure
- Food insecurity in Djibouti has been exacerbated by limited arable land, water scarcity and prolonged recurrent drought during the past several years.
  - The rural population subsists primarily on minimal agricultural production and nomadic herding. In agro-pastoral livelihood zones, the loss of livestock and main sources of income curtailed the purchasing power of poor households.
- **Land and water scarcity:** Less than 1 percent of the land area is arable and with 100 mm of average annual rainfall, precipitation is scarce.
  - 80 of the population lives in urban areas, leaving a large share of the population reliant on urban food systems.

# ***Agriculture makes up just 2 percent of the country's GDP BUT is source of livelihood for a fifth of the population***

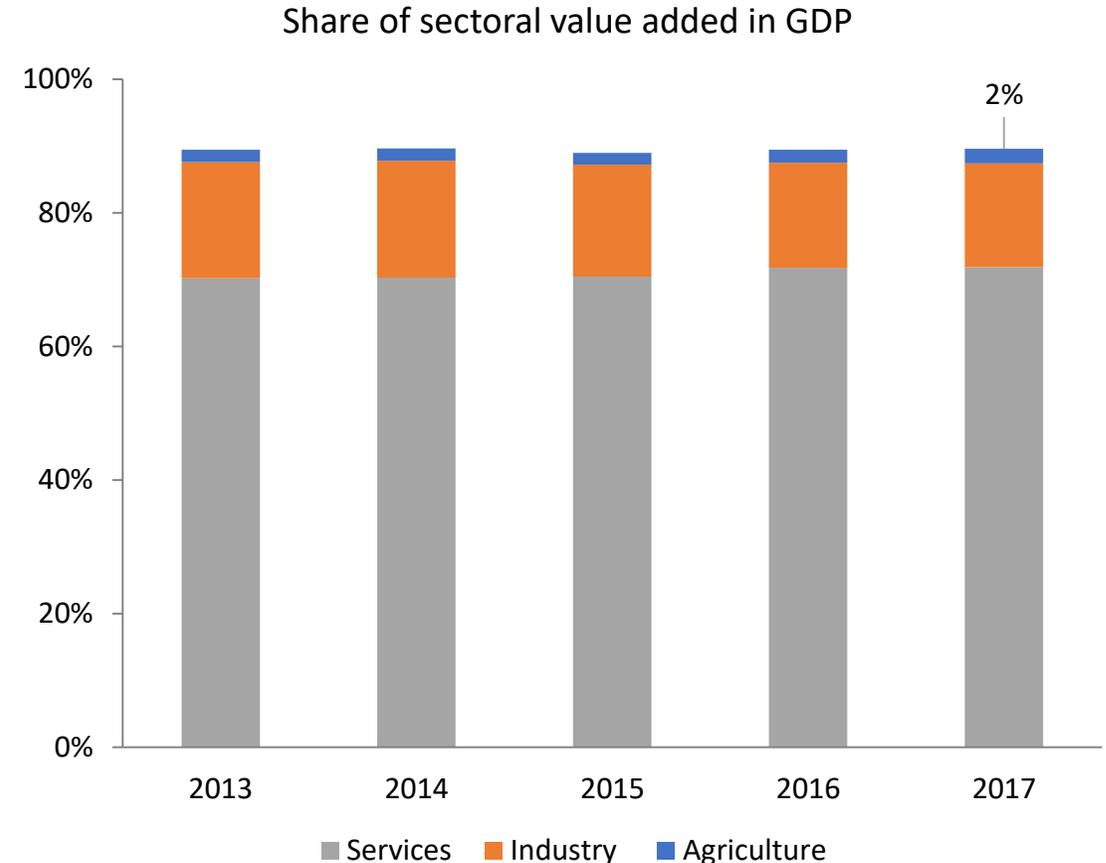
- **20% of the population depends on agriculture for its livelihood**

- More than 80 percent of the rural population consists of nomadic and seminomadic herders
- Livestock is main source of subsistence and it contributes to 85% of the agricultural sector's contribution to GDP
- 63% of rangelands are already overgrazed, putting added pressure on livestock numbers

- **In terms of farm structures - small plots and subsistence farming**

- A total of 1,815 farms operate with an average area of one acre and employ about 3,600 people

