Briefing Note: Humanitarian Impact of Water Shortages in Northeast Syria

April 2022

Background

The water crisis in Northeast Syria (NES) spans multiple dimensions – a meteorological drought, reduced flow in the Euphrates River, and a long-term reduction in groundwater levels. Together, these have led to a severe deterioration in the humanitarian situation. The drought began in late 2020 with a delayed onset of winter rains and low rainfall, later made worse by heatwaves and an early cessation of rains in the spring of 2021.[1] Water levels in the Euphrates then began to decline rapidly starting early 2021.[2] The changes in surface area can be seen in figure 2. REACH and other organisations reported on this in the summer and autumn months of 2021, noting the severe decline in access to clean water, electricity, and the impact on agriculture.[3,4,5,6]

This briefing note serves as an update on the humanitarian situation in light of the continued water crisis. Specifically, rainfall levels have remained substantially below long-term average levels in the current agricultural season.[7] Thus, the European Drought Observatory warned in March 2022 of a medium to high risk of drought impact on agriculture – for comparison, no areas had a high risk in March 2021.[8] Given the duration of the drought, it is likely that not only soils and surface water will be impacted, but also groundwater level.[9] This is particularly problematic as Syria has seen decades of overexploited groundwater, leading to severe reductions in groundwater levels. This is mainly due to agricultural usage, with certain crops and areas of NES relying heavily on irrigation.[10,11] The following thus investigates how the water crisis has impacted access to water and electricity, agricultural livelihoods, food security and health in NES.

The Euphrates water levels have improved since the beginning of the 2022, with March levels in lake Assad being around a meter higher than in 2021, though still two meters lower than in 2020.[2] However, the situation remains vulnerable as climate change and upstream water usage are causing further declines in water flow.[12,13] As the Euphrates is the single largest source of freshwater in Syria[10] as well as being an important source of electricity[6], these developments are highly relevant to the well-being of people in NES.

REACH SOURCES USED

HSOS KI▲ – Humanitarian Situation Overview in Syria (HSOS) regional key informant (KI) assessment conducted monthly by REACH in NES

HSOS HH▲ - HSOS urban household assessment conducted quarterly by REACH in NES

RNA▶ – Rapid Needs Assessment (RNA) conducted by REACH in March of 2022 to assess the impacts of the water crisis on agriculture in Al-Hasakeh governorate, Syria.

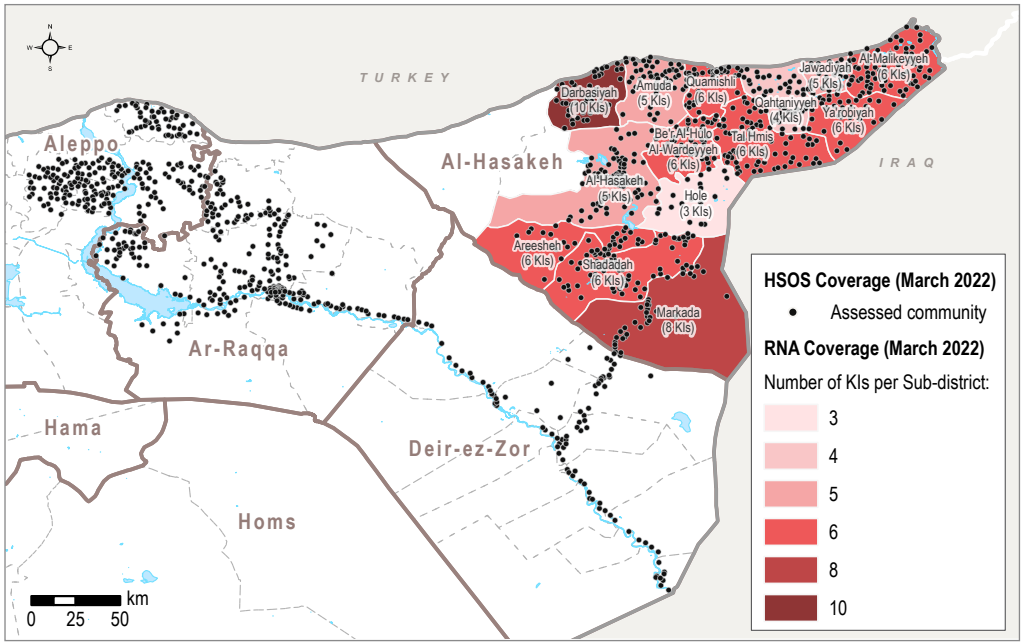
JMMI▶ - Joint Market Monitoring Exercise (JMMI) conducted monthly by REACH in NES

Methodology

Various REACH sources, secondary sources, and information from REACH's field team are used in this briefing note. This includes the monthly Humanitarian Situation Overview in Syria (HSOS) up to March 2022. In March, HSOS collected data on 1,267 communities through 4,828 KIs. While most communities in NES are assessed, the data is indicative of this situation in these communities. Additionally, January data from the HSOS Urban household assessment in Al-Hasakeh city is included. This data is representative of the households in Al-Hasakeh city (95% confidence, 10% error). Data from the Joint Market Monitoring Exercise (JMMI) is used, which interviewed 1,970 vendor KIs in March.

Lastly, REACH conducted a Rapid Needs Assessment (RNA reviewing the agricultural and livestock situation in Al-Hasakeh governorate). KIs in 14 subdistricts (see figure 1) were selected based on the field team's network and interviewed by phone. KIs were asked to report on their subdistrict, such that multiple responses to the same question are available within a subdistrict. Overall, 82 KIs were interviewed in March of 2022. Of these, 53 responded to the sections on rainfed and irrigated crop cultivation, and 54 to the section on livestock.

