
II.

AGRICULTURE VS FOOD SUPPLY



ETH Studio Basel
Contemporary City Institute
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Spring Semester 2013

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II. AGRICULTURE VS FOOD SUPPLY TRADITIONS AND NEW TENDENCIES

A SELF-SUFFICIENT DESERT COUNTRY?

Geographic Specificity
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KEEPING UP WITH MODERNIZED OMAN

Impact of Modernization
Measures Taken by the Government
Approaches to Supply Modernized Oman

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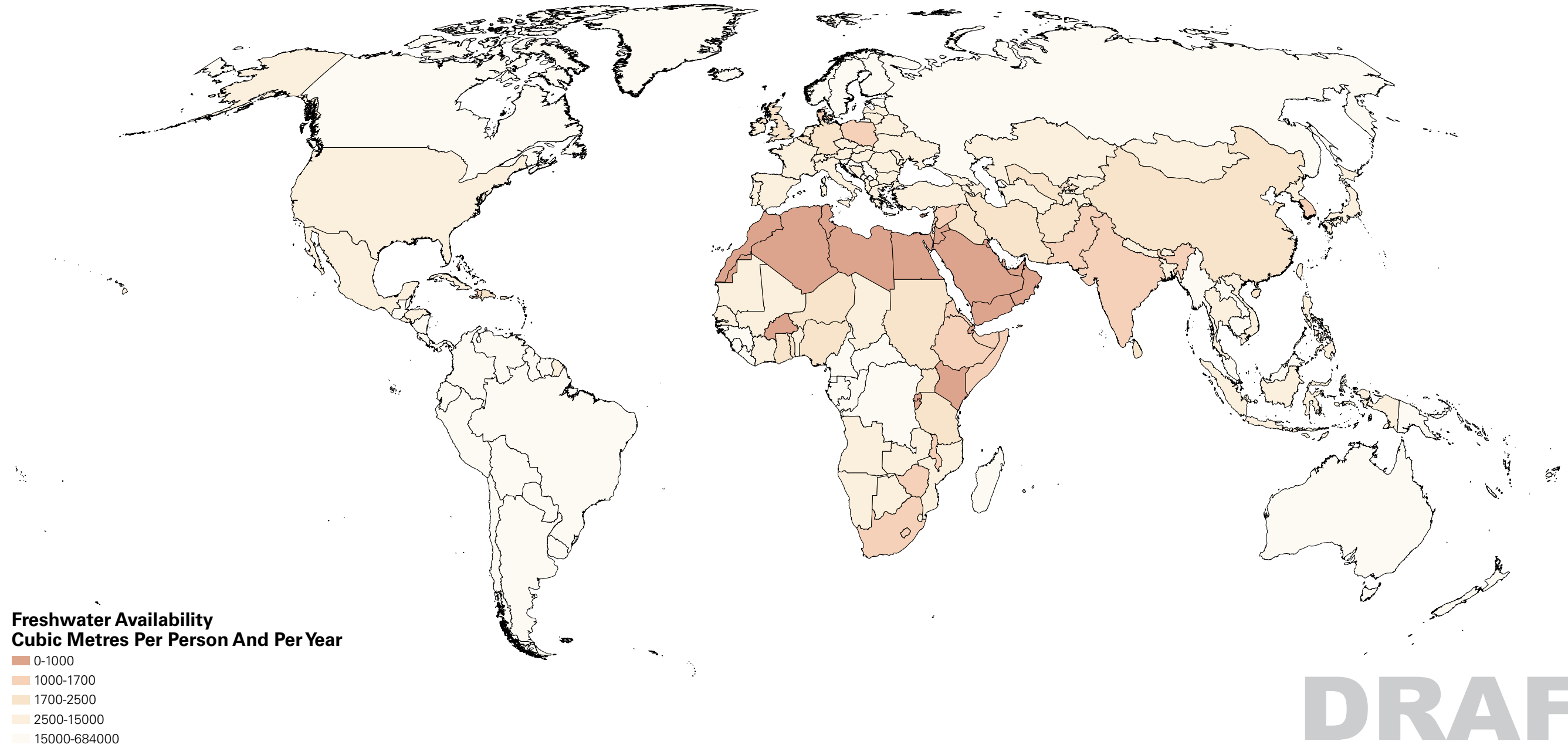
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A SELF-SUFFICIENT DESERT COUNTRY?

Situated on the Arab Peninsula Oman is among the driest countries in the world. But unlike its neighbours Oman has got fertile areas, this is possible because of one mountain range in the north and one in the south of the country which make the air condensate and therefore allow precipitation. Hence Oman has got a heritage of farming and most important the Aflaj, a traditional water management system which is still today observable in oasis settlements. Because of the discovery of oil and the following demographic change the need for food has increased enormously since 1970. Strange enough the government aspires towards self-sufficiency which seems a to be a very ambitious aim regarding the available resources and conditions.





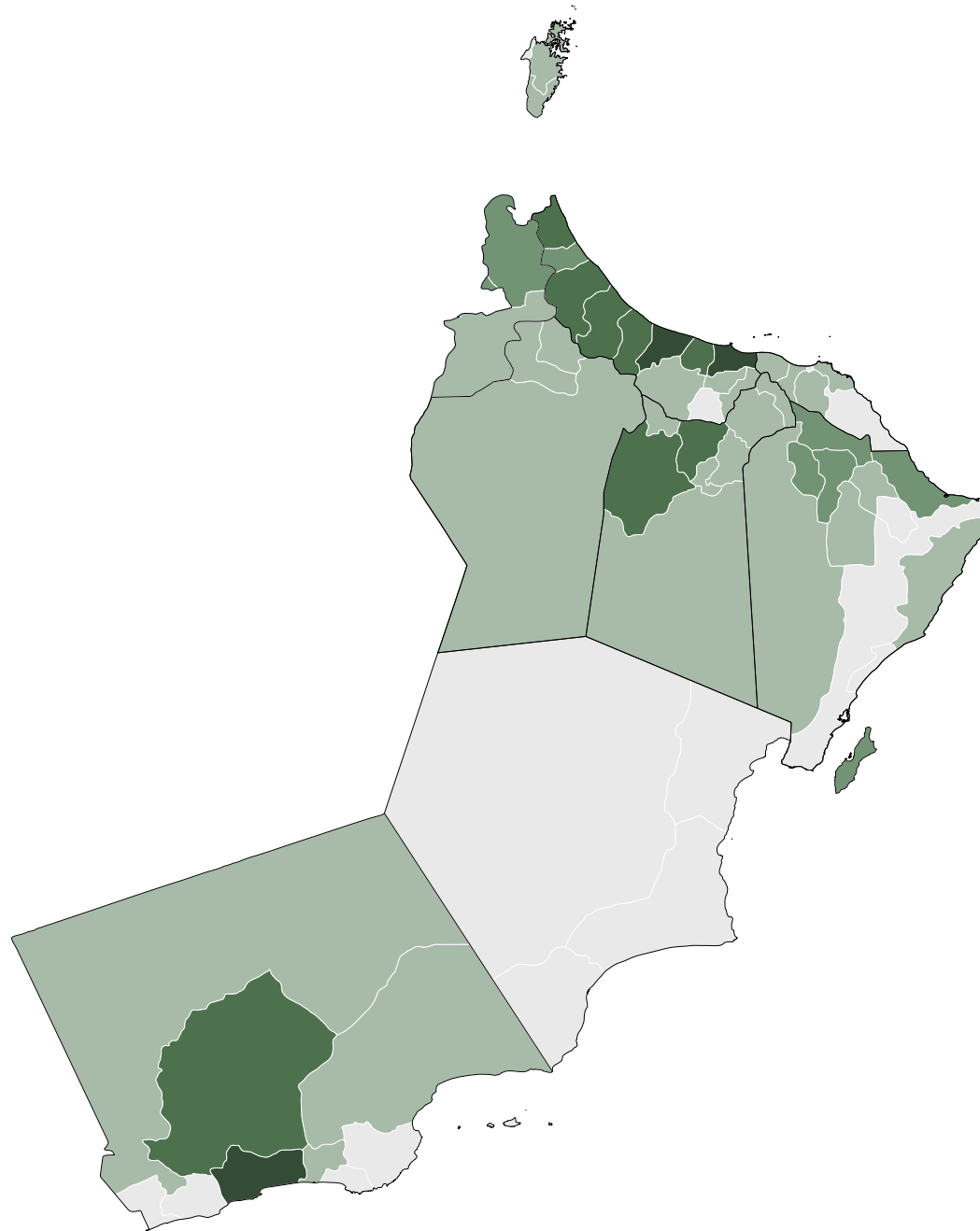

Geographic Specificity

The topography i.e. precipitation and the consistence of soil is crucial for any type of agriculture. In Oman, a country with approximately the size of Italy which consists of 81% desert area these special conditions are only found in the costal plains enclosed by the Jebel Akhdar Mountains in the north and the Dhofar Mountains in the south of the country.




Fertile Areas

Northern Al-Batinah plain and southern Salalah Plain have a similar soil type which becomes cultivable under irrigation. The climate though differs from arid to semi-arid in the Al-Batinah to a monsoon climate in the Salalah Plain.

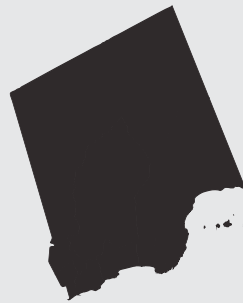
Oman

- 2.8 Mio Population
- 1/3 of the Population Employed in Agricultural Sector
- 30'950'100 ha Total Area
- 72'588 ha Cultivated Area
- 2% GDP Contribution



Al-Batinah Plain

- 772'500 Population, 28% of Total
- 1'250'000 ha Total Area
- 43'446 ha Cultivated Area
- 44% of Arable Land used for Profitable Production

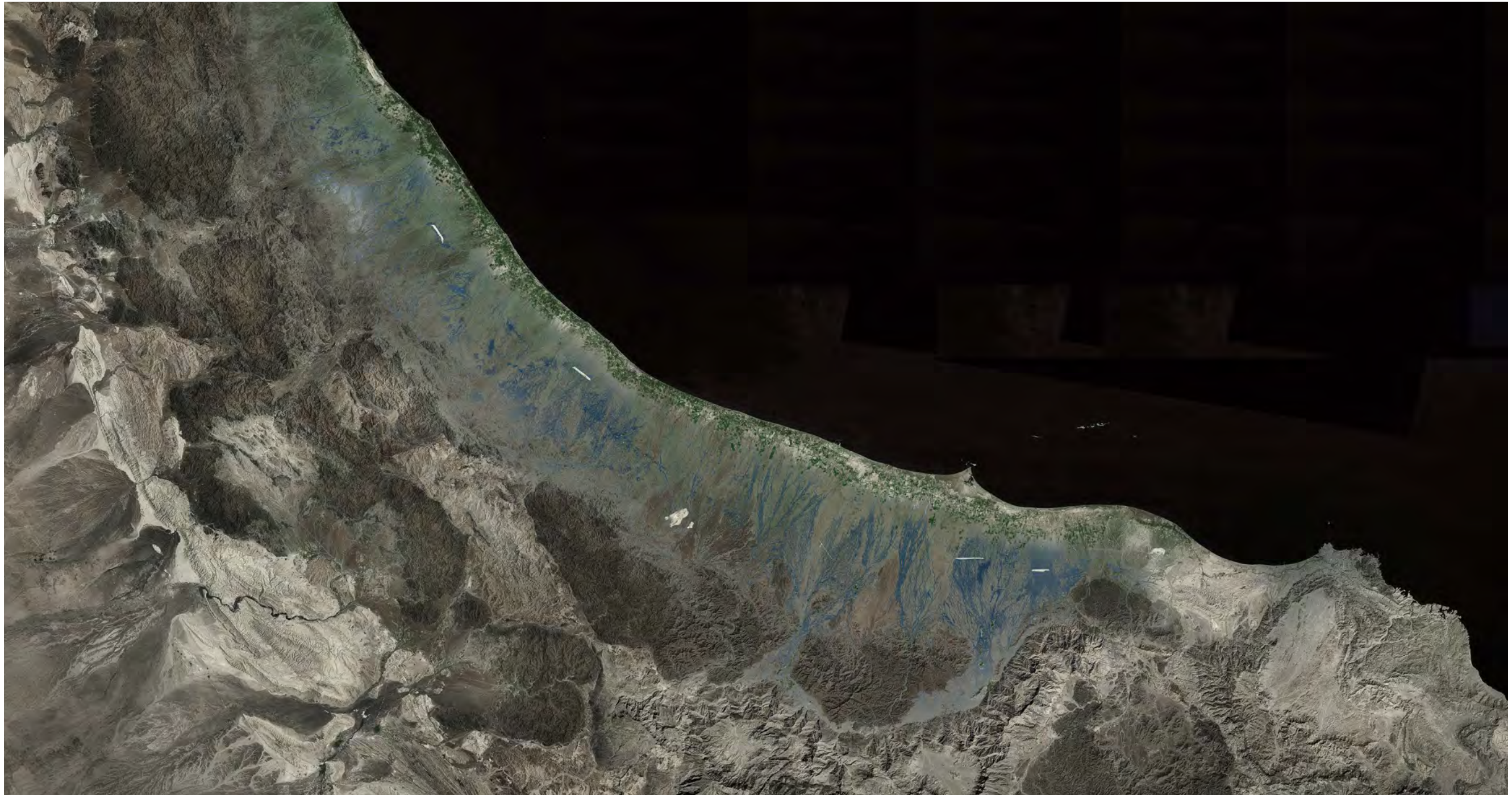


Dhofar

- 249'729 Population, 9% of Total
- 9'930'000 ha Total Area
- 14'927 ha Cultivated Area
- 29.9% of Arable Land used for Profitable Production