*Agriculture (including fishery and forestry contributes 2 percent of GDP*



*Source:* World Development Indicators

# ***Water and land scarcity constrain agricultural growth and food security***

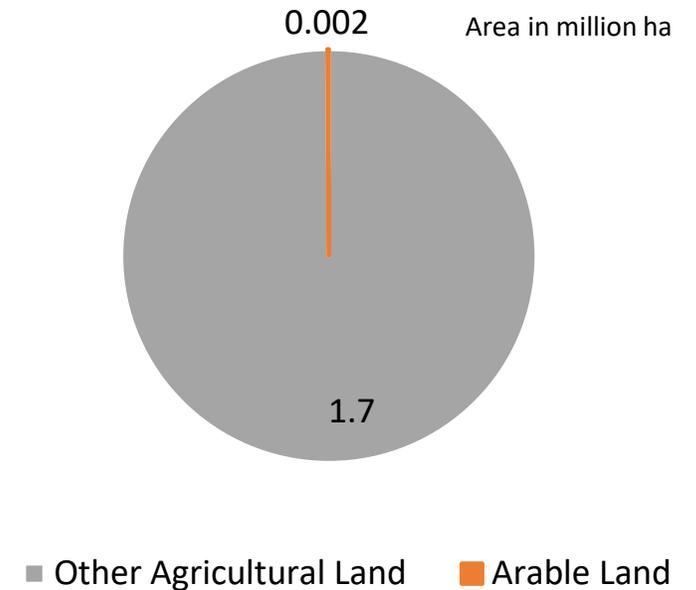
- **Extreme water-scarcity**

- About a fifth of the population has no access to potable water and that more than 70 percent of the rural population (and their herds) do not have access to water within a reasonable distance
- About 95 percent of total water use comes from groundwater aquifers, but the rate of a recharge is already below the usage rate
- Temperatures are projected to increase by 1.7-2.1°C by 2050, while precipitation is set to decrease by 4-11 percent

- **Arable land is very limited**

- Djibouti has just 2,000 ha of arable land

*Only about 1 percent of Djibouti's agricultural land (2,000 ha) is arable.*



Source: FAOSTAT 2017

# ***The GOD aims to diversify the country's economy – setting agriculture and fishing as key priorities***

- Djibouti's Vision 2030 and the Master Plan for the Development of the Primary Sector (PDDSP) developed by the Ministry of Agriculture, Livestock and Marine Affairs set ambitious plans to increase agricultural productivity and to improve food security.
  - The government targets to increase value addition to GDP of agriculture to about 4 percent in 2022 and 5 percent in 2035.
  - The government specifically aims to increase value addition and food exports through larger domestic production and by establishing agro-industrial production units.
  - The plan specifies goals to increase crop and animal production, as well as a better exploitation of the country's water resources.
- ➔ *This study assess potential value chains and alternative frontier technologies that would contribute to achieving the government's vision to the agriculture sector*

# What is the proposed way forward?

## 1) Developing key high-value supply chains with large potential to generate income and to create jobs

- *Fish and livestock value chains play a key role in food and nutrition security and to generate income.*
- *These value chains create several jobs along the value chain*