1. Coverage



REACH Informing more effective humanitarian action

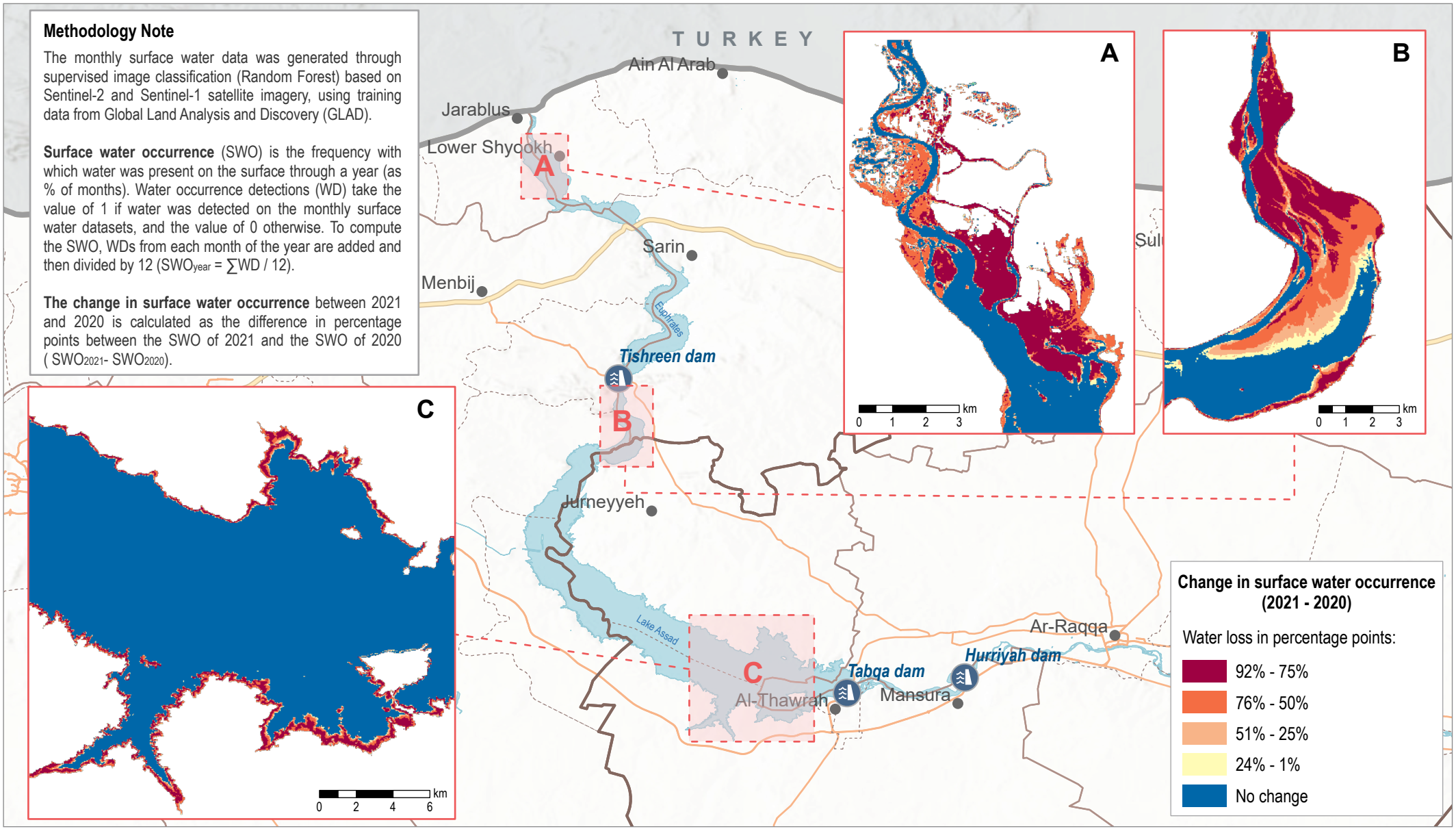
IN COOPERATION WITH

NES NGO FORUM

North East Syria Sector (NES) FOOD SECURITY & LIVELIHOODS Agriculture Working Group

WASH Working Group North East Syria

2. Average Loss of Surface Water from 2020 to 2021



REACH Informing more effective humanitarian action

IN COOPERATION WITH

NES NGO FORUM

Water and Electricity Access

Reduced water levels in the Euphrates paired with low levels of rainfall led to strong declines in access to water across 2021. This was due to water levels sinking too low for water stations to operate and low levels of hydroelectric power meaning that not enough electricity was available to power the stations. Accordingly, KIs on average reported that 21% of households in their community had insufficient access to water in August 2021. As the water network became less reliable, households reportedly relied more on private boreholes or wells, and water trucking. However, the high cost of water trucking was the most cited barrier to water access, reported by KIs in up to 46% of communities.▲ These costs meant that households had to spend money on water at the cost of other necessities. Water access improved after August 2021 due to the onset of the rainy season and increased flow in the Euphrates. Thus in March 2022, KIs reported on average that 14% of households in their community had insufficient water access. However, as rainfall levels have remained low and groundwater levels have declined substantially, the situation is likely to worsen during the summer 2022.

Most of the network electricity in NES comes from dams on the Euphrates – with decreased water flow in 2021, these dams produced much less electricity. In January 2021, KIs in 50% of assessed communities reported having 9 or more hours of electricity per day in their community – by December, this had reduced to 19%. Levels have remained low into March 2022 despite rising water levels in the Euphrates because rationing has continued.▲ Households are unable to cope with network shortages as the alternatives, solar and fuel-powered generators, are beyond the purchasing power of most. At the same time, water stations and other essential services are heavily impacted by the lack of electricity.

Health Impact

Reduced water access has led households to restrict their hygiene practices (particularly bathing and doing laundry), which may make them more vulnerable to infectious diseases and skin diseases. Furthermore, the use of untreated water from boreholes, wells and water trucks increases the risk of waterborne diseases. In August, KIs in 19% of all assessed communities reported that drinking water was perceived to be making people sick – at 32%, this was even higher in communities that primarily relied on private water trucking for drinking water.▲ Unsafe water is thus likely the cause of a strong increase in diarrhoea cases observed in 2021. Diarrhoea can further increase the risk of malnutrition, which is particularly problematic as the high cost of food has already led to unprecedented high rates of food insecurity across Syria.

Livelihoods Impact

NES is seeing high rates of livestock death and sell-offs due to the inaccessibility and high cost of fodder.▶ This is a result of the failure of fodder crops, including barley, and the drying up of pastures in 2021 due to the shortage of rainfall. As current rainfall levels have remained low, there are concerns that agriculture – and hence livestock – will see further negative impacts of drought in 2022. Due to difficulties in importing food and rising global food prices, this shortfall in regional production cannot be adequately compensated, leading to strong increases in food and fodder prices.

REACH conducted a rapid needs assessment in March of 2022 to assess the situation of agriculture in Al-Hasakeh governorate. Here, KIs reported severe decreases in livestock numbers. Sheep were most strongly affected, with 67% of KIs reporting herd sizes in their subdistrict decreasing by over 25%. Correspondingly, farmers have reportedly been giving up on livestock farming while crop cultivation and agricultural wage labour were similarly reported to be decreasing.▶

This has the twofold impact on livelihoods of farmers lose their livelihoods and while food prices increase further, leading to a strong decline in purchasing power.

Food Security Impact

Food insecurity in Syria now is higher than at any other time since the onset of the crisis. In NES, households particularly struggle with the high cost of foods paired with low purchasing power; in March 2022, KIs in 82% of communities reported that households were unable to afford essential food items.▲ Low wheat harvests in 2021 due to the drought have strongly contributed to this. Thus, with low rainfall continuing into the current agricultural season and considering the global surge in food prices, it is likely that this situation will worsen over the course of 2022. In response, KIs have reported a large number of coping strategies centred around borrowing money and reducing expenditure. More extreme coping strategies are also employed, such as skipping meals (KIs in 20% of assessed communities in March) and reducing meal sizes (19%).▲

Table of Content

The water crisis has particularly affected households in their source of water, with the use of networked water decreasing and reliance on unregulated sources such as boreholes, wells, and private water trucking increasing. Particularly the dependence on water trucking is difficult for households, with the high price of water from trucks being the primary barrier to water access reported. While water levels in the Euphrates are set to alleviate some of the problems, persistently low rainfall levels will continue to impact household water access in the coming year, especially for households relying on surface and groundwater.