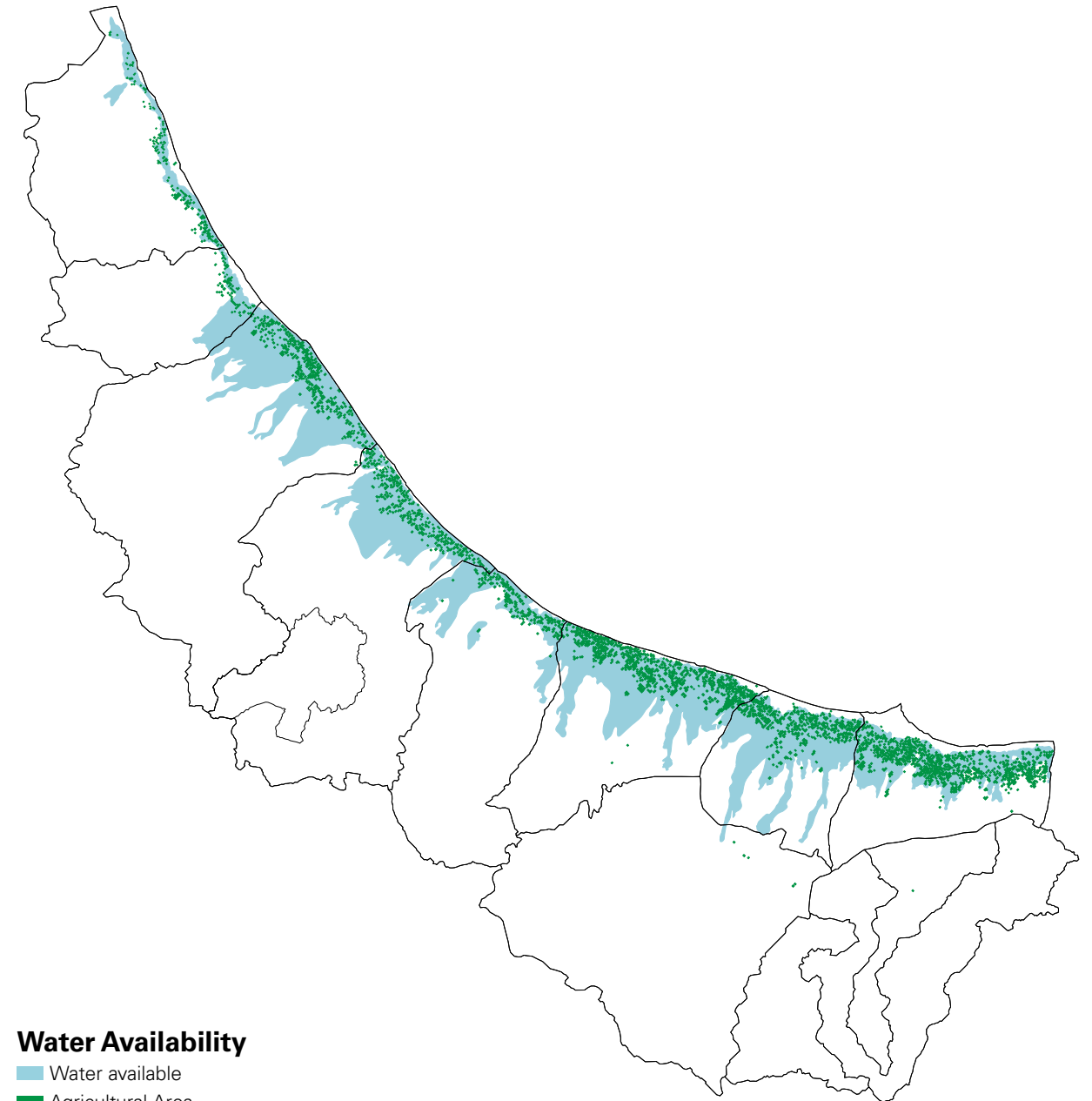
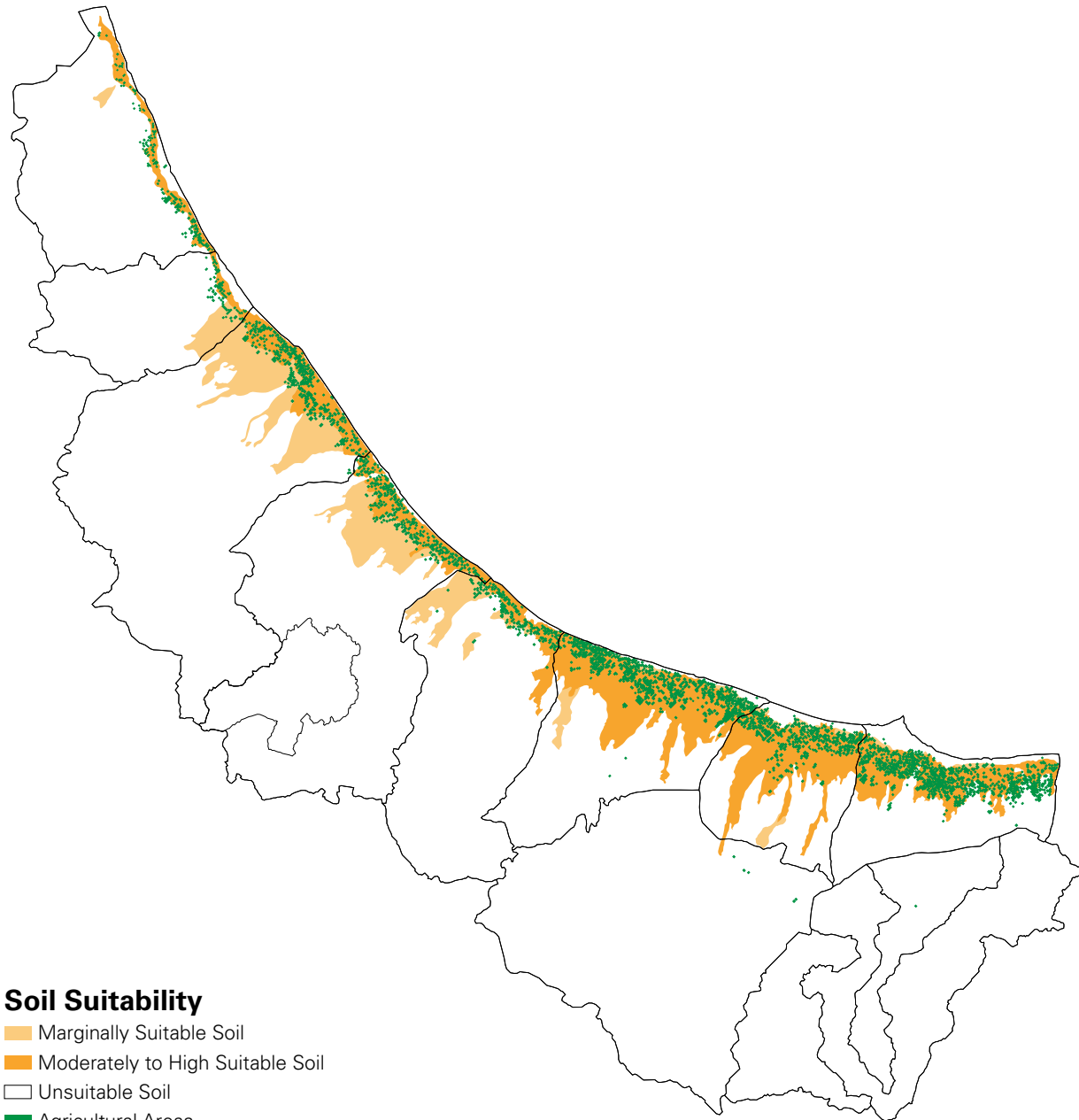
Arable Land Used for Profitable Production

Major parts of Oman consist only of desert this is also reflected in the areal contribution to the agricultural market. Only the Al-Batinah Plain and the Salalah Plain play a relevant role for the countries agricultural output based on the amount of land used for agriculture.



Breadbasket Al-Batinah Plain?

In such a dry country as Oman special attention is to put on a very fertile and productive area as is the Al-Batinah Plain, origin of all vegetables of domestic production and being home for two thirds of the population. Can the production of this area meet all needs of supply in order to achieve the aim of self-sustainability although all water resources are already overused, saline intrusion is increasing and the availability of cultivable land itself is very limited?



Soil Suitability

- Marginally Suitable Soil
- Moderately to High Suitable Soil
- Unsuitable Soil
- Agricultural Areas

Land Fertility

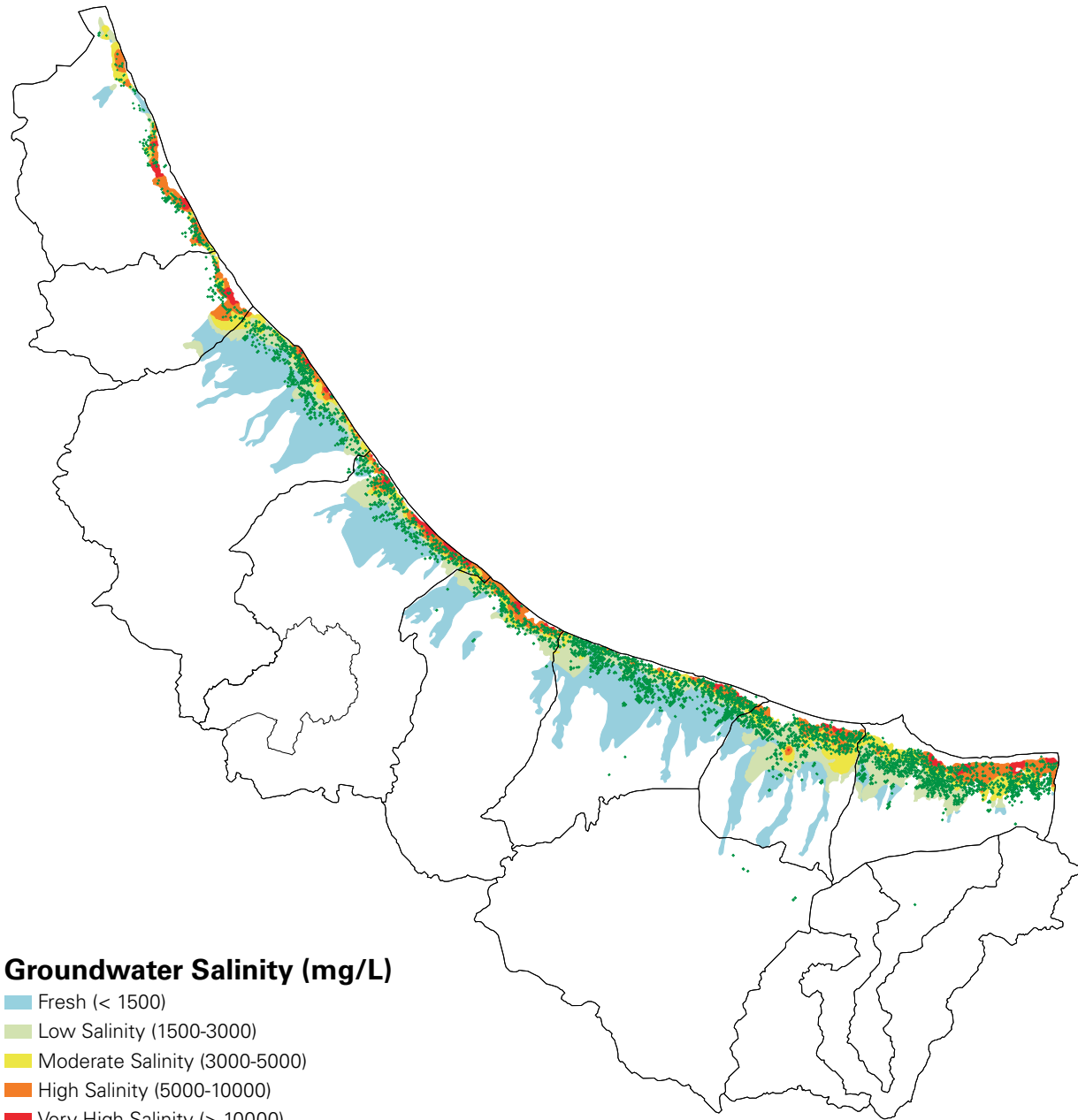
The suitability for agricultural land use is strongly connected to its fertility. In the Al-Batinah Plain the soil suitability is at its highest closest to the coast and decreasing in the wadi runoff areas. Hence most of the agriculture can be found closer to the coast.

Water Availability

- Water available
- Agricultural Area

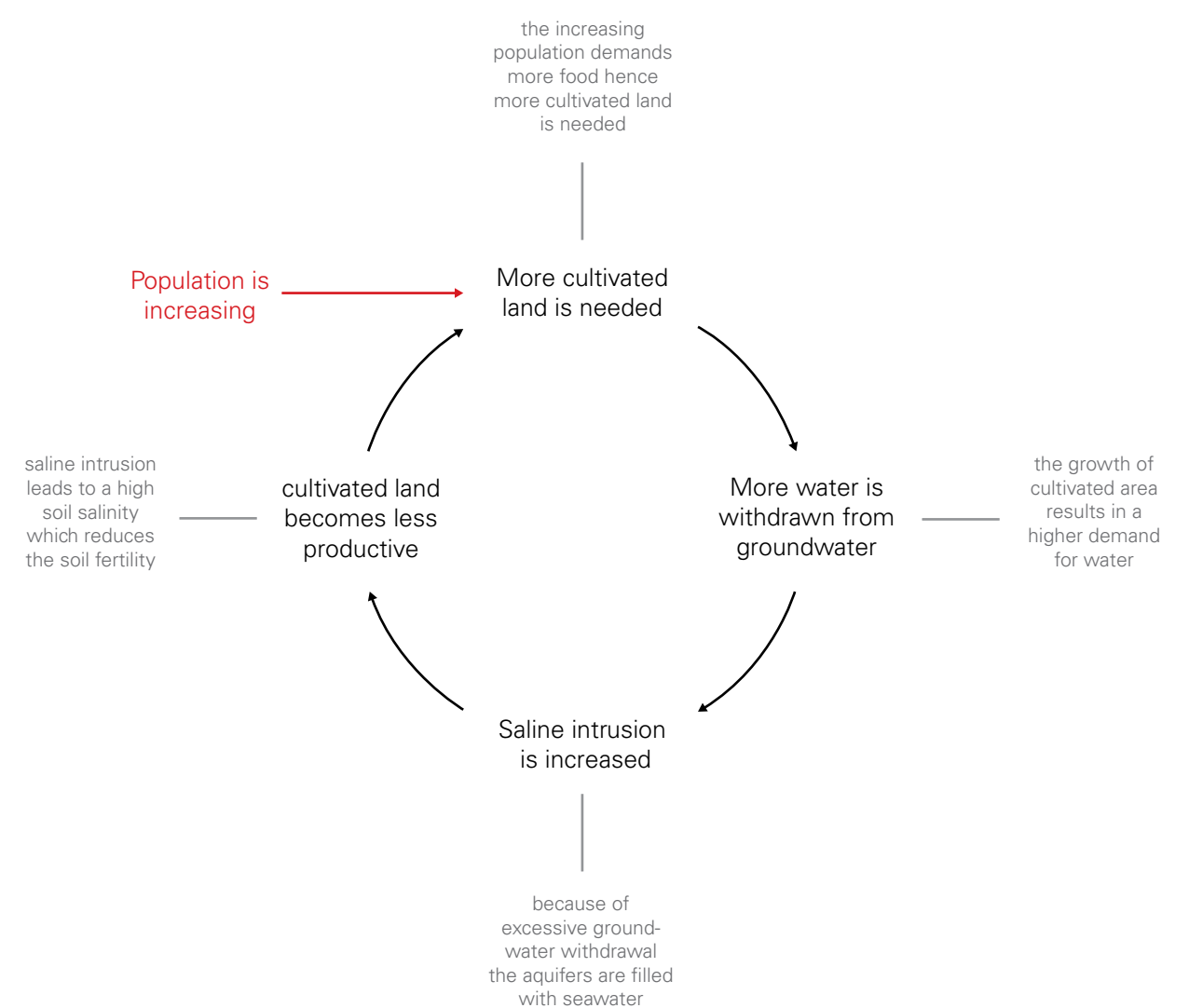
Groundwater Availability

The runoff which is found during the few annual days of heavy rainfall is distributed by wadis, dried out riverbeds, from the Jebel Akhdar Mountains down to the coastal plain. It becomes apparent that the soil fertility strongly correlates with the availability of water.