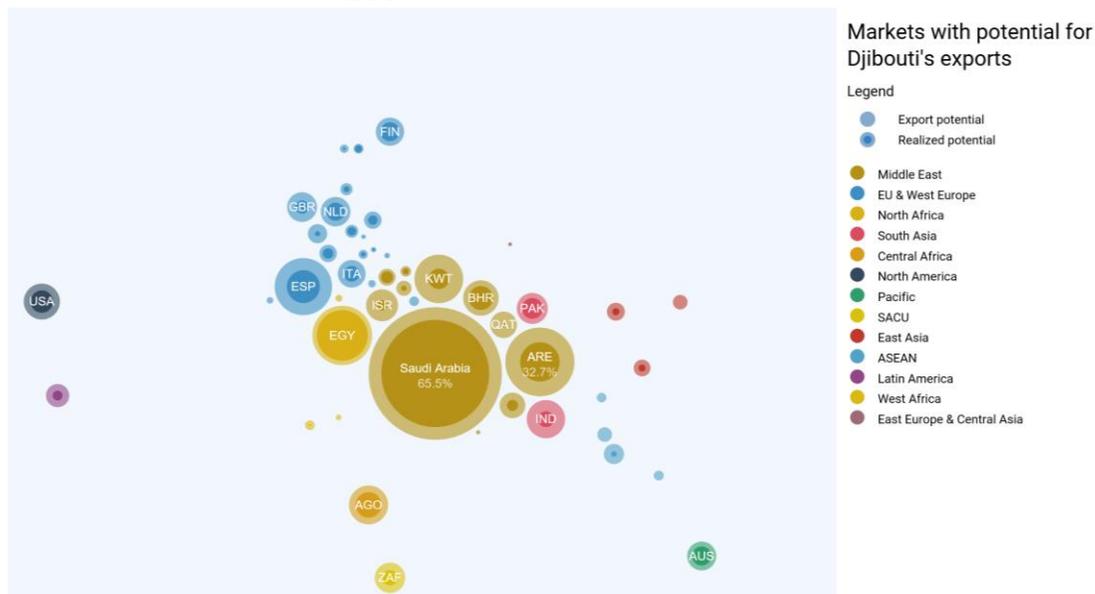
## 2) Investing in alternative agricultural production technologies to improve food security and to create income opportunities

- *These alternative technologies can overcome the problems of water and land scarcity in Djibouti*

# **1) High-Value Supply Chain Development for Generation of Income and Jobs in Djibouti**

# Identification of ag value chains in Djibouti

- Available data (example from the International Trade Center) shows that Djibouti's ag exports makes up more than half of its total
- These exports, however, look more as Djibouti's re-exports from its neighboring countries, rather than its own exports
- Djibouti can add significant value addition along the livestock value chains before re-exporting
- The markets with greatest potential for Djibouti's exports of All products are Saudi Arabia, United Arab Emirates and Egypt.



*Although it is small in absolute value, agricultural export contributes about half of the country's exports – yet this data should be used only as indicative*

Code	Product label	Exported value	Share in total export
<b>DJIBOUTI</b>			
	All products	147.11	100.0%
'01	<b>Live animals</b>	<b>49.67</b>	<b>33.8%</b>
'99	Commodities not elsewhere specified	32.32	22.0%
'09	Coffee, tea, maté and spices	18.64	12.7%
'44	Wood and articles of wood; wood charcoal	12.73	8.7%
'82	Tools, implements, cutlery, spoons and forks, of base metal	5.60	3.8%
'84	Machinery, mechanical appliances, nuclear reactors, boilers	3.95	2.7%
'07	Edible vegetables and certain roots and tubers	3.65	2.5%
'86	Railway or tramway locomotives, rolling stock and parts thereof;	2.77	1.9%
'27	Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral ...	2.57	1.7%
'17	Sugars and sugar confectionery	1.73	1.2%
'12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit;	1.65	1.1%
'64	Footwear, gaiters and the like; parts of such articles	1.48	1.0%
'03	<b>Fish and crustaceans, molluscs and other aquatic invertebrates</b>	<b>1.04</b>	<b>0.7%</b>

## ***Besides impacts on food security, export potential and Djibouti's comparative advantages are key value chain selection criteria***