Low Water Levels in the Euphrates

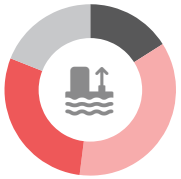
At the Euphrates River, the majority of water stations were working at limited capacity last summer due to low water levels. In October of 2021, the latest date for which information was available, at least 88 of 136 water stations were affected. This is particularly true for stations close to the main dam, Tabqa, and downstream of it.[14] Ar-Raqqa and Deir-ez-Zor governorates were notably affected, which decreased access to water. For Ar-Raqqa, at its height in August 2021, KIs in assessed communities reported on average that 20% of households in their community had insufficient access to water,[a] For Deir-ez-Zor, access stayed consistently low with reports indicating that more than 20% of households in the community having insufficient access from January 2021 up through August 2021. With water levels in the Euphrates having risen since January 2022[2], improved performance of the water stations is expected. Correspondingly, KIs in more communities in Ar-Raqqa reported the main water network being the primary water source, up to 68% in March after a low of 47% in June 2021.[b] For Deir-ez-Zor, it was more common for communities to combine piped water with water trucking. This is due to the low reliability of the water network in Deir-ez-Zor, with KIs in assessed communities reporting less than 2 days of functioning networks for most of 2021, necessitating a secondary water source. Thus, while the use of the piped network with or without water trucking was reported for 29% of assessed communities in March of 2021, this went up to 63% in March of 2022, indicating improved functionality.

Alouk Water Station

Additionally, the reduced water flow in the Euphrates slowed electricity generation, limiting production capacities even for water stations off the Euphrates. Alouk water station is an important example. It is situated in Al-Hasakeh governorate, close to the Turkish-Syrian border. Here, it supplies around 460,000 people with piped drinking water, including in Al-Hasakeh city, in addition to 500,000 people receiving trucked water. Water production has been low since late in 2019 due to difficulties in cross-line provision of electricity and access for technical teams.[15] However, this has been exacerbated by the water crisis, with the station not having functioned between mid-June and the end of July 2021. Since the 1st of August 2021 to the 28th of March 2022, Alouk was operating at less than half capacity for at least 84% of the time, during which it was not pumping at all for at least a third of the time (see figure 3).[16] This is despite water being sourced from groundwater, which is less strongly affected by water crisis.

REACH's January 2022 HSOS Urban Household Assessment in Hasakeh city▲ reflects the disruptions to Alouk as almost every household reduced their consumption of non-drinking water. 72% of households further relied on private water trucking as a secondary source of drinking water, being an on-demand source enabling households to compensate for network disruptions.▲ This is part of larger changes in the choice of primary water source in the past year, with the use of piped water notably decreasing in Hasakeh subdistrict during the summer. The piped network reportedly was the primary water source for 26% of assessed communities in the subdistrict in April 2021, but this figure dropped to zero from May to September 2021[c,▲], likely due to the strong decrease in functionality which Alouk experienced during that time.[16] Looking at the whole of Al-Hasakeh governorate, KIs on average reported that 23% of households in their communities did not have sufficient access to water in August, the highest rate recorded in 2021. This is higher than in any other governorate, where rates ranged from 12 to 20% in the same month.▲ Here again we see an insufficiency of the piped network, with HNAP (Humanitarian Needs Assessment Programme) data* suggesting that 81% of households had to use a second water source last summer if their primary source was the network, substantially higher than for other water sources (61% for closed household wells, the most common primary source).[17]

3. Alouk Water Station Functionality between 1st August 2021 and 28th March 2022 (as % of days)



16% Half capacity or more
36% Less than half capacity
29% Not functional
19% No data

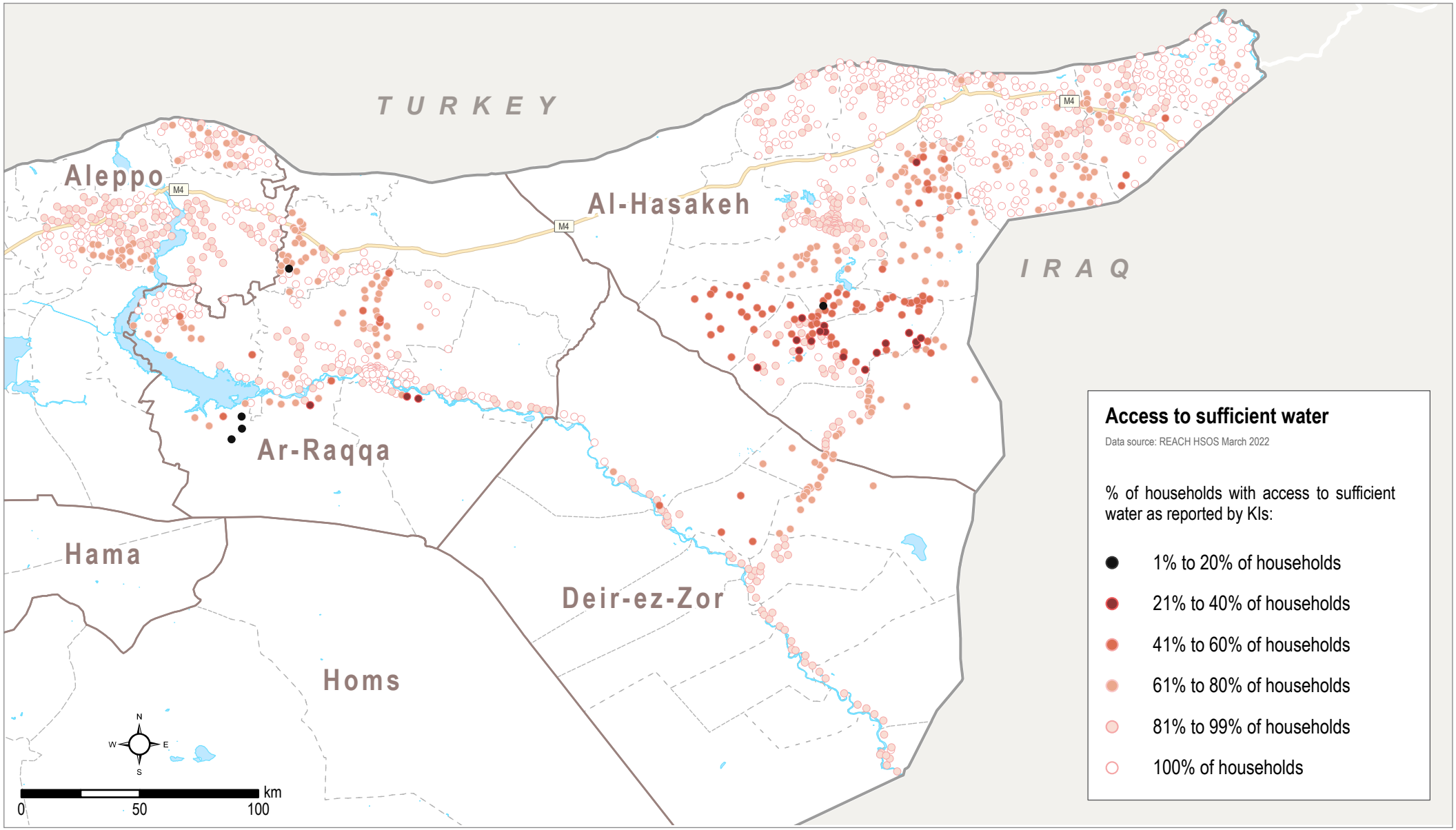
Decreased Water Access

Despite HNAP data* suggesting that households in Al-Hasakeh governorate had the highest levels of water insufficiency during the summer of 2021, almost no household went without water for two consecutive days in the 30 days prior to data collection. By contrast, in Deir-ez-Zor, around 17% of households – almost all households that had reported some insufficiency in water – went without water for at least two consecutive days, by far the highest rate in NES.