Groundwater Salinity

The excessive use of electrically pumped wells results in an alarmingly high groundwater withdrawal which leads to saline intrusion and ultimately results in a very high groundwater salinity. This reduces the land fertility and clearly has a big impact on the productivity of the whole area.



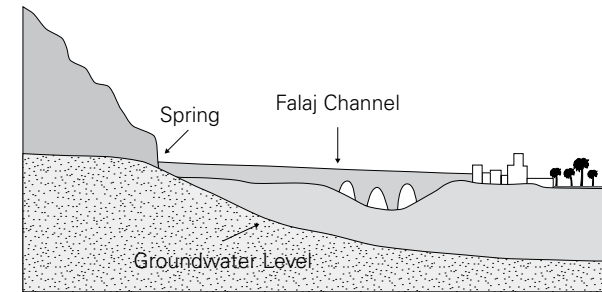
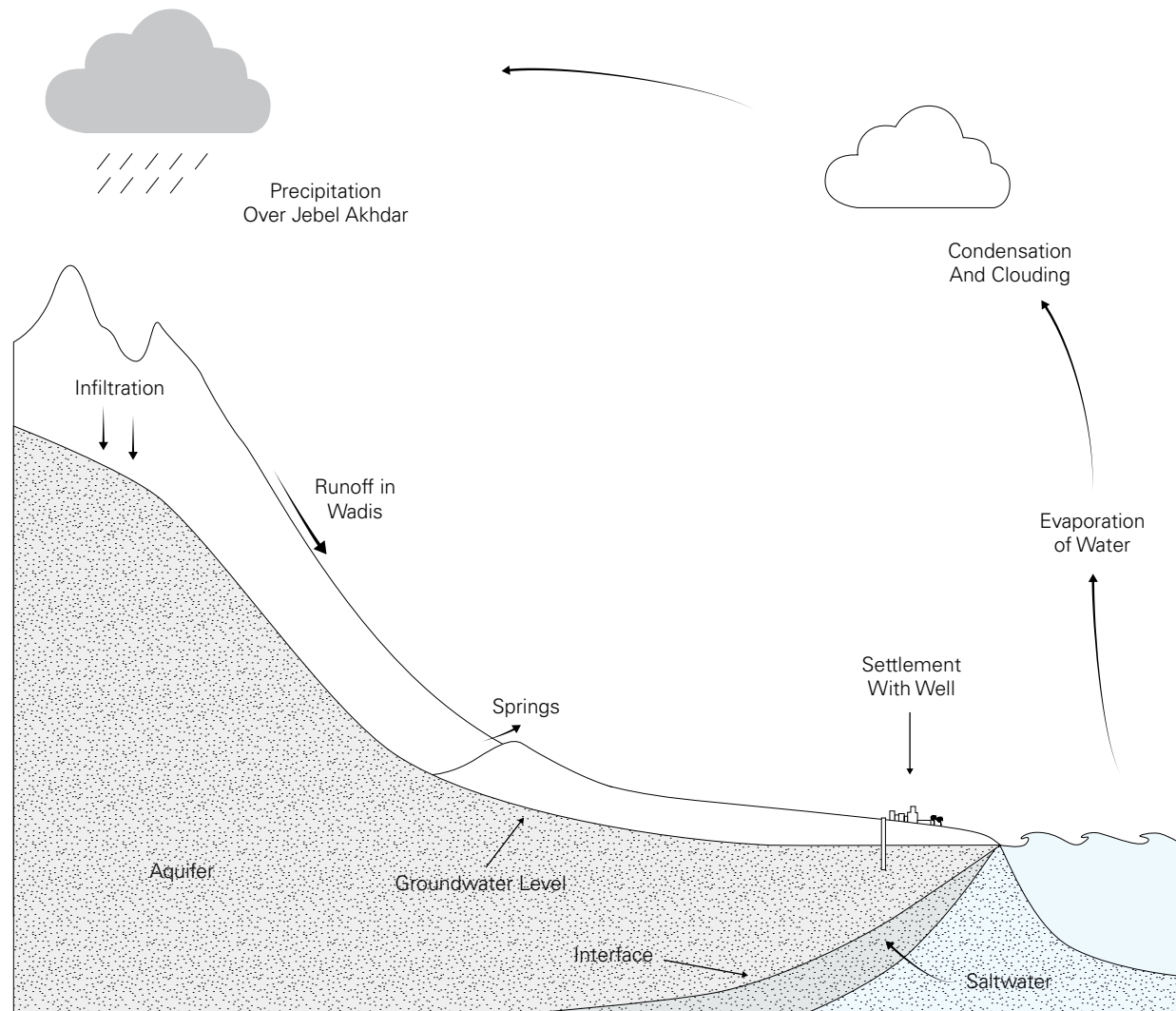
Vicious Circle

Oman's population is constantly growing which results in an increasing demand for agricultural goods. With the limited resources and the apparent disturbance of the former system Oman will not achieve its aim of a self-sufficient country unless serious measures in water management and technologization in agriculture are taken.

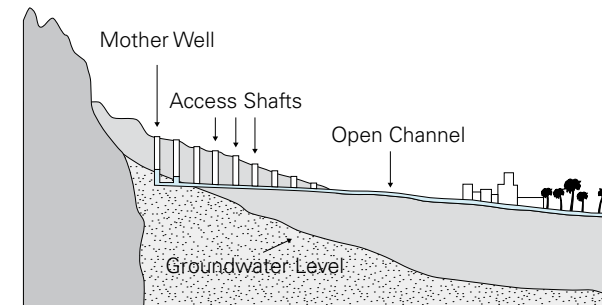
WATER CYCLE UNDER PRESSURE

In the past centuries the Omani developed a highly sophisticated and regulated water management system in order to meet everyone's demand. But since Oman started drilling oil and thereby multiplied its wealth, the country has undergone a rapid modernization. This development was accompanied by a remarkable population increase and industrialization, especially in the comparatively well supplied Al-batinah Region. It is evident that the available water resources can not satisfy the increasingly upcoming demand of people, industries and agriculture. This is particularly reflected when observing the momentary water consumption which is at 124% of the available water resources.

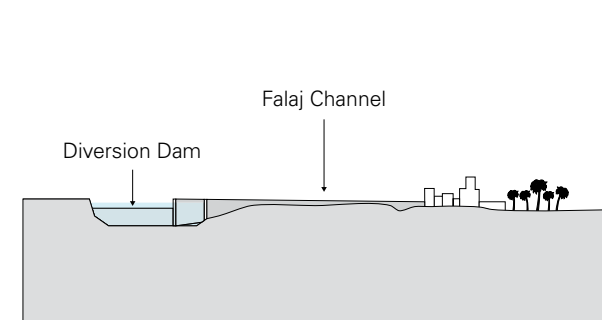




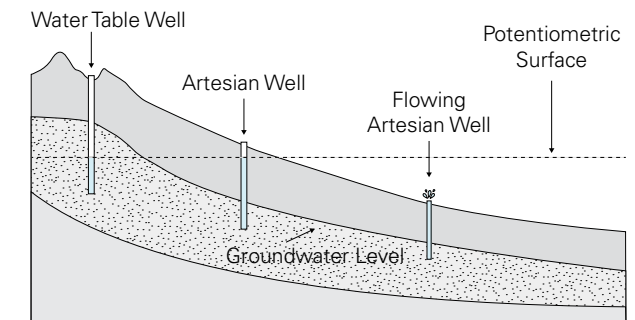
Aini Falaj, water from natural spring



Daudi Falaj, water from dug mountain well



Ghaili Falaj, water from wadi



Well, groundwater

Water Cycle Before "The Renaissance"

The particular topographic circumstances provided necessary frame conditions for an agricultural tradition and heritage, over centuries crops were grown in fertile Al-Batinah region. Water scarcity was always a key issue but an equilibrium was established which made it possible to supply Oman's inhabitants. The absence of modern technologies made it impossible to withdraw more water than naturally available thus it was only used as long as easily reachable which certainly protected Oman's resources.

Aflaj

Traditional water management is regulated and distributed by open channels, the Aflaj. The water is collected directly from natural springs or dug mountain wells or redirected from a wadi and then, by falaj, led directly to the settlements where it is distributed on the fields.

Wells

Dug wells have been existing for centuries, they withdraw directly from the groundwater aquifers which are refilled by rainwater infiltration. Nowadays every farm on the Al-Batinah Plain has got its own well, this excessive use of electrically pumped wells threatens the freshwater supply.

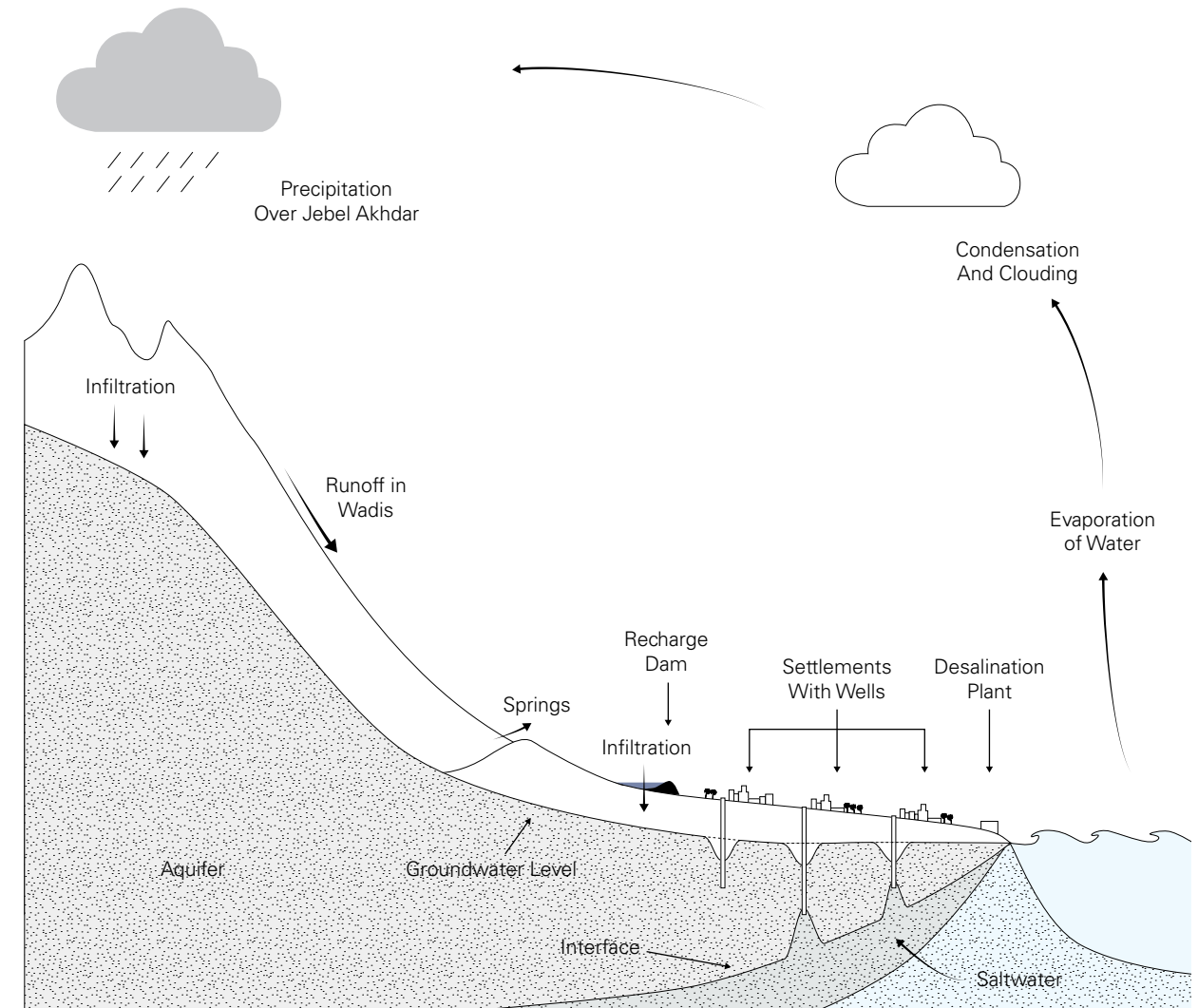


Traditional Oasis

- Palmgrooves
- Agriculture
- Falaj
- Wadi

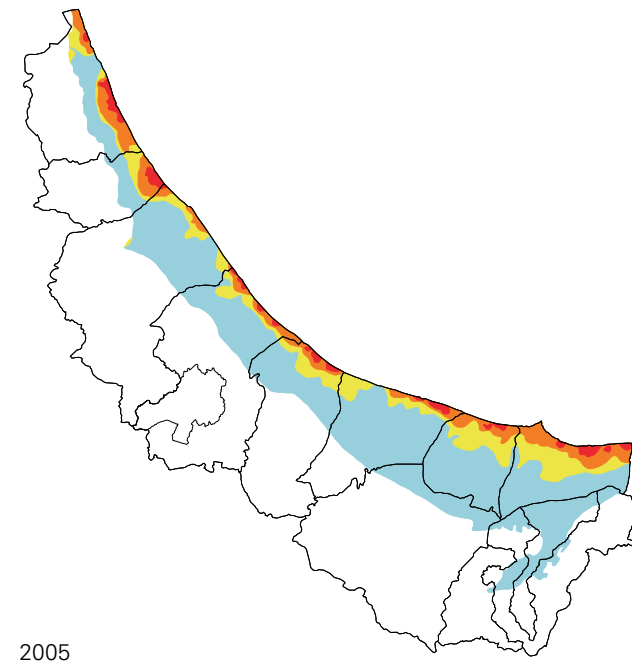
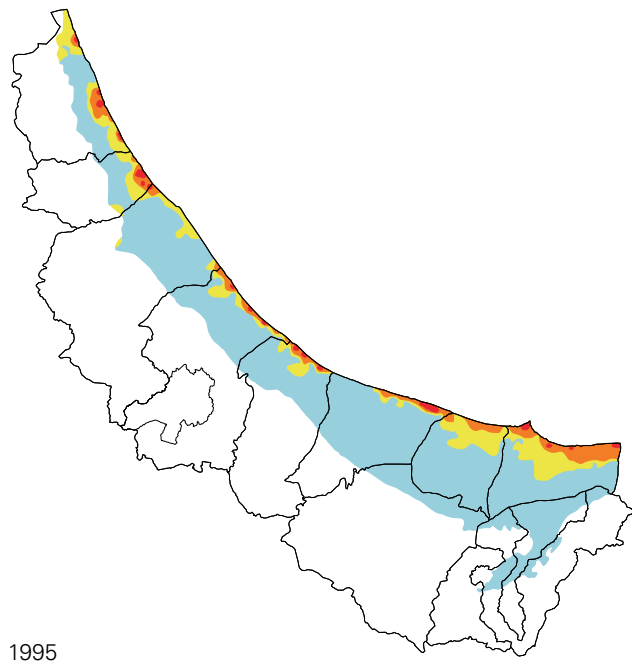
Traditional Water Distribution System

Before the Water was used for irrigation drinking water was withdrawn, then the Falaj was led through the mosque and the mosque wash place before it passed the fort and was finally distributed on the fields.