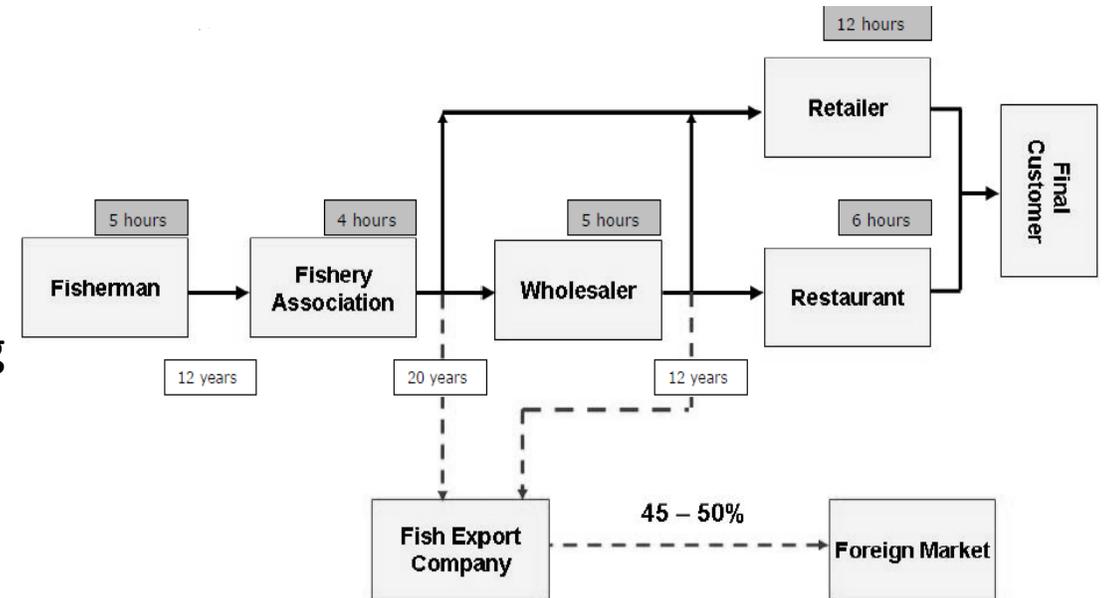
### ***Selection of the Fishery and Livestock Value Chains for the following reasons:***

- Export of live animals (and skin) are the main merchandise exports from Djibouti and it has a large untapped export potential (almost as large as the realized export). Better livestock management and development of further livestock value chains (meat and milk) are therefor important.
- Only half of Djibouti's export potential for live animals is realized (with an untapped export potential of about US\$25 million)
- Given the country's close to 400 km of coastline and its nutrition value, developing the fish value chain is an obvious priority for Djibouti.
  - *This reflects Djibouti's comparative advantage in fish production*
- Fishery and livestock value chain development were two of the six priority themes in the 2010 National Program for Food Security (NPFS)



# Fishery Value Chain

- **Fishing's contribution to the Djiboutian economy remains marginal**
  - The country has 372 km of coastline and the fishing and related activities subsector employs about 3,000 people
  - it remains largely artisanal with catches not exceeding 2,000 tons per year compared to an estimated potential of 47,000 tons
  - Constraining factors:
    - organizational issues in the sector in terms of human resources and distribution capacity.;
    - regulatory framework



***Developing market information systems and capacities of producer associations can overcome the problem of value chain fragmentation***

The fish value chain is fragmented and is not well organized. Thus, the following solutions can improve the value chain:

- *Developing market information system to improve efficiency*
- *Developing capacities of associations to follow and react on domestic and export markets developments and demands*
- *Developing research and advisory services to increase productivity and marketing*

# ***There is potential to increase the value of fish export from Djibouti***

The following interventions can improve fish export from Djibouti:

- *Establishing and enforcing private standards that would reflect domestic and export market preferences*
- *Export market developments, especially by opening new premium export markets*
- *Supporting the private sector in opening new export markets;*
- *Establishing a food safety system in the sector*
- *Inclusive value chain financing and micro-credit mechanism, which is inclusive of small-scale fishermen and women*
- *Financing and supporting cold chain and transport logistics*



# *Livestock Value Chain*

- The livestock sector
  - Has a significant contribution to the country's GDP
  - Makes up above three quarter of its agricultural GDP
- Livestock breeding is nomadic and the major activity of the rural population
  - Above 70 percent of Djibouti populations is engaged in pasture-based production systems
- Regional cattle export centre is already a significant advantage
  - It helps to improve the exportation and exploitation of cattle in conformity with the sanitary and veterinary requirements of the importing countries
  - It is regularly inspected by officials from the partner countries

## ***Djibouti can increase efficiency in livestock value chain by improving the weak coordination***

- Providing support to establish new and strengthen existing value chain-based innovation platforms and commodity associations/platforms
  - These platforms provide opportunities to bring together all value-chain actors to find solutions to challenges that affect the value chain as a whole
- Increasing awareness on the need to adopt value-chain approaches among key stakeholders in the region
- Range management policies especially those relating to forage/feeds and water management are critical
- Investing in research and dissemination of technologies and knowledge is important
- Improving veterinary services to improve livestock health and hence increase productivity
- Developing research and advisory services to increase productivity and marketing