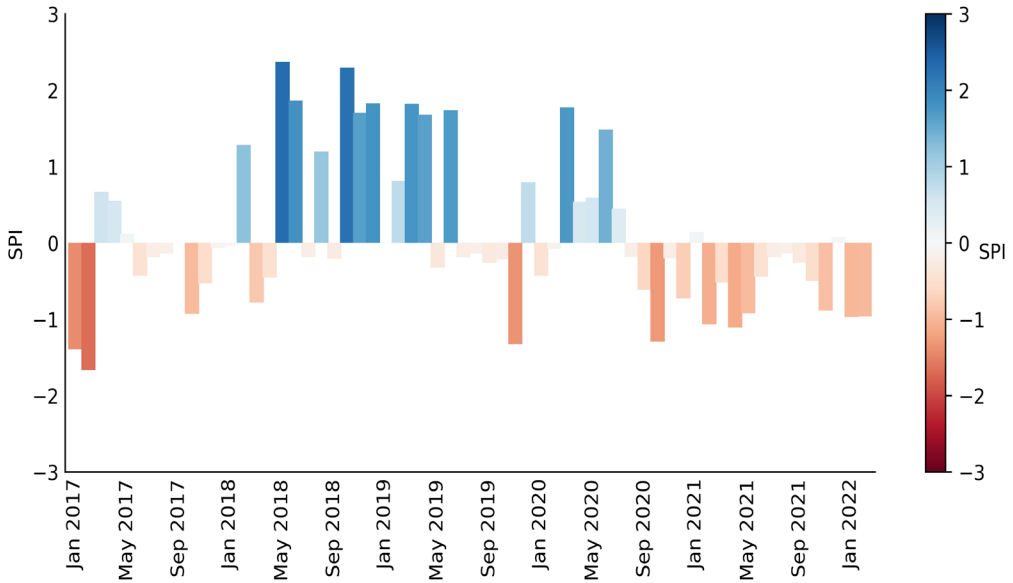
(Continues on page 7)

* Statistics were obtained by aggregating household data from sub-districts in which HSOS assessed at least one community in March 2022. Statistics are therefore not representative for NES.

4. Access to Sufficient Water in March 2022



5. Monthly Rainfall Levels Compared to Long-term Average Rainfall for NES (SPI)



This is likely due to the low rates of use of the water network, used by 47% of households while 52% reported water trucking as their primary water source. The use of trucking was necessary due to the low functionality of the network, leading to substantially higher relative expenditure on water at 5% of total income, according to HNAP data* from summer 2021.[17]

Looking at NES overall, the lowest level of reported community water access was reached in August, with KIs reporting on average 21% of households in their communities having insufficient access.▲ HNAP data* indicated that 46% of households had to use a secondary water source in summer – primarily water trucking – up from 26% in at the beginning of the year, suggesting that various sources of water had become unreliable or insufficient.[18] However, access recovered after October 2021, with values dropping to around 16% from November, similar to the year before.▲ With the rainy season beginning around October, water demand tends to decrease and reservoirs refill, thus naturally decreasing barriers to water access. See figure 4 for levels of access in all assessed communities in March.

Sources of All Purpose Water

The Standard Precipitation Index (SPI), which quantifies differences between current rainfall and the long-term average[d], shows that rainfall since late 2020 was extremely low for NES, on average (see figure 5). A rainfall shortage over 6 months already leads to reduced streamflow and reservoir storage. Above 12 months, recharge of groundwater and reservoirs is affected.[9] This impacts all households, but most directly those relying on rainwater collection (for instance in wells), surface water, and boreholes.

In March 2022▲, KIs in 46% of assessed communities reported (private or community) boreholes or wells as being the primary source of water, making the persistent shortage in rainwater a serious risk to water access. This particularly affects Aleppo governorate, where KIs in 74% of assessed communities reported this source, and Al-Hasakeh governorate with 55%. In 2021, reliance on boreholes further increased while reported use of the water network declined. This was such that when use of the network as a primary source was at its lowest in September 2021, reported by KIs in 29% of communities (down from 39% in December 2020), use of boreholes and wells had increased to 46% of assessed communities, (up from 42%). However, besides the depletion of groundwater, this comes at the associated cost of drilling deeper boreholes and increased expenditure on fuel, the latter of which is particularly prohibitive due to high fuel prices.[19] For a map of water sources for all assessed communities in March 2022▲, please see figure 8.

Sources of Drinking Water

Note the distinction KIs in NES made between water for all purposes and drinking water, the latter being predominantly sourced from the network (KIs in 39% of assessed communities in March 2022) and from private trucking (32%). The use of private trucking specifically for drinking water became somewhat more common during the previous summer, reported by KIs in 39% of communities in August of 2021 (highest point).▲ According to HNAP data*, 25% of households who relied on closed individual wells as their primary water source last summer used a different source for drinking water, compared to 10% of those whose primary source was the network.[17] This is necessary as groundwater in Syria tends to have high salt and mineral concentrations which make it unsuitable or harmful for human consumption.[10]

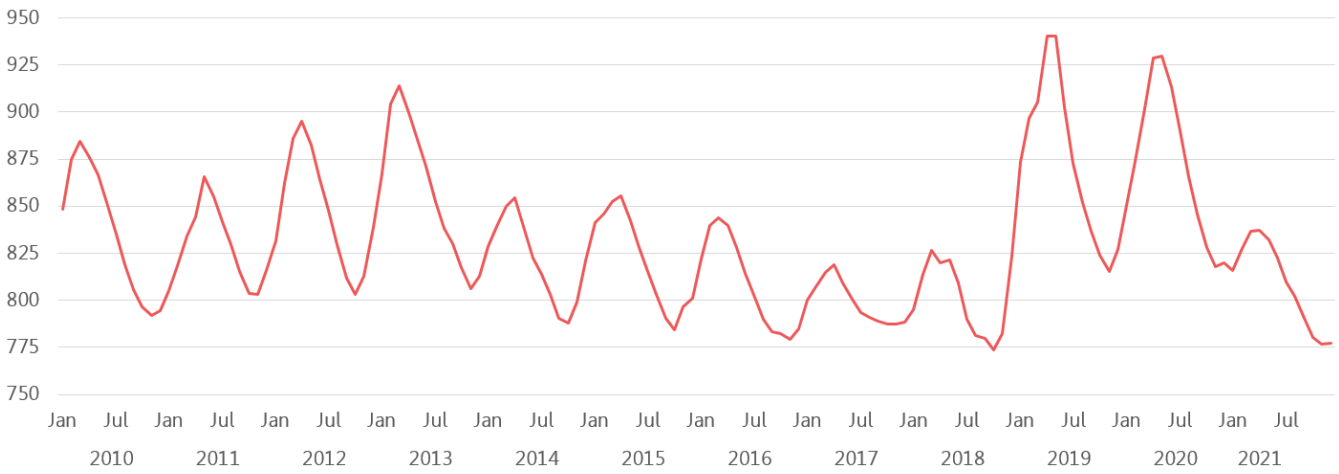
Situation for Out-of-Camp IDPs

The situation for out-of-camp IDPs was notably worse than that of the host community, as indicated by REACH's profiling of informal sites and settlements last October. Particularly in Aleppo and Deir-ez-Zor, KIs in almost half of all assessed sites reported that at least 50% of IDPs had insufficient access to water. The situation was reportedly relatively better in Al-Hasakeh.