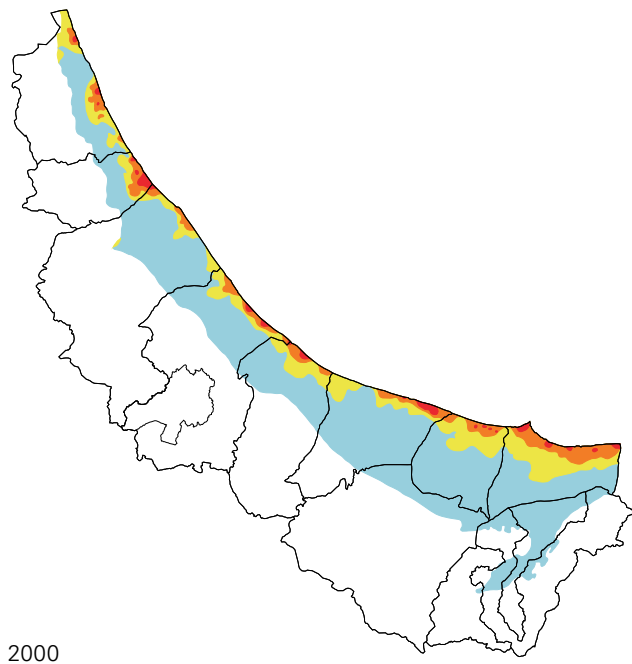
Overuse and Quick Fixes

After new technologies became available and the population of Oman kept constantly growing the country got more and more urbanized which was accompanied by an increasing demand for agricultural products. Hence the agricultural sector had to become more productive. More wells were dug and irresponsible amounts of water were withdrawn. This behavior resulted in saline intrusion and thereby to high groundwater salinity. Nowadays several measures are taken to react on this problem. Water withdrawal has undergone harsh restrictions, recharge dams have been built in order to allow rainwater infiltration and desalination plants have been established to make seawater usable.

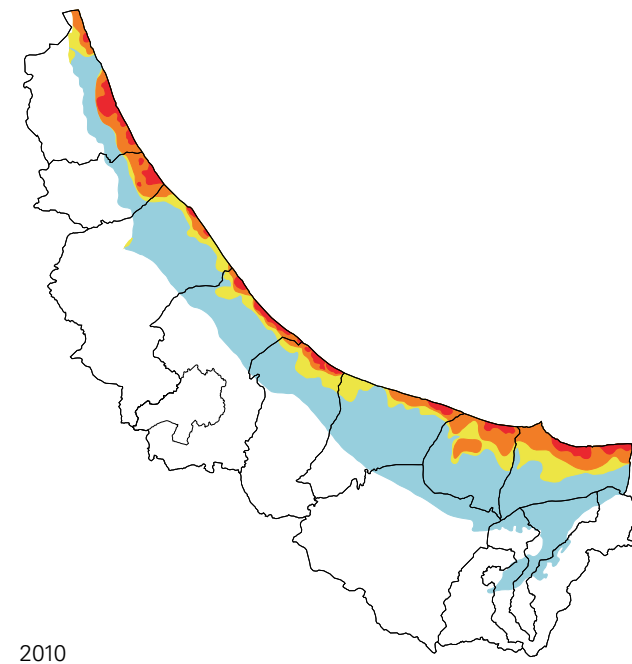


1995

2005



2000



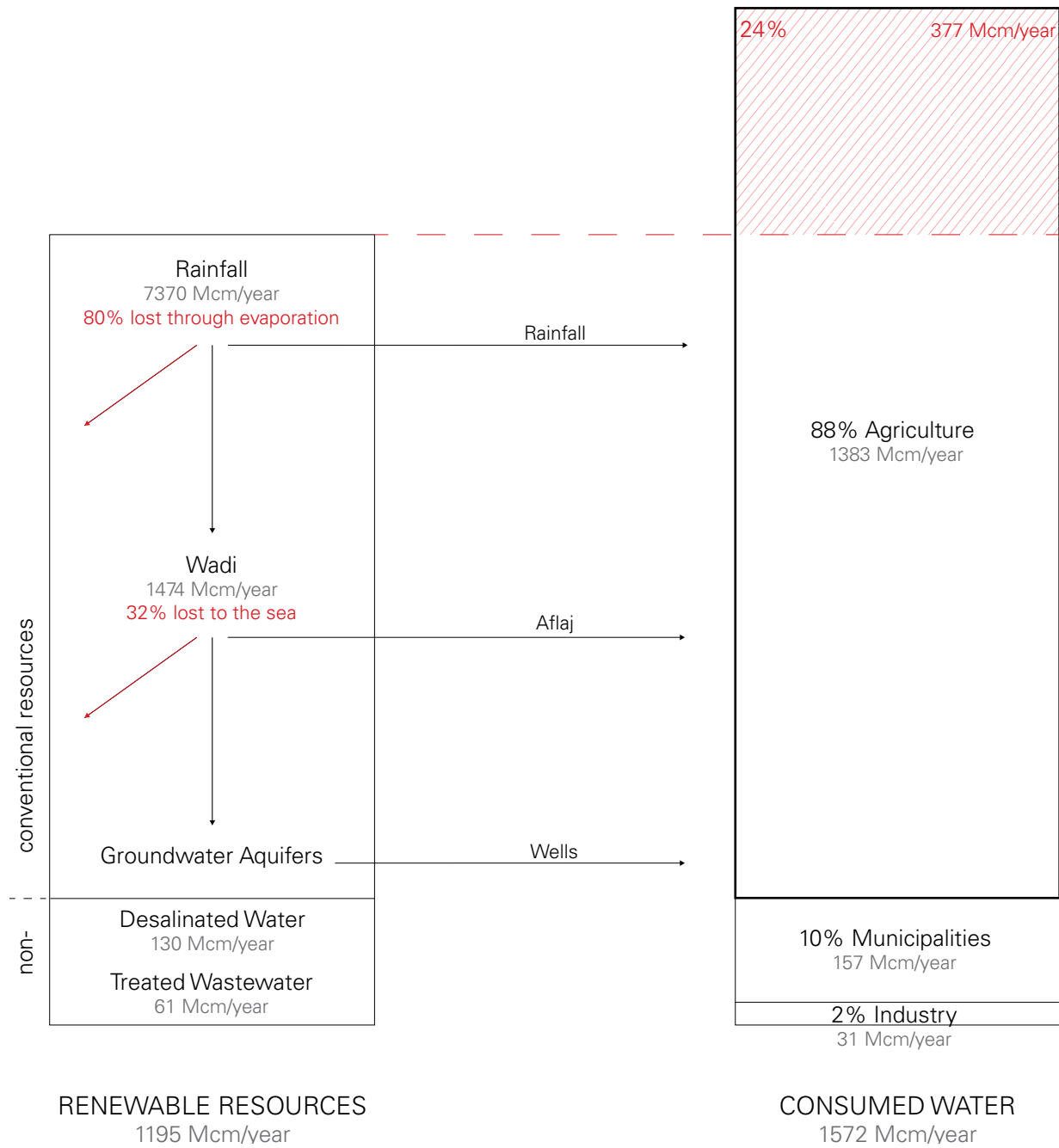
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Saline Intrusion

Due to excessive groundwater withdrawal the amount of infiltrating rainwater is not able to keep up the former balance. Thus saline water from the sea is refilling the groundwater aquifers. While farmers carry on using this pumped salty water for irrigating their fields the soil fertility is strongly diminished.

Groundwater Salinity (mg/L)

- Fresh (< 1500)
- Moderate Salinity (1500-5000)
- High Salinity (5000-10000)
- Very High Salinity (> 10000)



Falaj surface irrigation



Sprinkler irrigation



Localized drip irrigation



Negative Water Balance

Observing Oman's water consumption underlines the inefficiency of the present agricultural water management. The unbelievable share of 88% which is consumed for irrigation compared to a 2% contribution to the GDP seems ridiculous. However most alarming is the fact that 24% non renewable water is withdrawn each year which threatens the overall water supply and soil fertility.

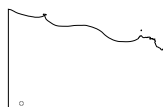
Irrigation

While most farms still use traditional flooding irrigation fed by falaj or wells also usual sprinkler irrigation can be found but the dripping tubes, the most efficient way of irrigation is not widespread yet. usual sprinkler irrigation can be found but the dripping tubes, the most efficient way of irrigation

A FARMERS INVENTORY

On the Al-Batinah Plain between the coast and the Jebel Akdahr Mountains a whole spectrum of different farmers can be found. Some of them holding on to a traditional lifestyle, giving great importance to heritage and family values while others seize to catch up with the rapid development of Oman. Furthermore an exceptional example of a highly efficient agricultural company.





Sunnar: Picturesque Oasis Farm

In the back of a valley in the Jebel Akhdar Mountains directly besides a wadi Ibrahim and his family hold on to the traditional farmers lifestyle. A drought lasting for already seven years puts the whole village in difficulties, parts of the land can not be irrigated anymore hence the yield is decreasing.

	owner		workers
	female family members		tools / machinery
	male family members		trade
	house		
	1.5 feddan		
	water source and irrigation		



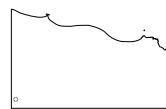
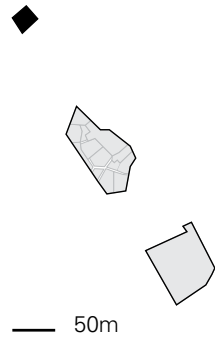
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A Traditional Oasis

The people of Sunnar enjoy living in their village of long tradition, the houses are still like they used to be. But since a new road has been built modern influence becomes apparent. A new mosque has been built and desalinated drinking water is pumped up the valley.



Istal: Traditional Lifestyle Farm

Located in a mountain valley close to the city Al-Awabi Hamad lives the life of a traditional farmer. A Hospital built in 1987 made the village important for the whole valley. Since a new road was built two years ago it became possible to work in other cities and have access to supermarkets in the region.

	owner		worker
	female family members		tools / machinery
	male family members		cows
	house		goats
	1 feddan		trade
	water source and irrigation		

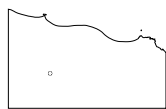
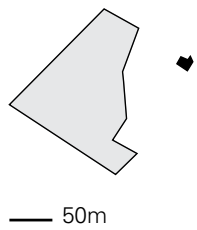


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The Farm Does Not Supply a Family

Hamad likes cultivating his own crops but for more than occasional exchange with his neighbors his farm is too small. To supply his family he needs to rely on his sons who work in nearby cities. He himself earns some extra money by driving the school bus of the village.



Nakhl: Farm on the Urban Edge

At the border of Al-Batinah Plain in Nakhl an obvious clash between tradition and modernization is observable. Since nearby an allotment area with new houses was established the whole traditional vil- lage of Nakhl was abandoned and is now used only for agriculture.

	owner		worker
	female family members		tools / machinery
	male family members		goats
	house		sheep
	6.5 feddan		local market
	water source and irrigation		

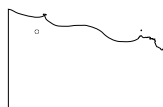
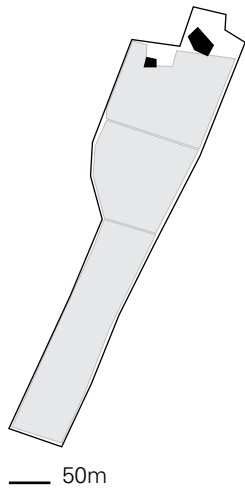


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Land Allotment

Before he retired and was still working in the army Nasser had the possibility to buy allotted land in the new part of Nakhl he built a modern house and moved out of the traditional home which belonged to his parents. Since then the old house is being used as a shelter for his sheep and goats. The land he is cultivating he bought partly from his brothers who were not interested in maintaining the family farm. Being asked about any help from the government he tells a story about a plane spraying pesticides against a palm disease over the whole area.



Billa 1: Between Farm and Garden

South of the coastal highway in the Barka wilayat this farm is found in a small organic settlement. Farm and farming license the two brothers inherited from their father and decided not to divide the farm. All the family members work in Barka or Muscat while the farm is operated by their workers.

	owners		workers
	female family members		tools / machinery
	male family members		cow
	house		goats
	6.5 feddan		trade
	water source and irrigation		

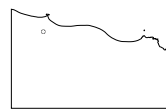
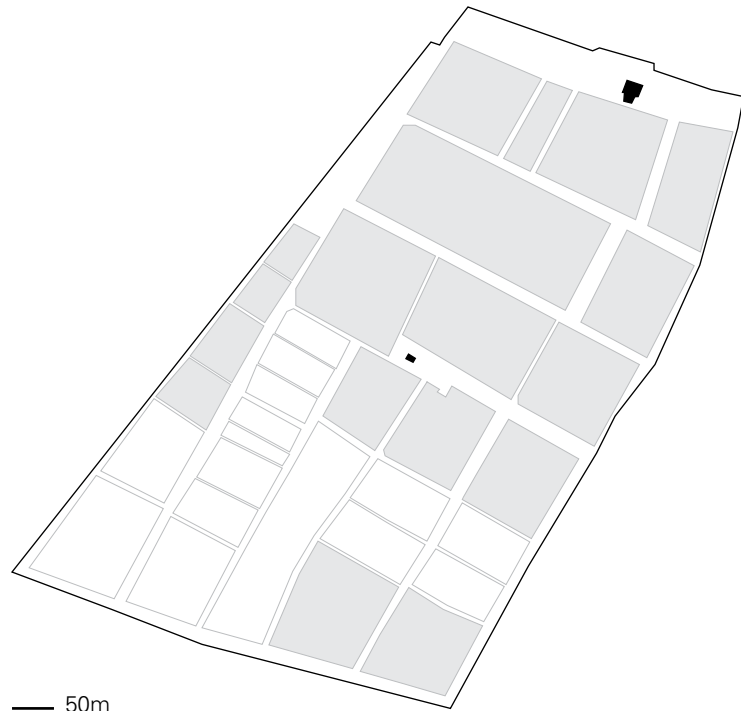




The Farm as Family Heritage

Since everyone has got a job in the city the farm is kept out of its heritage value and family pride. Also the next generation is not planning to divide the farm in order to keep it a reasonable size. The water supply is secured with a license for one well and luckily they are not yet affected by saline intrusion.