## ***Promoting gender responsiveness in both fish and livestock value-chains is critical***

- The participation of women and other marginal groups in fishery and livestock value-chain activities is constrained by factors such as
    - unequal sharing of unpaid work
    - limited opportunity to develop capabilities (e.g. literacy skills, education),
    - mobility constrained by cultural practices and social norms,
    - differential poor access to and control over productive resources,
    - limited access to markets.
- ➔ *It is important to increase women's access to land, technologies, credit and other financial facilities, technical know-how, education and skill development*

## 2) Alternative agricultural production technologies to improve food security and to create income opportunities

- *Besides the above value chains – fish and livestock– fruits and vegetables are critical for nutrition security in Djibouti*
- *Alternative agricultural production technologies, such as hydroponics, can therefore have large potential in improve food and nutrition security as well as creating income opportunities in the country*



## ***Hydroponic vegetable production has huge potential in Djibouti where prices of F&V are much higher in Djibouti than neighboring countries***

- Djibouti relies on imports to meet its demand for fresh fruits and vegetables, with import costs of about US\$ 95 million in 2017 (UN COMTRADE 2018).
- And, prices of F&V are much higher in Djibouti than in neighboring countries (FAO, 2009)
- High vegetable prices make it much harder for poor households to meet their nutritious needs.
- According to sources that track costs of living indicates that, for example, the price of lettuce – a crops that can be grown in hydroponic farming – is around \$2/head in Djibouti, compared to a world average of \$ 1.2/head.
- *Thus hydroponic vegetable production could be a great alternative to these households to meet nutrition needs while at the same time offering an opportunity to generate income by selling excess production in local markets.*

# *Djibouti has potential to benefit from adoption of frontier agricultural technologies*

- Hydroponics/aquaponics can produce 7/8 out of 10 food groups essential for adequate dietary diversity and nutrition
- In the right markets, these technologies are viable for commercial production and can provide employment without necessitating advanced skills
- These are water and land efficient technologies
  - Hydroponics can use as little as 10 percent of water use of traditional agriculture
  - These technologies do not depend on large land availability.
- Some technologies are mobile and can be moved if necessary, making them suitable investments for non-permanent communities.

*Several nutritious food crops can be produced with alternative hydroponic systems*

Food Group	Foods that can be produced in hydroponics
White roots and tubers	White potatoes, yams, and beets
Vitamin A rich vegetables and tubers	Sweet potatoes, vitamin A rich yams, beets, carrots, bell peppers
Dark green leafy vegetables	Leafy greens, kale, swiss chard, arugula, micro-greens
Other vegetables	Radishes, celery, cucumbers, peppers, wheatgrass, onions, leeks, parsnips, squash, corn, bok choy, watercress, chives, broccoli, cauliflower, cabbage, radishes,
Other Fruit (non-vitamin A rich)	Tomatoes, watermelon, cantaloupe, strawberries, blackberries, raspberries, blueberries, grapes, dwarf citrus trees (lemons, limes, oranges), dwarf pomegranate tree, bananas
Legumes, nuts, and seeds	Beans, peas
Herbs / spices and condiments	Chives, oregano, mint, basil, sage, rosemary
Grains	Rice, barley
Fish and seafood	Pacu, prawns, carp, catfish, barramundi, goldfish, salmon, trout, mussels, crayfish, murray cod, koi, white bass, sardines, carp, sunfish, shrimp, silver perch, blue gill, tilapia
Sweets	Honey

## ***What are Djibouti's advantages to benefit from investments in frontier technologies?***

- Excellent conditions for using solar power
- High domestic food prices and few alternative options for production leaves more margins for food production with higher startup costs to be financially sustainable
- High real costs of factor inputs for conventional production, such as land and water inputs makes resource-efficient technologies more competitive in Djibouti
- Short geographic distances facilitate availing inputs and spare parts for more advanced technologies