(Continues on page 10)

* Statistics were obtained by aggregating household data from sub-districts in which HSOS assessed at least one community in March 2022. Statistics are therefore not representative for NES.

6. Average Groundwater Levels in NES between 2010-2021 (mm per month)

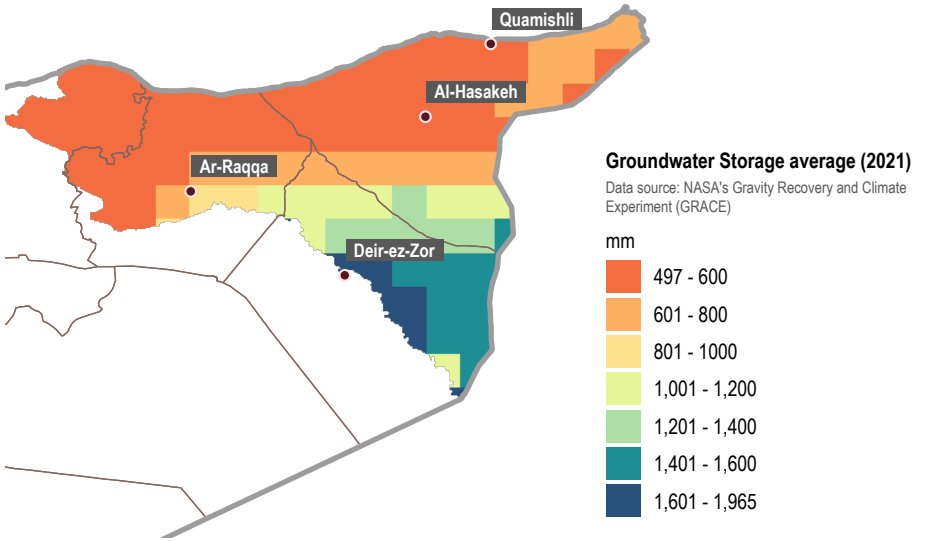


Note on Ground Water Analysis

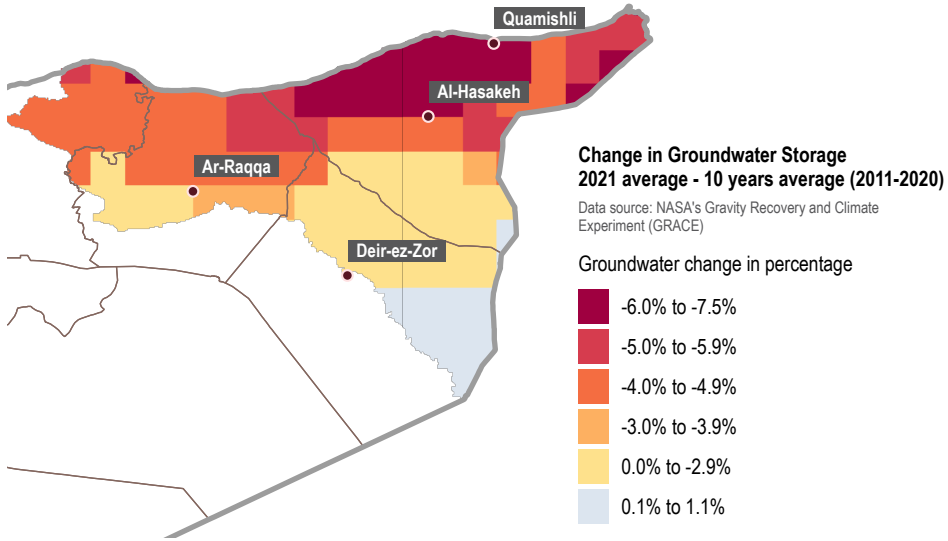
REACH is developing an analysis of groundwater levels in Syria using remote sensing data. As noted above, groundwater levels in NES have been falling over the past decades[10], and reoccurring droughts prevent water levels from recharging. This is evident from the graphs shown here, with water levels across NES having substantially declined in 2021 compared to 2020. As groundwater levels decline, deeper boreholes are required and more energy is needed to pump the water to the surface – either from electricity or from fuel – which increases costs. These rising costs have already priced out many farmers who would ordinarily have relied on irrigation from boreholes (see section on livelihoods). This is particularly true in Al-Hasakeh, Ar-Raqqa and Aleppo, where water extraction for irrigation is the highest.[10] (See methodology in the endnotes).

7. Average Groundwater Storage in NES (mm)

Situation in 2021



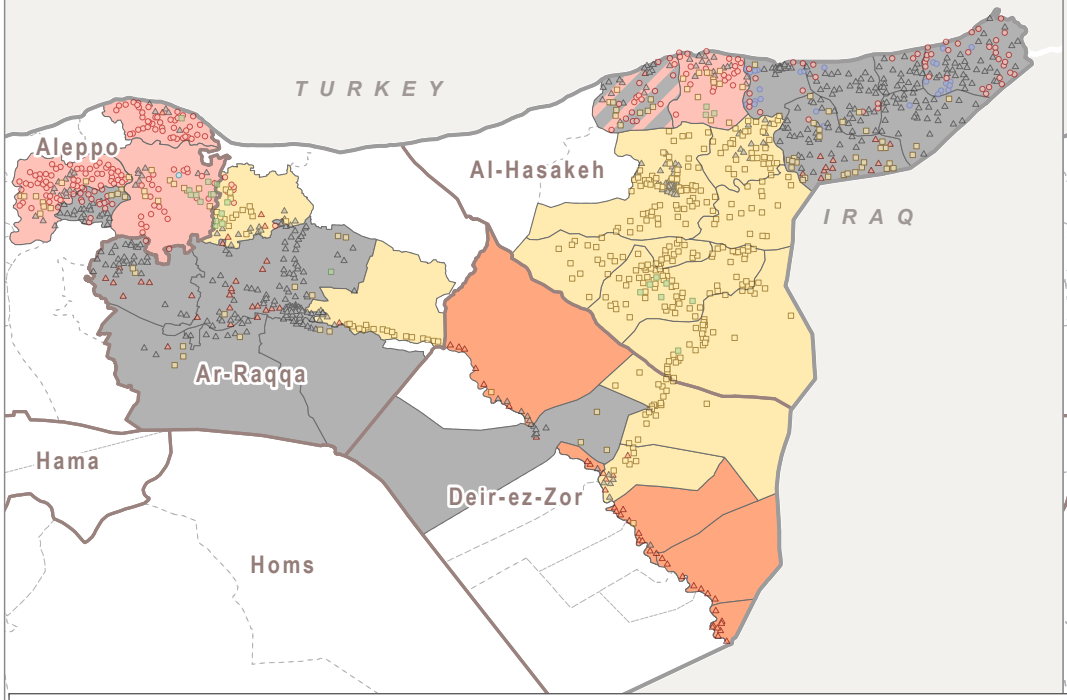
Difference between the Situation in 2021 and the 10 Years Average Over 2011-2020