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Murayjat: A Farm as Family Heritage

Located in Barka wilayat, Saeed and his brother overtook the farm from their father, sheik of the local tribe. The farm is in the family for a long time and this shouldn't change in future. Instead of dividing it they rather built new houses for the growing family in order to look after the farm together.

	owners		10	workers
	female family members			tools / machinery
	male family members		120+	camels
	4			local market
	76 feddan			
	water source and irrigation			

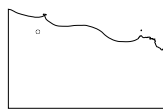
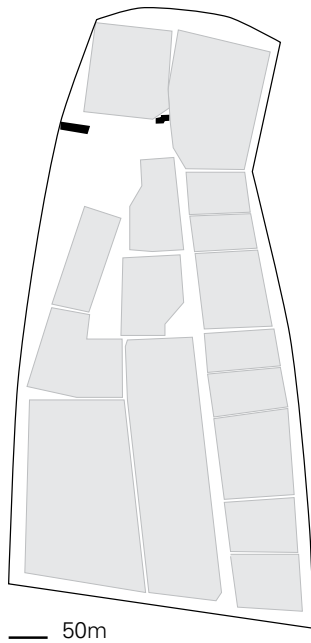


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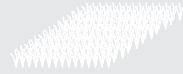



Camels Make the Money

Even though they cultivate their land the farm is not very productive, usually they only use half of the area for cultivation in order to let the other half rest for a year. Most effort they put into camel breeding because of its tradition and profitability.



Billa 2: Traditional Production Farm

The farm manages to profitably produce agricultural goods, the farmers had access to governmental programs of knowledge transfer and received subsidies for a modern irrigation system. But a planned expansion is not possible because the government has already other plans with the surrounding land.

	owners		8-30 workers
	female family members		tools / machinery
	male family members		5 cows
	house		20 goats
	43 feddan		14 sheep
	water source and irrigation		local market

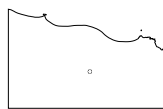
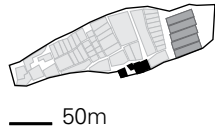


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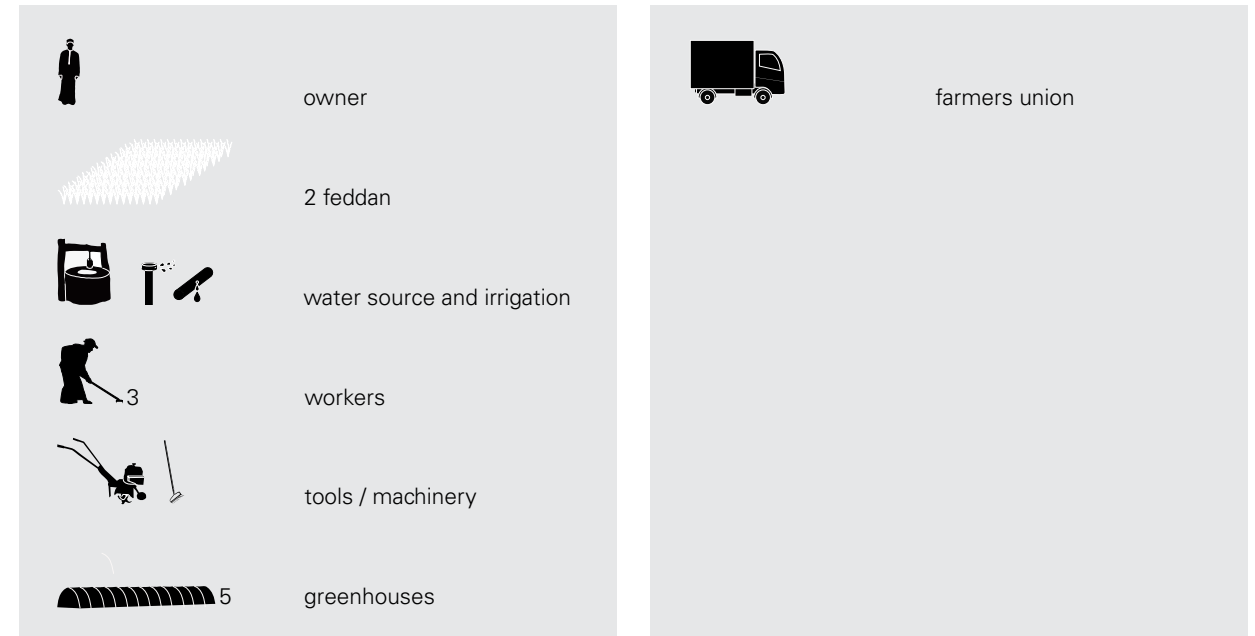
Uncertain Future

Although Ramis and his brother can provide for their families, the eldest son who should take over is not interested and none of the other children is. This makes the future of the farm very uncertain. Nonetheless they plan to replace the old family home, which is housing both families at the moment, with a new one. Like most Omanis they don't work on the fields themselves but have workers hired up to 30 in the harvest season.



Bidbid: A Modernized Farm

In a small traditional oasis this farm is the only example of a modern approach to farming. Subsidized by the government the farm is only used for production and not connected to any family or emotional values. The owner lives in another city from where he is managing his business.



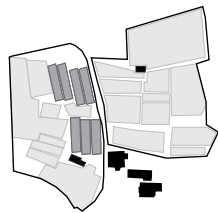
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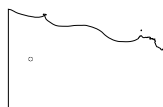


Distribution in the Region

On the small area available by the use of air-conditioned greenhouses the productivity is enhanced a lot. With a small local desalination unit the water gets purified to achieve best growing conditions. The cucumbers get picked up by trucks of the farmers union on a regular basis which is then organizing the distribution in the whole region.









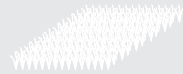




50m



Khatum: Business Farm

Khalifa is eager to make his farm profitable. With his air-conditioned greenhouses, which were subsidized by the government, he can achieve high productivity. He even wants to expand, with a special governmental program he will be given additional 25 feddan which he can keep, if productive.

	owners	 5	workers
	female family members		tools / machinery
	male family members	 7	greenhouses
	house		cows
	4 feddan		farmers union
	water source and irrigation		



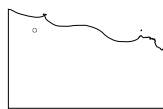
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An Ambitious Entrepreneur








Even though his farm is cultivated only with traditional tools and no machinery thanks to modern irrigation systems, greenhouses and seeds from Holland he can produce enough for a weekly collection by the farmers union. The farm used to be bigger but when it was inherited by him and his brother it got divided. The difference couldn't be more obvious, he is producing as much as possible and his brother is lazy and holds on to traditional and easy date production.

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Tawoos: An Agricultural Company

This highly efficient farm is the biggest agricultural company and thereby biggest producer of vegetables in the GCC. The goods are distributed in the whole country and 30% of the production is exported worldwide. Despite the big importance for Oman they don't get any support from the government.

	owners		national and international
	1070 feddan		
	6		
	550		
			
	30		
	water source and irrigation		
	workers		
	tools / machinery		
	greenhouses		



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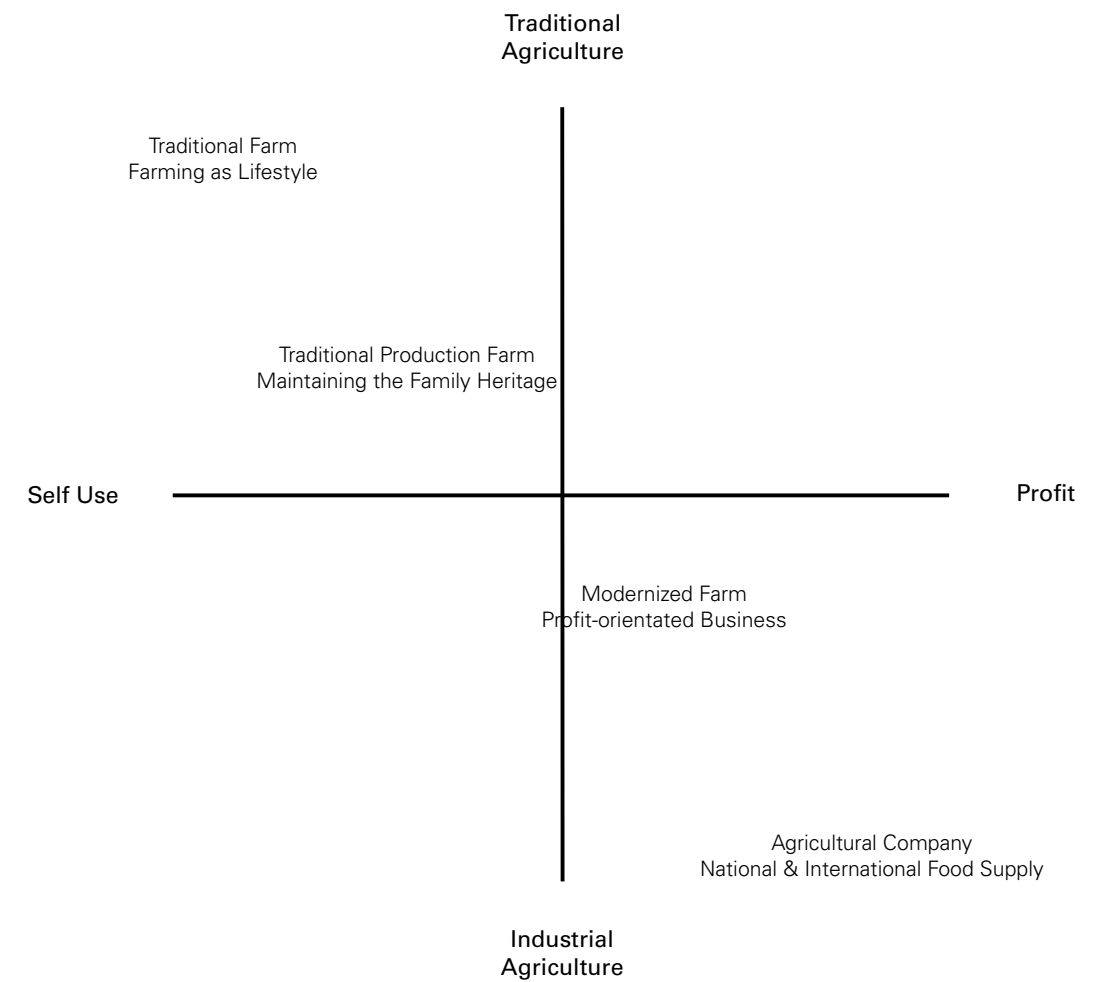
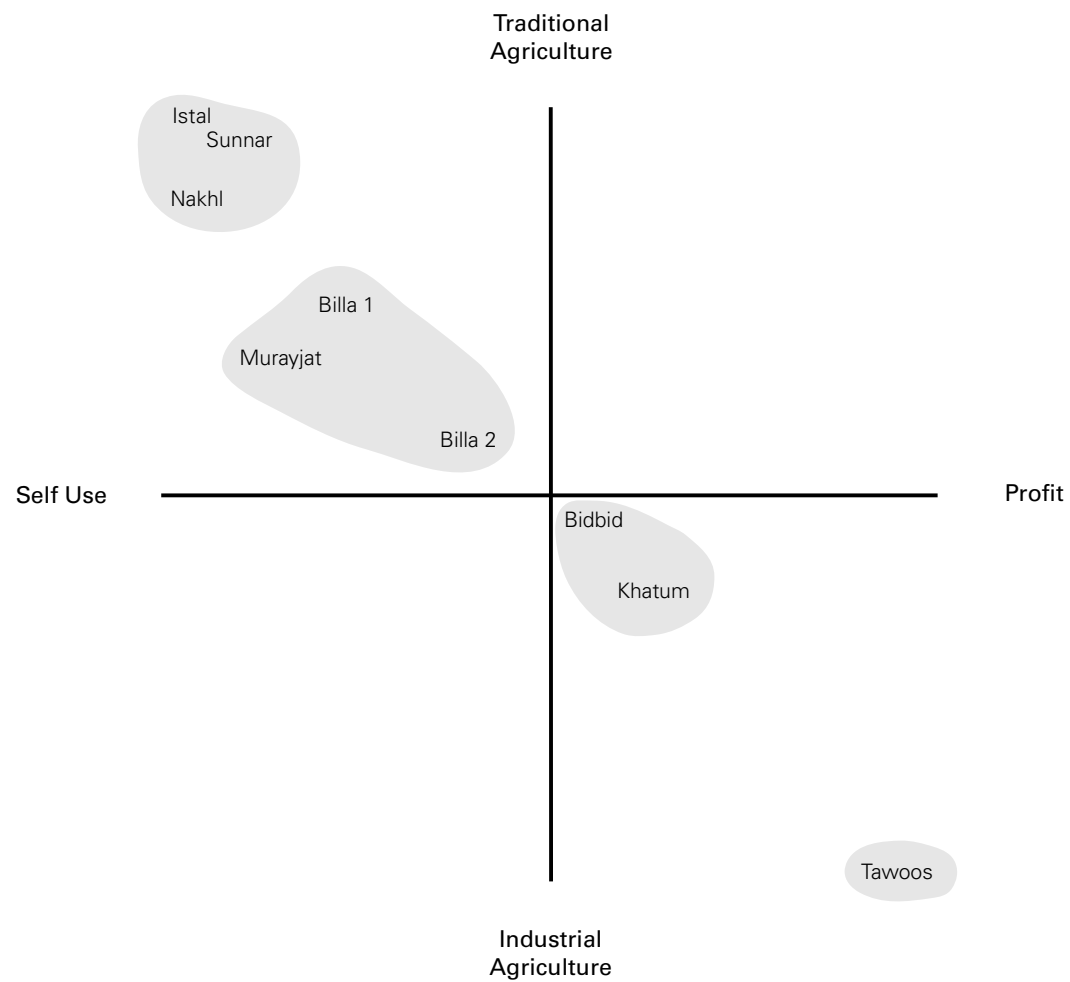
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Running a Business