# Which technology options are more suitable for Djibouti?

Technology	Food	Water Use <sup>+</sup>	Energy Use	Technological Complexity	Maintenance	Start-Up Cost	Financially self-sustaining	Mobility	Suitability for Djibouti
<b>Bio-intensive farming methods</b>	Crops	Medium	None	Simple	Low-medium	Low	Medium-High	Low-Medium	*****
<b>Wick Systems</b>	Crops	Low	None	Simple	High	Low	High	Low-High	****
<b>Deep Water Culture</b>	Crops	Low	Medium	Medium	Low	Medium-High	Medium	Low	***
<b>Ebb &amp; Flow</b>	Crop	Low	Low-High	Complex	High	Medium-High	Low	Low	*
<b>Drip Method</b>	Crop	Low	High	Complex	Low	Med-High	Low	Low	*
<b>Nutrient Film Technique</b>	Crops	Low	High	Complex	Med-High	High	Medium	Low	*
<b>Aquaponics</b>	Crops & Fish	Low	Low-High <sup>**</sup>	Complex	High	Medium-High	Low	Low	**
<b>Aeroponics</b>	Crops	Low	High <sup>+++</sup>	Complex	High	High	High	Low	*

Source: Adapted from Verner et. al., 2017

<sup>+</sup> Open systems recirculate water closed systems do not recirculate water

<sup>\*\*</sup>Based on international farm-budgets, not specific for Djibouti.

<sup>+++</sup>Depending upon pump size and heating requirements. Aquaponics require a constant electrical source or backup energy (battery, generator).

## ***Access to finance, inputs, and skills will be necessary to unleash the new technologies***

*Different approaches will be needed to target entrepreneurs vs. small-scale subsistence producers*

- **Finance for start-up costs:** equipment, solar panels, simple building-structures.
- **Inputs and equipment:** mobilize input providers for easily accessible liquid mineral fertilizers or salt blends for hydroponics; filters and spare-parts with domestic distributors for more advanced technologies.
- **Skills:** Specially trained extension staff or formal collaboration with NGOs or commercial off-takers to provide skills and support services. Options for advisory services via mobile phones, e.g. cost-free phone-services, apps, and/or other.
- **Alternative service providers:** Skills for technologies targeting household subsistence farming that are mainly for food security and increasing dietary diversity may be disseminated via NGO's or women's health centers, rather than traditional extension services.

## ***Despite challenges for adoption of frontier technologies, these technologies are economically viable in Djibouti***

- High initial costs of the system might be a serious constraint for small and largely poor holders.
  - So, financing of these system is also a question to be explored.
- The system requires constant supervision, technical knowledge and expertise. In Djibouti, however, above half of the total population and 68 percent of women are illiterate.
- These systems can also become susceptible to power outage – one of the key problems for business in Djibouti.
  - Above 10 percent of electricity is generated by private generators
- There is also a risk of high temperature, saline water, and possible disease propagation
- Rough estimates using local input costs and current lettuce world price shows that investing in a deep-water culture hydroponic farm using a 285 sq meter greenhouse would be commercially viable, yielding an annual financial return of about US\$1030.
- *Yet, detailed business plans are recommended for private and public investments in frontier ag technologies*
- *And, available hydroponic techniques should be first tested and adapted to the country's conditions, before scaling-up the system.*

## ***Key policy recommendations***

<b>Area</b>	<b>Key Actions to be Taken</b>
<b>Fish value chain</b>	<ul style="list-style-type: none"><li>• Increase women's access to technologies, credit and other financial facilities, technical know-how, education and skill development</li><li>• Support development of logistics and cold warehousing nodes</li><li>• Establishing a food safety and quality system along the entire fish value chain</li><li>• Facilitate smallholder-driven value chain development through farmer cooperation, advisory service development, and market access measures</li></ul>
<b>Livestock value chain</b>	<ul style="list-style-type: none"><li>• Increase women's access to land, technologies, credit and other financial facilities, technical know-how, education and skill development</li><li>• Support development of logistics and cold chain infrastructure</li><li>• Develop rangeland management policies especially those relating to forage/feeds and water management</li><li>• Support R&amp;D and dissemination of technologies</li><li>• Invest in advanced veterinary services to improve livestock health and livestock productivity</li></ul>
<b>Alternative frontier technologies</b>	<ul style="list-style-type: none"><li>• Capacity building and skill development</li><li>• Financing of start ups</li><li>• Alternative service providers: Skills for technologies targeting household subsistence farming that are mainly for increasing dietary diversity may be disseminated via NGO's (e.g. Care Int.) or women's health centers, where traditional extension services are not present.</li><li>• Developing nutrition awareness creation platform</li></ul>