8. Main Sources of Drinking Water and Water for All Purposes in March 2022

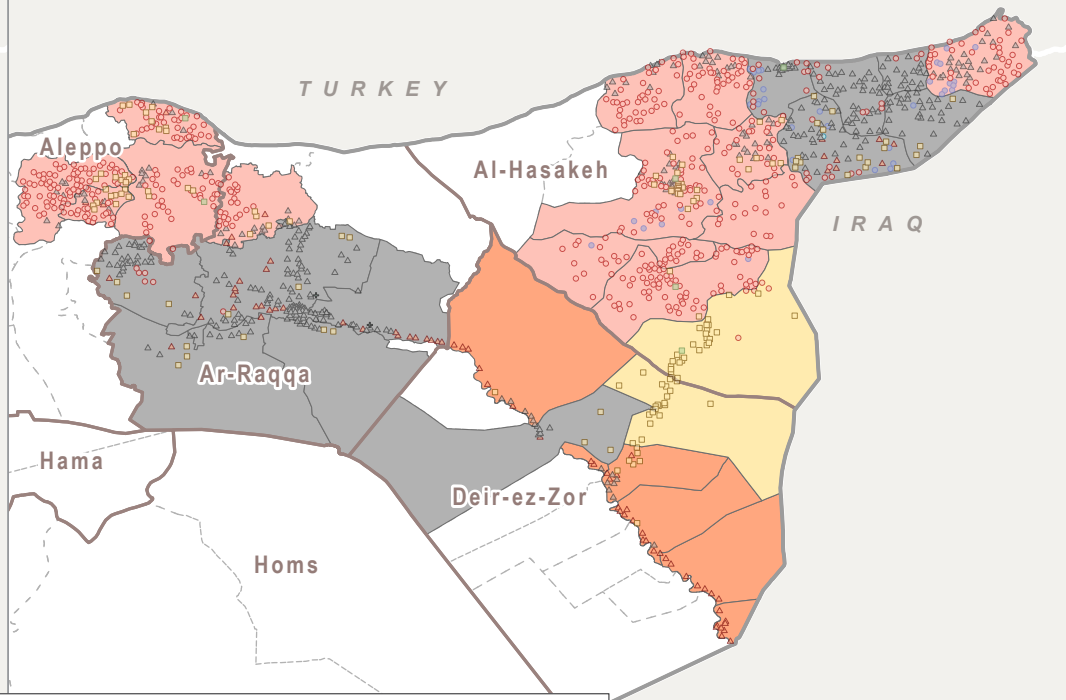
Main source of drinking water

Data source: HSOS March 2022



Main source of water for all purposes

Data source: HSOS March 2022



Most reported by Sub-district:

- Piped water network
- Combination of water network and private water trucking
- Private borehole or well
- Private water trucking conducted by private citizens
- Private borehole or well and piped water network

Community:

- Piped water network
- Combination of water network and private water trucking
- Water trucking conducted by authorities or an NGO
- Private water trucking conducted by private citizens
- Community borehole or well for free
- Community borehole or private well
- Private borehole or well
- Surface water lake pond dam river
- Springs

N W E S

km 0 25 50 100

REACH Informing more effective humanitarian action

IN COOPERATION WITH

NES NGO FORUM

WASH Working Group North East Syria

Here, the main source of water was NGO trucking in contrast to the other governorates, which reportedly relied on private trucking.

Barriers to Accessing Water

Although KIs in 2021 reported similar levels of water access in assessed communities compared to the previous year, KIs more often reported barriers to accessing water. In August of 2021, KIs in 73% of assessed communities reported this barrier compared to 56% in January 2021. Correspondingly, KIs in more communities reported coping strategies, at 73% in August up from 58% in January. This suggests that even as access to water becomes more difficult, households find solutions to ensure their access.

High Cost of Water

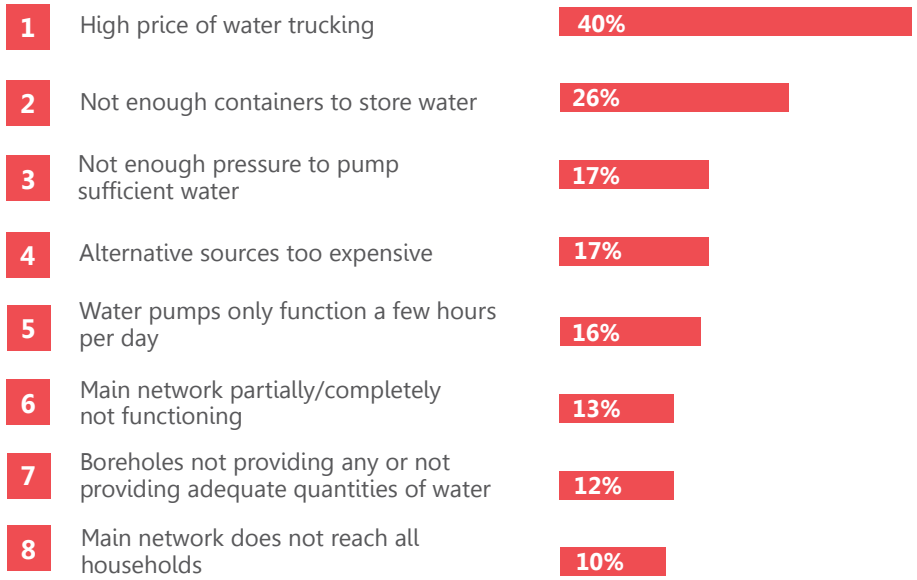
The most commonly cited barrier to water access was the high cost of water trucking, which was reported by KIs in up to 46% of communities in the past year, and in 38% in March 2022 (see figure 9). This was substantially more than in the previous year (41% on average in 2021 compared to 32% in 2020), which can be explained by two factors. The first is that according to REACH's market monitoring, the median price of water trucking in NES increased by 69% during 2021 (see figure 10 for changes in household water expenditure from January 2021 to August, and August to March 2022). The other factor is the increased amount of water sourced from water trucks. In the summer of 2021, according to HNAP data*, around 26% of water used by households came from water trucking. By contrast, only 16% of water earlier that year came from trucking. HNAP data* suggests that both average absolute expenditure on water and expenditure relative to income was highest in Deir-ez-Zor and Al-Hasakeh. This appears to be due to the lower levels of income in these governorates and a greater reliance on private water trucking. This meant that in Deir-ez-Zor, around 5% of monthly income was spent on water and 4% in the Al-Hasakeh, compared to 0.8% and 1.3% in Aleppo and Ar-Raqqa respectively.[17]