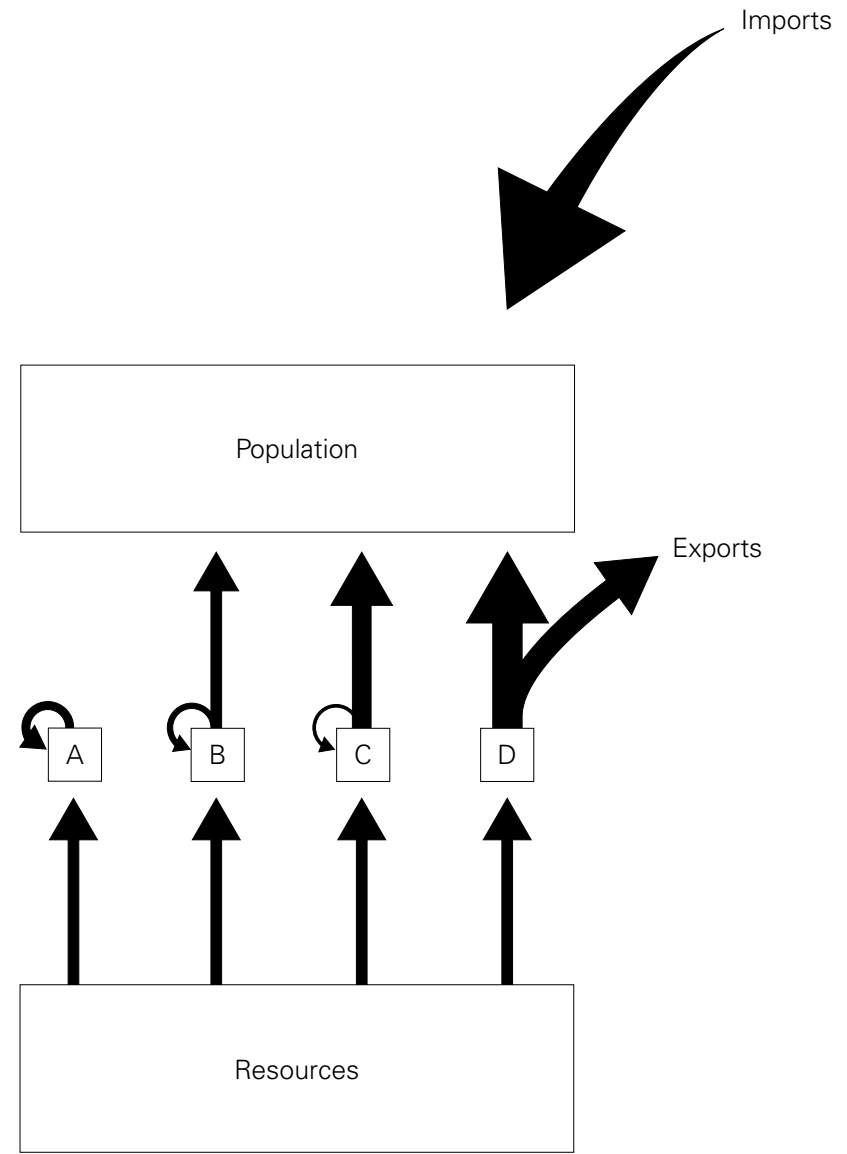
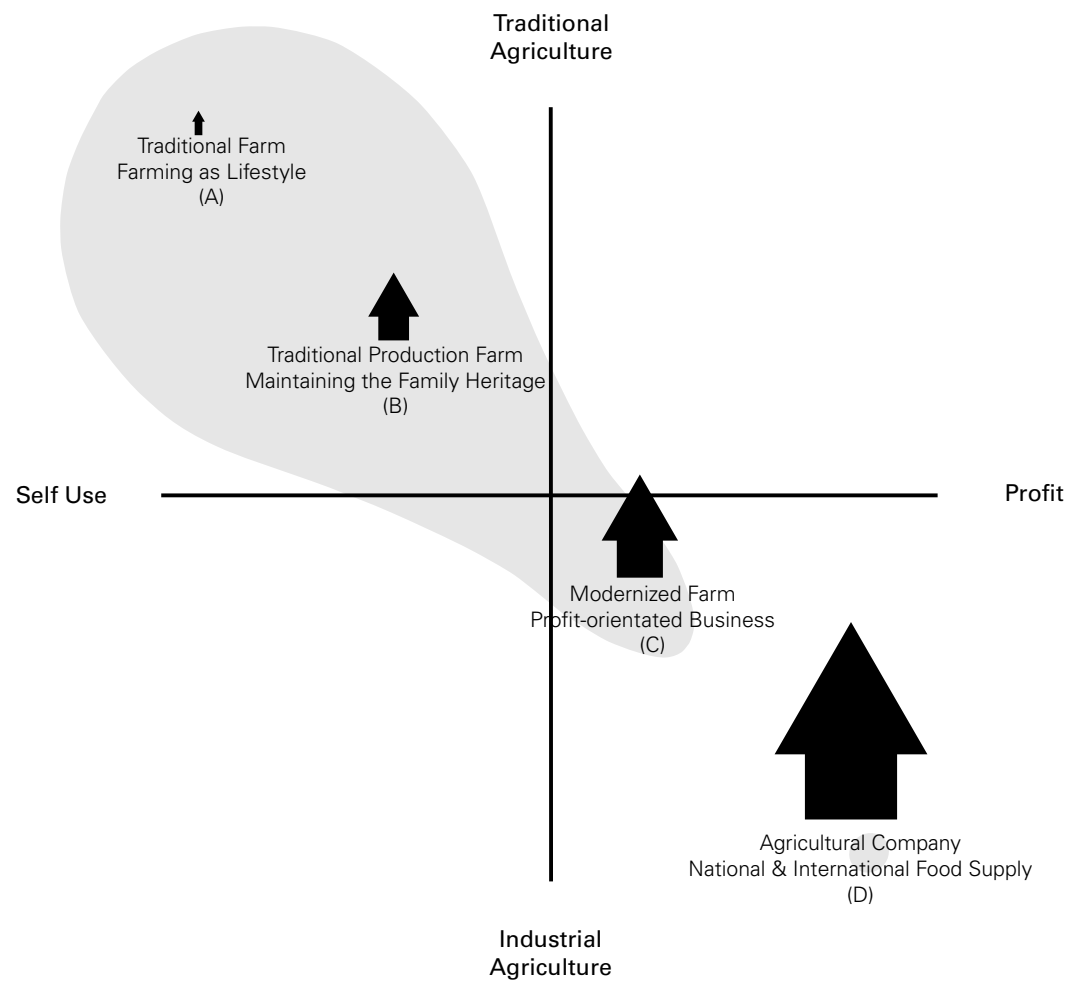
Several production managers are assigned with the perfect coordination of the farm. Newest machinery and irrigation are crucial for the success of this company. Being such a big water consumer they are under strict regulations and controls. For every reparation or inspection of their wells a government official needs to be attendant.

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Spectrum

The different farms can be categorized and allocated between traditional and engineered farming as well as between private and economic value. Most of the analyzed farms mingle in a more traditional ambiance and are clearly not used for economic benefit. Four different types of farms become apparent and can be allocated in the diagram.



Productivity and Number of Farms

Observing the agricultural output i.e. productivity compared with the number of each type of farm, it becomes evident that the least productive farms are outnumbering the productive ones by far.

Exhaustion of Resources vs Food Supply

Each type of farm has access to the same kind of resources but is using them in a very diverging manner. Beneficial and also indispensable for societies economy are only the ones actually generating an output which is reaching the regional, national or international market.

KEEPING UP WITH MODERNIZED OMAN

Since oil has become a major economic factor for Oman, the country has undergone a rapid and unexampled modernization. The population has increased hence cities have multiplied in size, streets and infrastructure has been built and overall wealth has become a standard. But with the finite nature and instability of oil supply it seemed advisable to establish and structure different industries and tourism as a reliable source of income. Somehow the agricultural sector, with only a 2% contribution to the GDP, has been left behind in this development and is now struggling to catch up.





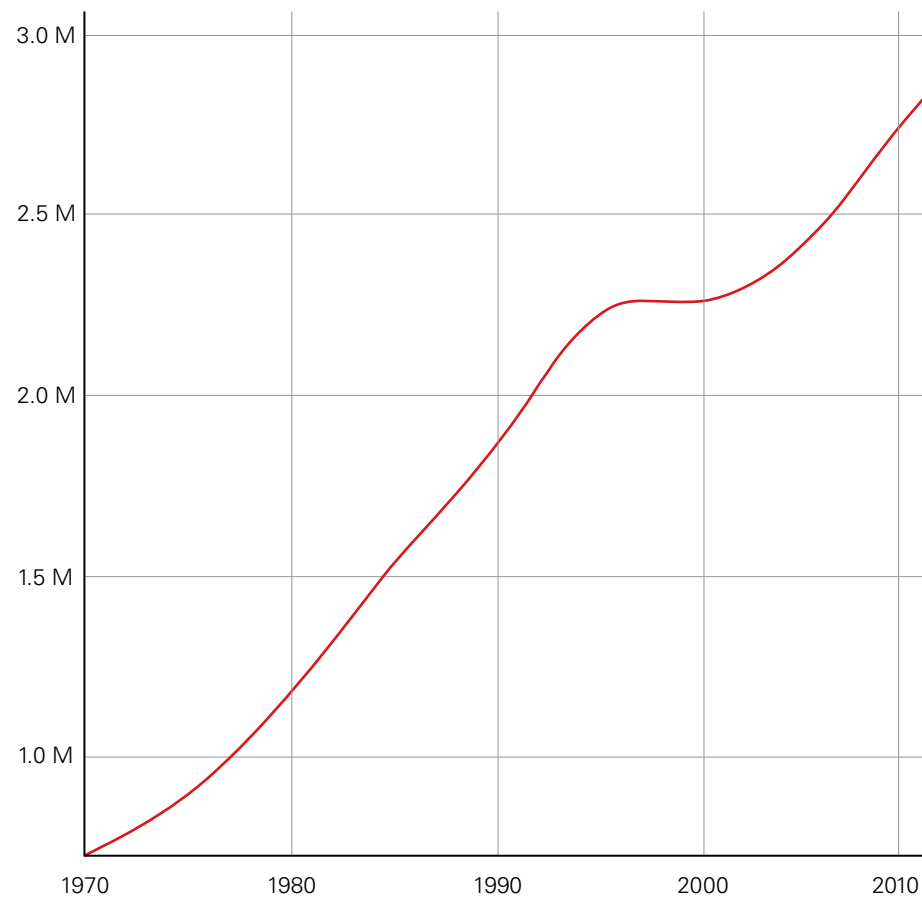
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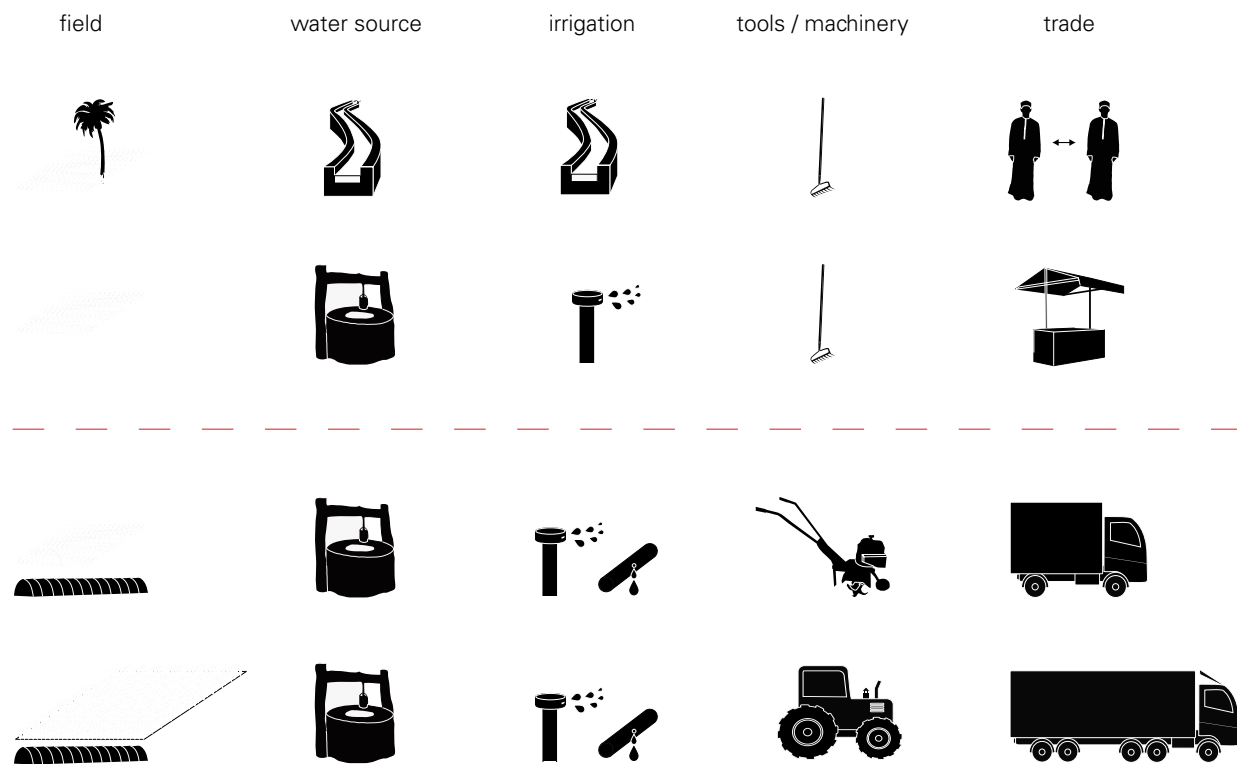


Impact of Modernization

The modernization of Oman is strongly connected to a remarkable population increase. The whole country has changed and became urbanized. Only the agricultural sector was not keeping up with the development. But more and more farmers try to modernize their business and begin trading on larger scale, even the labour working on the fields are people from other countries somehow interwoven in global trading networks.

A Whole Sector Left Behind

Simultaneously with increasing wealth and technologization Oman also changed its physical appearance. New houses, streets, highways, whole new cities were built. The wealth is showing in coastal promenades and representative buildings. But the agricultural sector did somehow miss the opportunity and is now trying to catch up.



Changes in Trading Behavior

The traditional farmers still rely on the former habits of exchanging goods with their neighbors or trading them on the local markets. Only recently a 'Farmers Union' has been established to give farmers access to the regional and national market. Tawoos the big agricultural company depends on a global exchange network.



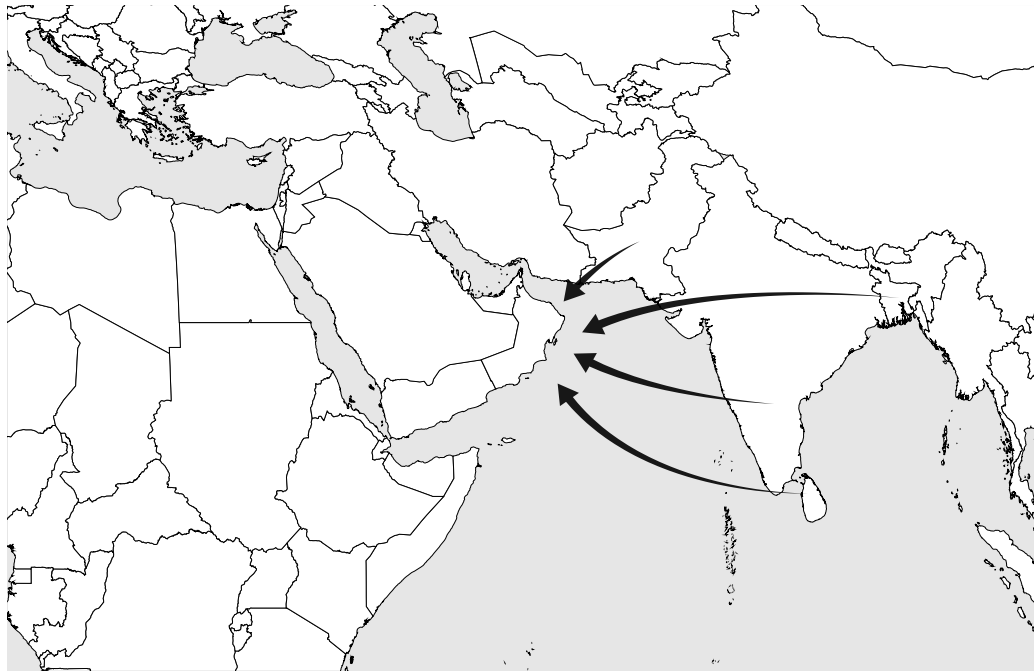
High Quality Products

In Order to be competitive on the global market the agricultural company Tawoos is cultivating products of certified high quality standard.



World Trade

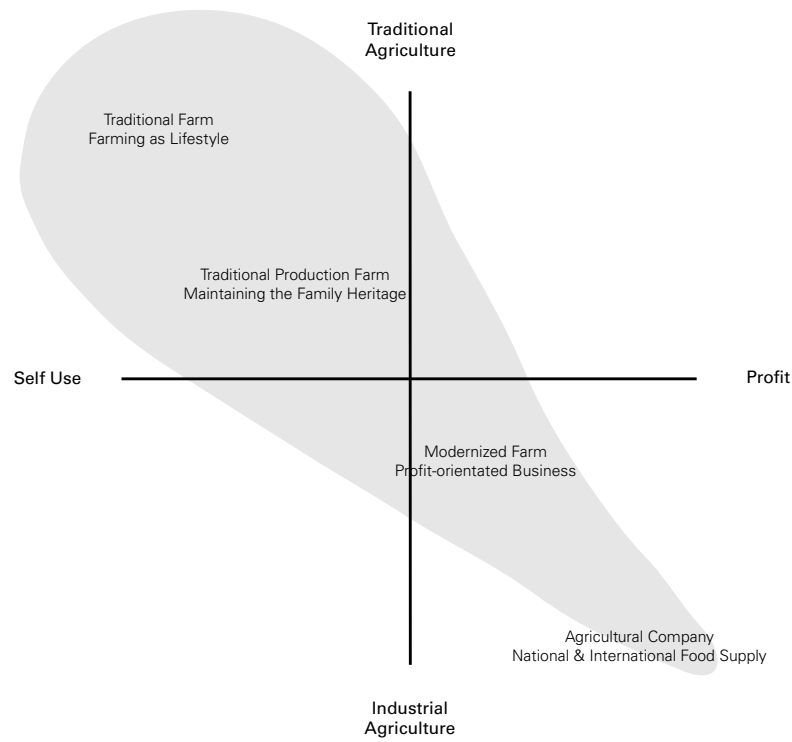
Omans food supply is mostly relying on imports, except for fruit and vegetables where they are almost self-sufficient. A strong export good are dates and high quality vegetables which are exported mainly to GCC, Europe and Japan.



Main Countries of Immigration



A Workers Home



Main Workforce: Expats

With the wealth of the oil-age the Omani didn't feel the need to work on their fields anymore. Happily any kind of displeasing work is handed to low wage expats.

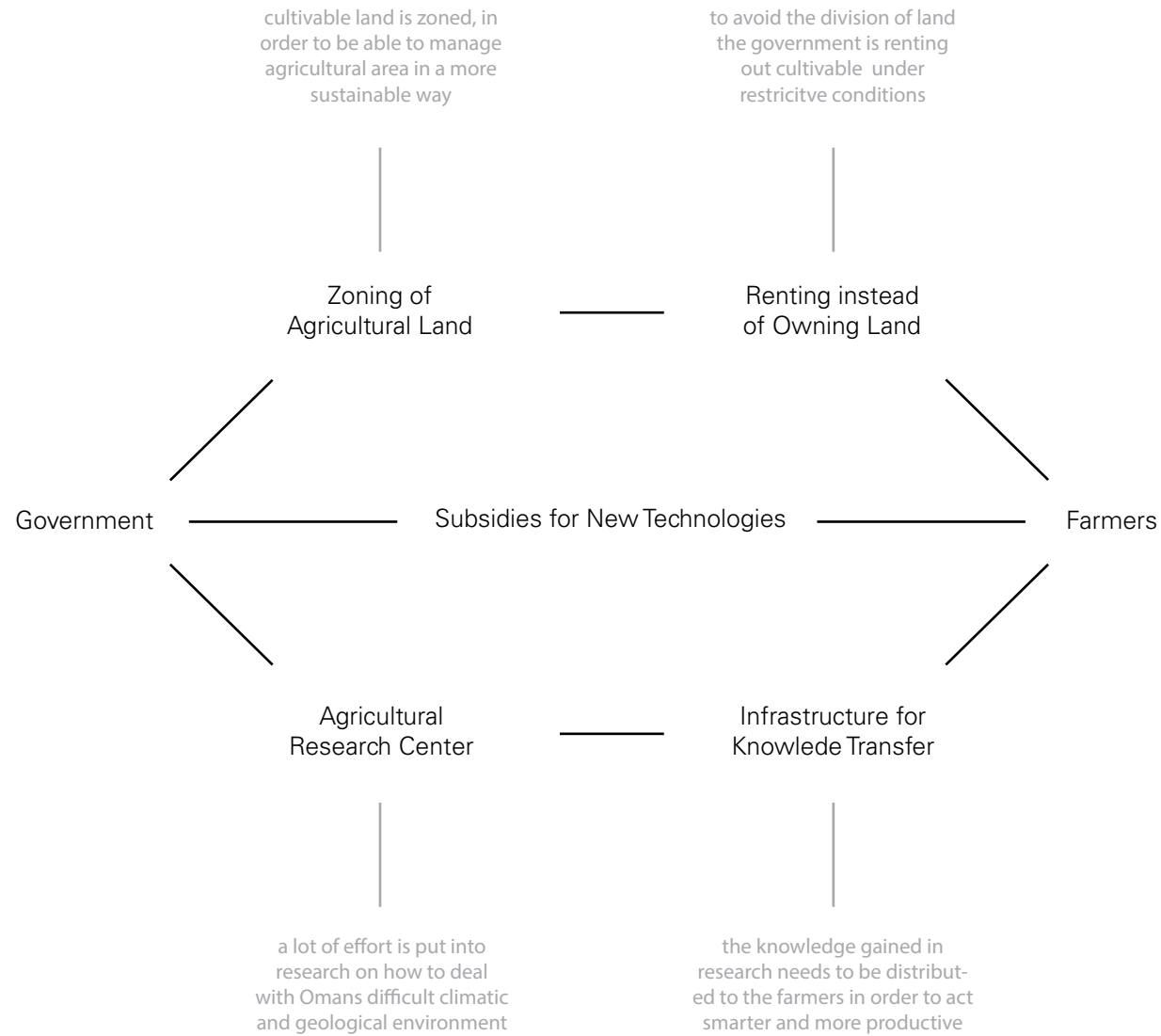


Pakistani Worker



Movement Towards the City

Because of increasing wealth and the accompanying rise of living standard many Omani are rather working in an office instead of the family farm. The young people are losing the interest in tradition and move towards the cities.



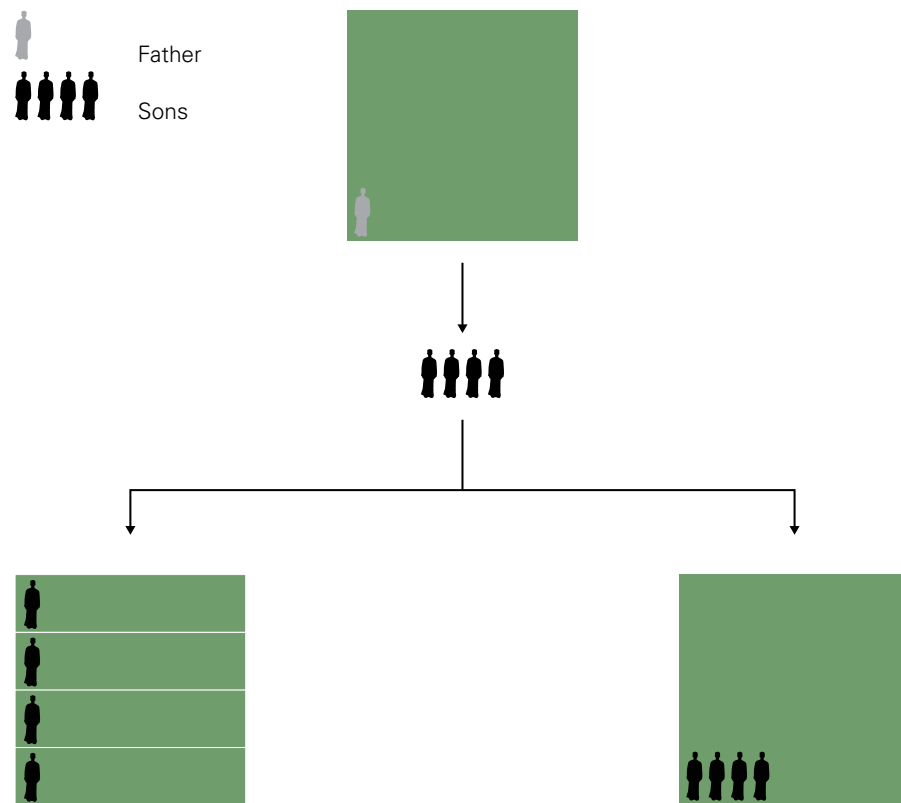
Measures Taken by the Government

To address the problem of lacking productivity in the agricultural sector the government is developing several strategies to enhance domestic contribution to overall food supply. This is achieved by subsidizing acquirement of new farming methods and technologies, general land reforms and identifying arable land which is distributed by alternative approaches of land ownership and knowledge appropriation and simultaneous transfer of dealing with the local resources and climatic circumstances.



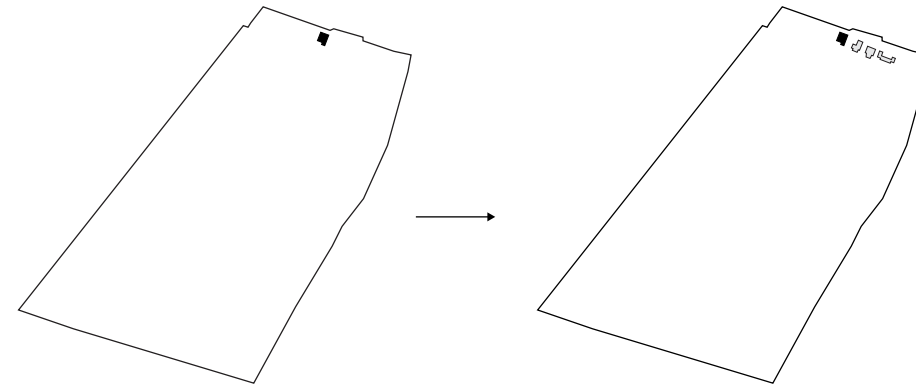
Agricultural Research Station

To enhance overall productivity the Ministry of Agriculture is running a research station. A key issue which is worked on are water saving irrigation and different growing media for the crops. In adjusted environments a number of trials is run. Another focal point is the identification of adequate fertilizers and the selection of suitable crops for the challenging climate.



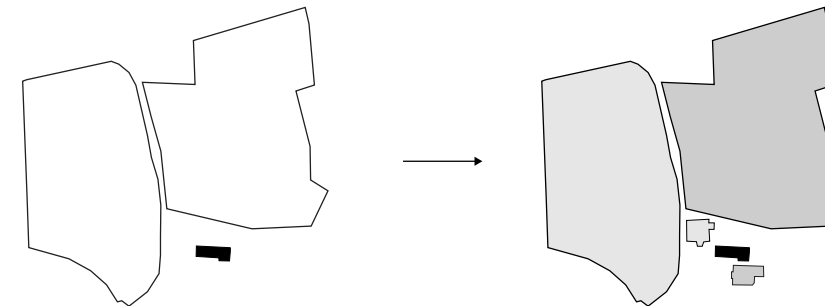
Inheritance Fragments Arable Land

It is a global occurrence that land property gets divided by inheritance into small plots which become unusable for efficient farming. Therefore the government is leasing or renting recently zoned arable land to farmers under the condition of a reasonable high productivity. If the preset aims are not achieved the land is given to another farmer.



Murayjat Jointed Family Farm

By tradition this farm is not divided but kept as it already is for generations. The family members who are interested in maintaining their personal heritage built a new house on the same land for their own family. But the farm is run together with the brothers.