Households are likely unable to adequately cover these costs as monthly expenditures substantially exceed incomes, according to HNAP data*,[17], and households have exhausted their savings.[20] In line with the high cost of water trucking, KIs in 28% of assessed communities reported in March 2022 that community members bought water with money that would usually have been spent elsewhere, down from its highpoint of 40% in July 2021. This coping strategy may be detrimental to the household's welfare. Particularly in light of high and rising food prices (see section on food security)[21], diversion of household funds towards drinking water are expected to have negative effects on the household's nutritional status.[6,22]

Infrequent Water Access

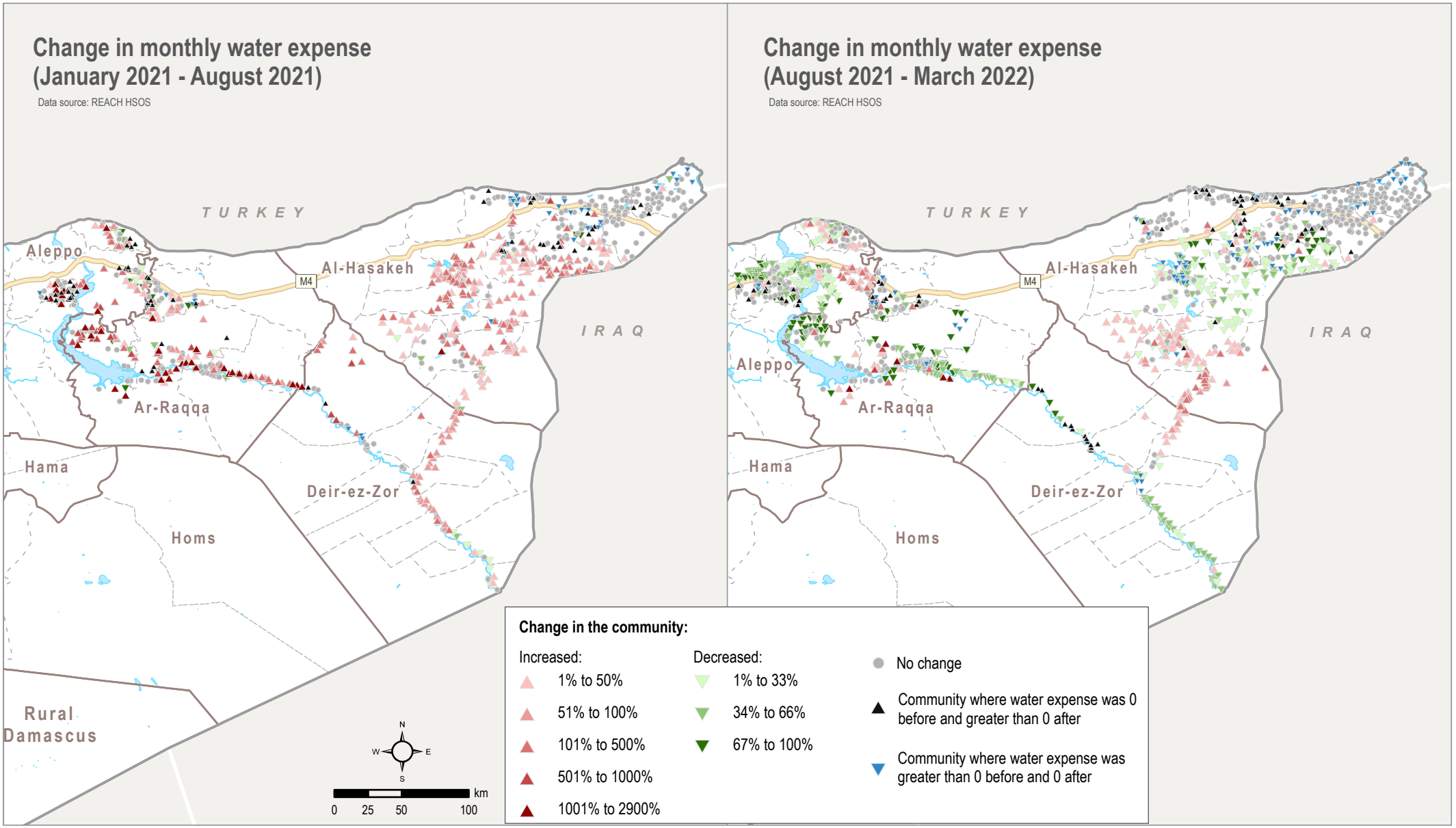
The second most frequently reported barrier in the past year was a lack of storage containers, reported by KIs in 33% of assessed communities at the highest point in August 2021. This corresponds to the coping strategy of relying on drinking water previously stored, which was reported by KIs in 40% of communities in August 2021. Note that there are strong differences between governorates. KIs in 38% of communities in Aleppo reported the lack of containers for water storage as a barrier during the past year, which was the highest rate observed for any governorate. Correspondingly, Aleppo had the lowest reported rates of relying on water previously stored at 20%. By contrast, KIs in 21% of communities reported this barrier in Deir-ez-Zor while the use of stored water was reported in 57% of communities. Availability of containers for safe water storage is particularly important in Deir-ez-Zor and Al-Hasakeh, where more households rely on water trucking.

9. Barriers to Accessing Water in March 2022 (% of communities)



* Statistics were obtained by aggregating household data from sub-districts in which HSOS assessed at least one community in March 2022. Statistics are therefore not representative for NES.

10. Change in Monthly Water Expense between January 2021 and March 2022 ▲



NES is heavily dependent on electricity generated by dams on the Euphrates River. Decreased water flow in the Euphrates have led to large declines in electricity generation, and hence availability. This is particularly problematic as households cannot afford alternative power sources. It also severely affects the functioning of critical infrastructure, including water stations, hospitals, and the food supply chain.

Electricity Production – The Dams

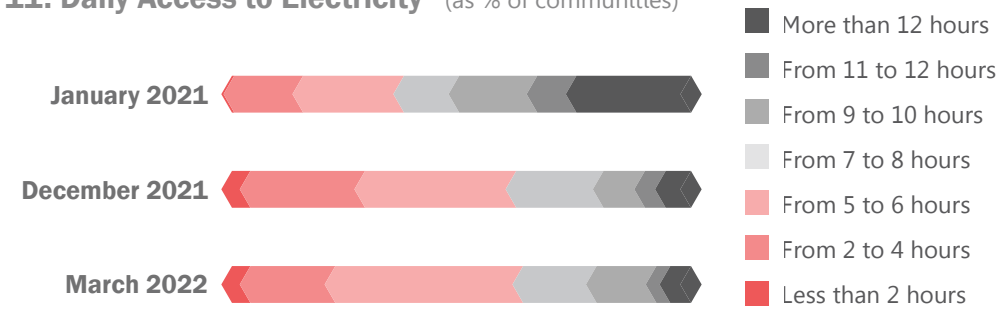
The most important source of electricity in NES are the Tabqa and Tishreen dams. Both are situated on the Euphrates River within NES, jointly providing electricity to 3 million people across NES.[6] The dams are reliant on a certain minimum level of water below which they not only cease to function, but may also suffer serious damage if a shut-down of the turbines leads to internal flooding. These levels are 298 meters for Tabqa and 320 meters for Tishreen.[4] Looking at water levels over the past year, lake Assad (Tabqa dam) remained just over 299 meters (1 m above dead level) from June to December, 3-4 meters lower than the previous year. The most recent data for January to March however shows a substantial recovery up to 302 m, around 1 meter more than the previous year and 2 meters lower than 2020. For Tishreen dam, similar improvements were observed in early 2022 after having reduced to 321.5 meters (1.5 m above dead level) in July,[2] Increased water levels are expected at this time of year as January to April are the "flooding months" of the river.[23] However, the Euphrates has experienced a drying trend which is in part associated to climate change, in part due to extensive water usage.[12,13,24] Thus, despite the situation currently recovering, future declines in water levels are likely.