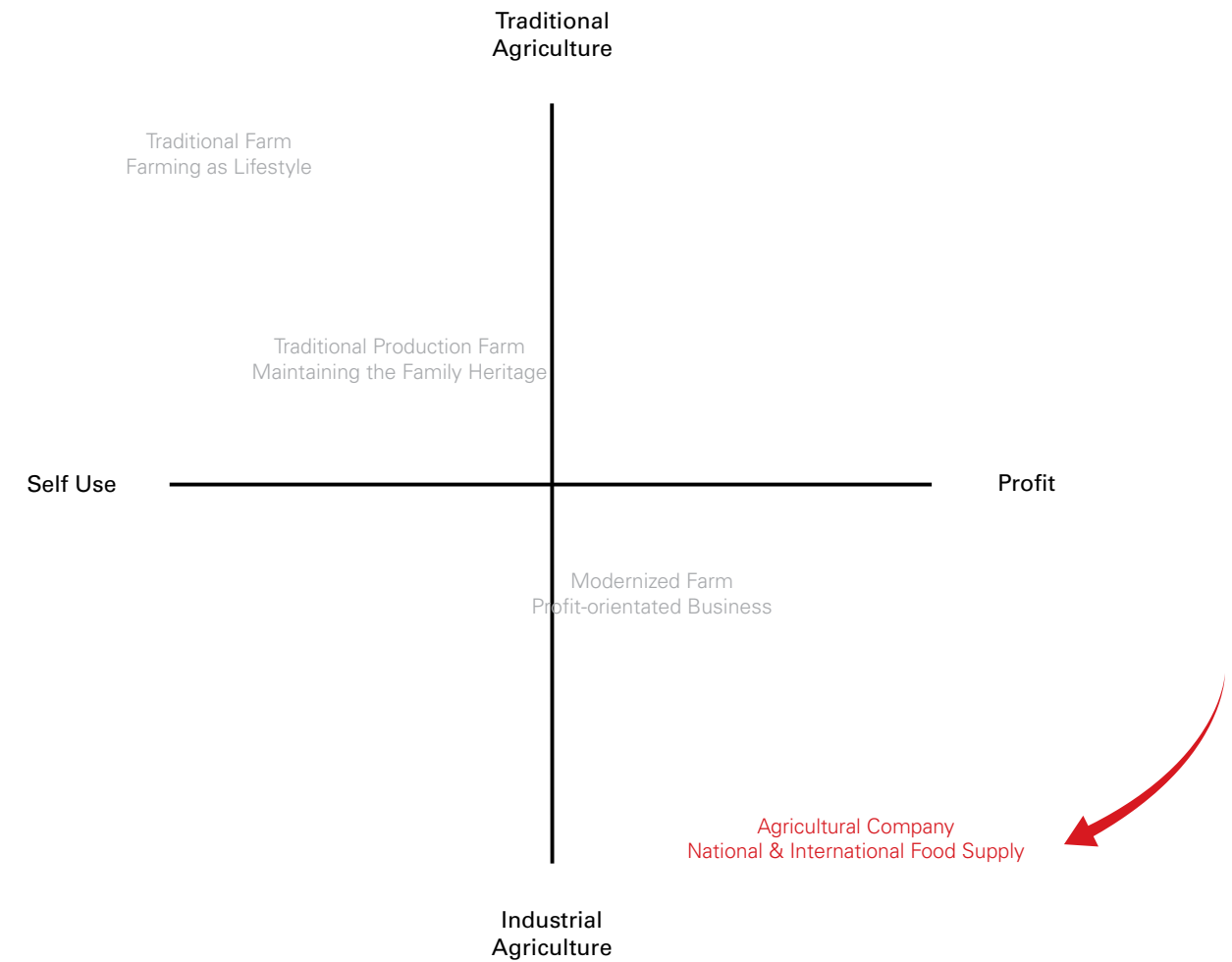
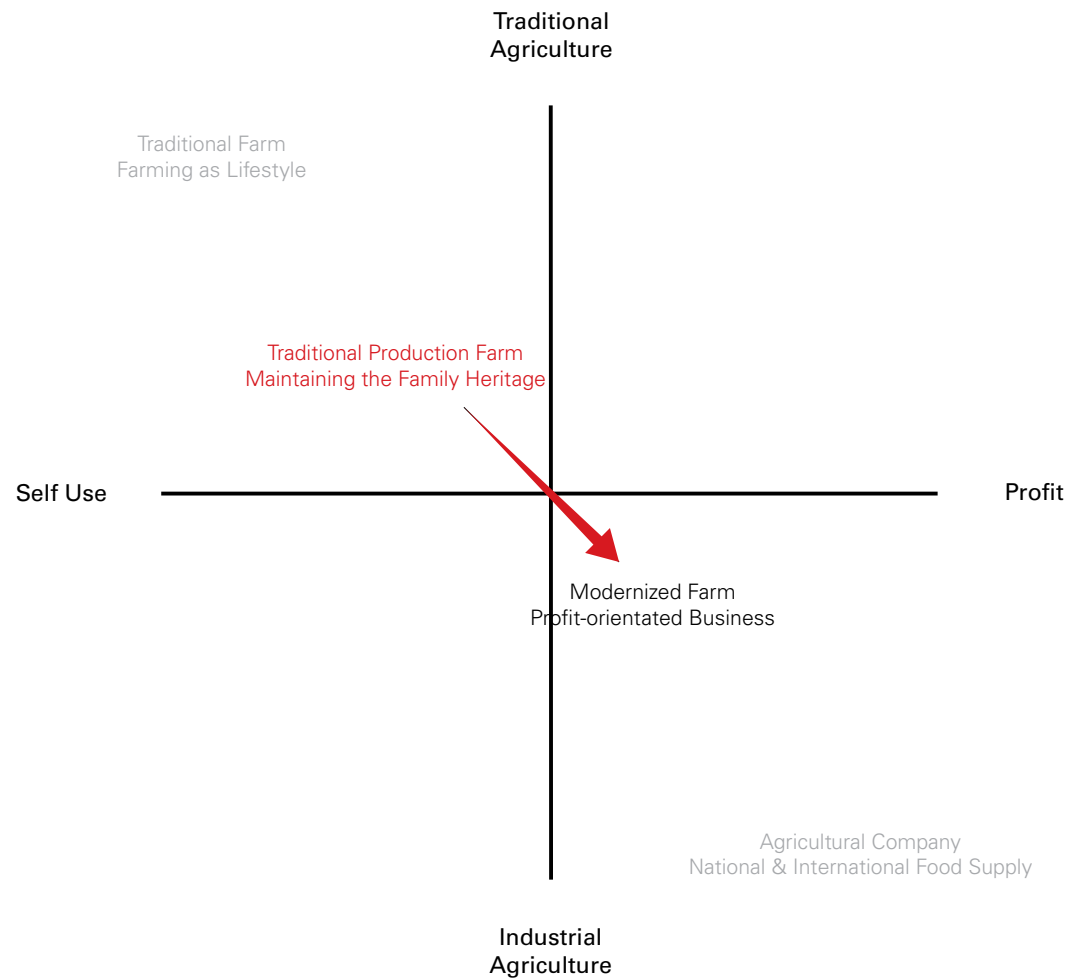
Kathum Devided Farm

Another example is a farm which has been divided between two brothers. They couldn't agree on cultivating their land together therefore each of them is running his own farm. The old family house is kept but not inhabited anymore, each of the brothers built a new house besides the old one.



Approaches to Supply Modernized Oman

In order to achieve a secured food supply for the future there have been identified four possible approaches of governmental intervention. Two are addressing the situation within the country i.e. enhancing the productivity of the ‘Rural Farm’ and giving incentives for the creation of ‘Agricultural Companies’. Two are addressing actions abroad i.e. investments abroad in land abundant countries or continuous relying on imports.

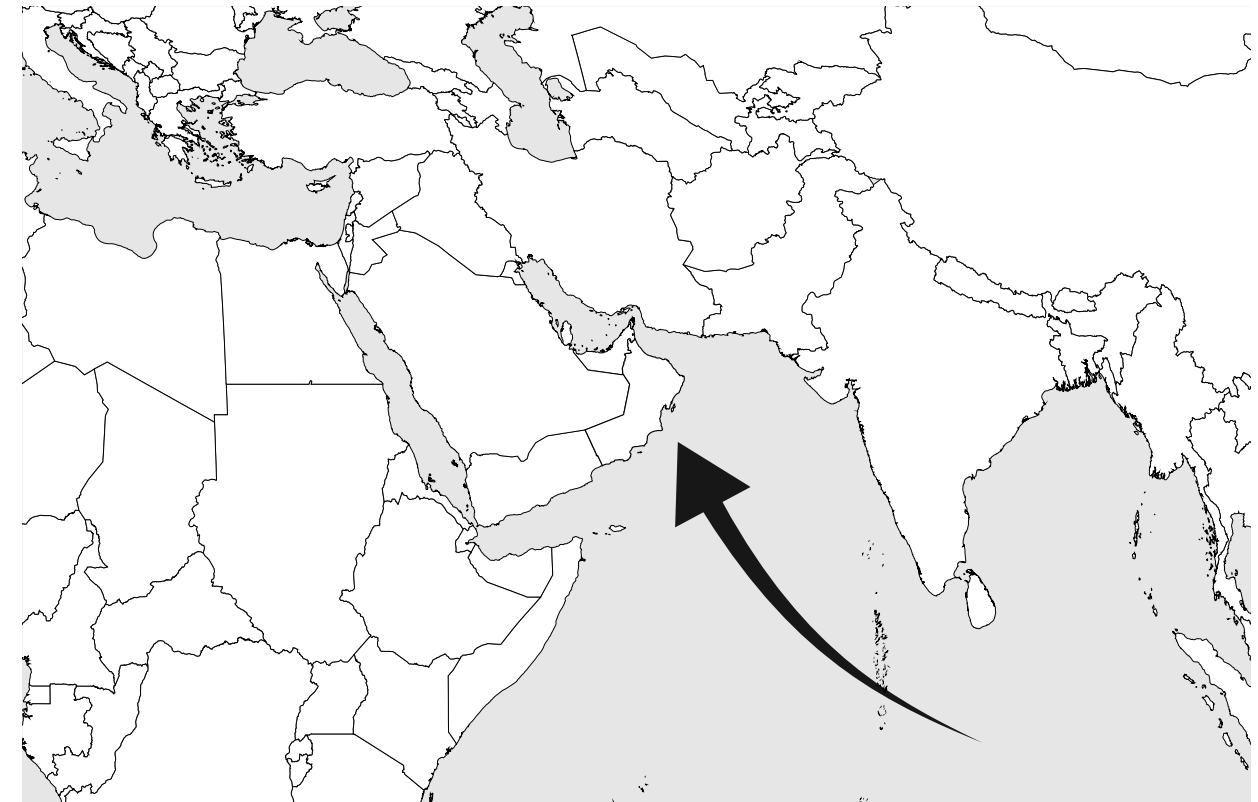
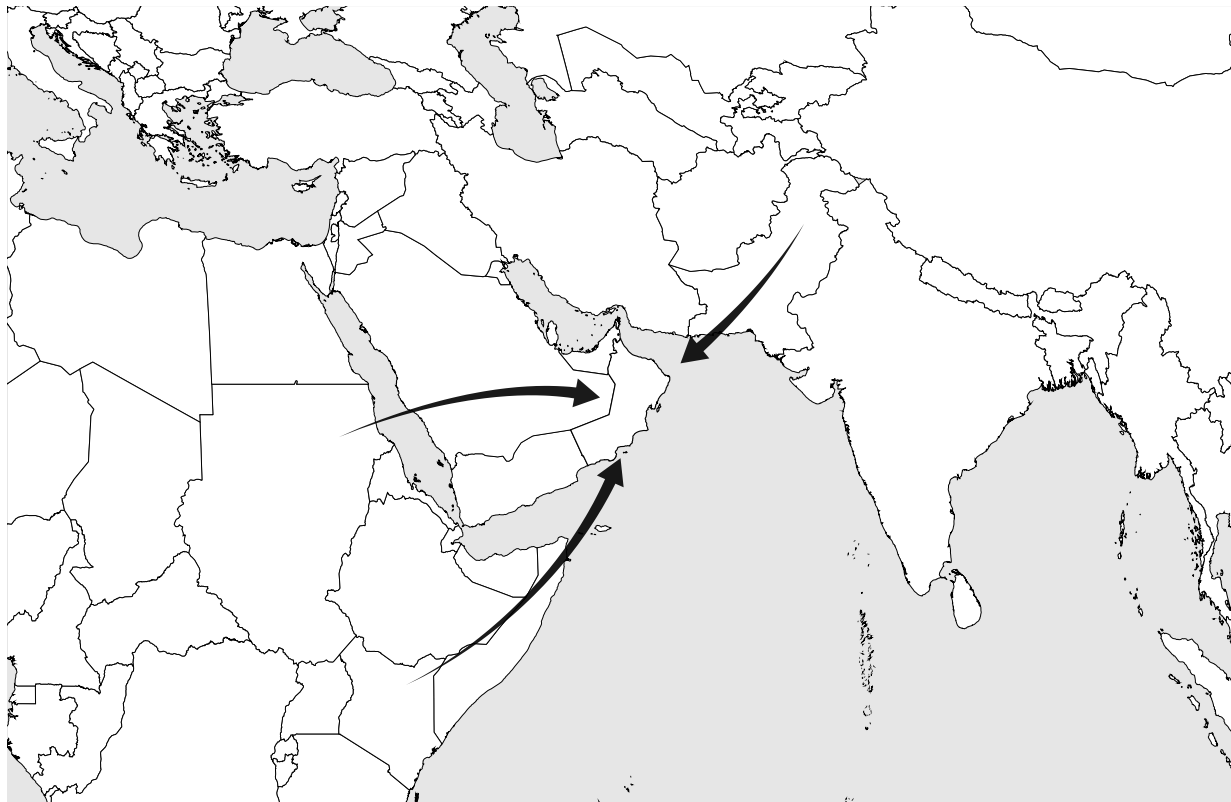


Transformation to Modern Oasis

The inefficient management of resources is a well known problem and needs to be addressed. In order to shift 'Rural Farms' to 'Modernized Farms' awareness for resource management has to be created. Furthermore farming has to become more attractive again for the younger generation, this can be achieved by subsidies and other incentives.

Creation of Industrial Farms

Especially 'Agricultural Companies' can contribute to overall food supply. The number of these farms needs to multiply distinctly. To achieve this, the government needs to create an enabling environment to attract private-sector participation. This could include financial incentives, support in planning and structuring a big business as well as reestablishing the farmer as a well perceived member of society



Investment Abroad

Other GCC countries which are facing the same problems, such as Saudi Arabia and UAE give a possible example of land leasing in land abundant countries. Suitable countries for outside investments would be Sudan, Kenya and Pakistan. This would give the possibility to control the quality of food production and secure the supply of agricultural good with adequate and steady costs.

Import

Significant expansion of domestic production to achieve food security needs is realistically impossible. Marginally, however, it might be possible to increase local production through improvements in land and water productivity, nevertheless Oman will always have to rely on imports. Hence other sectors have to be strengthened to improve incomes in order to make imported food commodities affordable.

IMAGE CREDITS

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P. 2, 7, 10, 26, 28, 32, 36, 40, 44, 48, 52, 56, 68
<http://www.bing.com/maps>

P. 73
www.tawoos-agriculture.com

P. 71
blog.getaway.co.za/photography/photos-the-sultanate-of-oman

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SOURCES

Papers

Msafiri Daudi Mbagu (2013)

“Alternative mechanisms for achieving food security in Oman”, Agriculture & Food Security

Ministry of Agriculture and Fisheries (2009)

“The Food and Agricultural Situation in the Sultanate of Oman”

Ministry of Agriculture and Fisheries (2004/2005)

“Agricultural Census 2004/2005”

S.Zekri, A. Al-Rawahy, A. Naifer (2011)

“Economic Impact of Salinity: The Case of Al-Batinah in Oman”

N. Ali, S. Zekri, A. Moazedi (2012)

“Oman Salinity Strategy - Main Report”

H. Kotagama, H. Boughanmi, S. Zekri, S. Prathapar (2010)

“Food Security as a Public Good: Oman’s Prospect”

Food and Agriculture Organization of the United Nations

(2011) “Oman’s agriculture on a rapid growth trajectory”

Zaher bin Khalid Al Sulaimani, Tariq Helmi (2007)

“The social importance and continuity of falaj use in northern Oman”

Zaher bin Khalid Al Sulaimani (2005)

“Water Resources Management in Sultanate Oman+”

Maps

Traditional Falaj Distribution System (p.20)

Anette Gangler, Oases Settlements in Oman, Edition Esfeld & Traub (2008)

Internet

www.maf.gov.om

www.fao.org

www.agrifedds.org

www.tawoos-agriculture.com

www.icarda.org

<http://maps.google.com>

<http://www.bing.com/maps>

Interviews

Dr Khalid Al-Zadjali, Director-General of Planning, Ministry of Agriculture and Fisheries, Personal Interview (18 March 2013)

Khamis bin Saif Alboiqi, Agricultural Research Center, Rumais, Personal Interview (24 March 2013)

Harat Al-Sibany, Tawoos Agricultural Systems LLC, Personal Interview (21 March 2013)

Hamad Al-Lawati, Istal, Personal Interview (14 March 2013)

Ibrahim Yaqoub Al-Naamany, Sunnar, Personal Interview (14 March 2013)

Abdullah Al-Habasi, Billa, Personal Interview (15 March 2013)

Ahmed Nasser Al-Bakri, Bidbid, Personal Interview (15 March 2013)

Nasser Saeed Al-Hadrany, Nakhl, Personal Interview (21 March 2013)

Khalifa bin Abdullah Al-Subhi, Khatum, Personal Interview (21 March 2013)

Ramis Al-Wihaibi, Billa, Personal Interview (22 March 2013)

Saeed Rhalfan Al-Shaidi, Murayjat, Personal Interview (22 March 2013)