Decline in Electricity Access

With reduced water flow, the rate of electricity production declined strongly.[6] The most obvious impact this has is on reduced electricity access in communities. According to REACH's HSOS▲, while KIs in 54% of communities that relied on the main network reportedly had 9 or more hours of electricity per day in January of 2021, only 15% did in December. Notice that these trends are similar when looking at all communities: regardless of their primary source of electricity, 50% had at least 9h of access in January 2021 to 19% in December 2021 (see figure 11). This has two reasons. The first is that as households lost access to the network, they transitioned to other sources of electricity that may not provide the same amount of electricity. Furthermore, communities that relied on generators also saw a decline in access, likely due to the prohibitive cost of fuel.[25] The most notable changes to access are observed at the higher and lower ends of the spectrum. KIs in 25% of all assessed communities reported more than 12 hours of access in January of 2021 compared to only 5% in December, and while less than 1% reported less than two hours in January, this increased to 4% in December 2021.

In March 2022 the situation looked largely similar to December 2021, though KIs in more communities reported 5 to 6 hours of access (41% compared to 33%) and most other intervals were correspondingly reported less frequently (see figure 11). For an overview of changes in electricity access by community year-on-year, please see figure 13. Considering the increased water levels in the Euphrates, improved electricity generation would have been expected in March. However, HSOS data does not show this. The reason KIs most frequently gave for the lack of electricity was rationing, as reported by KIs in 78% of communities in March. This is an increase from 2021, when reporting of this barrier increased from 58% in January to 73% in December. Rationing initially increased as a direct result of the water crisis.[26,27] According to a WASH expert, rationing may have continued in an effort to increase water levels in the reservoir. This should decrease the risk of the dams reaching their dead levels in case water flow reduces in summer. Thus, improvements in electricity access may be delayed.

11. Daily Access to Electricity▲ (as % of communities)



Alternative Sources of Electricity

Besides the number of hours of access, the primary source of electricity also changed. Between January and May 2021,▲ KIs in more than 80% of communities reported the main network as being the primary source. By August 2021, this was down to 71%. However, the primary electricity source differs strongly by governorate. In March 2022, KIs in 99% of communities in Aleppo and 97% in Ar-Raqqa reported that the network was most commonly used (62% in Al-Hasakeh). In Deir-ez-Zor, only 12% did – here, KIs mostly reported community generators (71%). Deir-ez-Zor governorate has faced long-run issues with network power supply due damage done to the infrastructure during the conflict.[28,29]

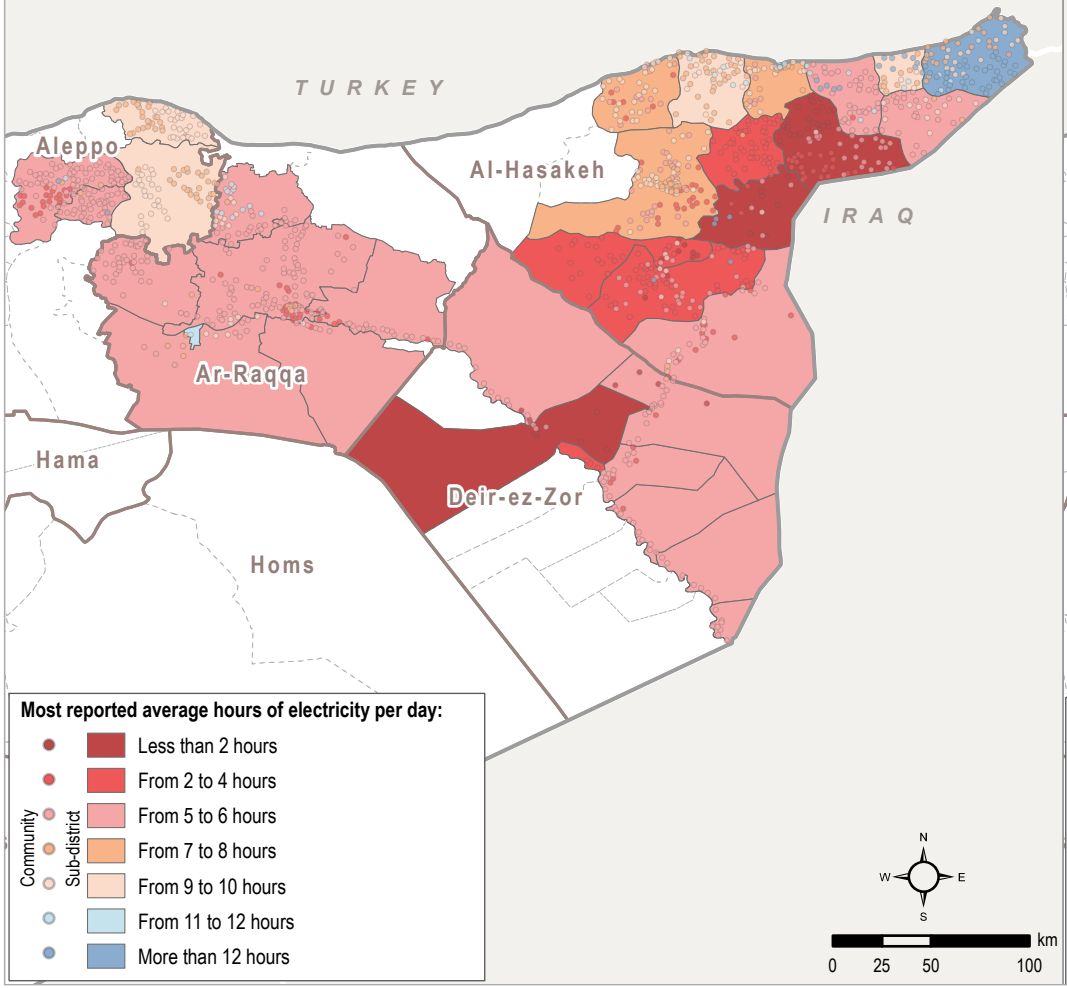
Next to electricity rationing, the most commonly reported barriers in March 2022 and across 2021 is that solar panels, batteries and fuel for generators are too expensive. These barriers are indicative of households trying to decrease their reliance on the electricity network in favour of alternative sources of electricity.

(Continues on page 14)

12. Access to Electricity and Main Source of Electricity in March 2022

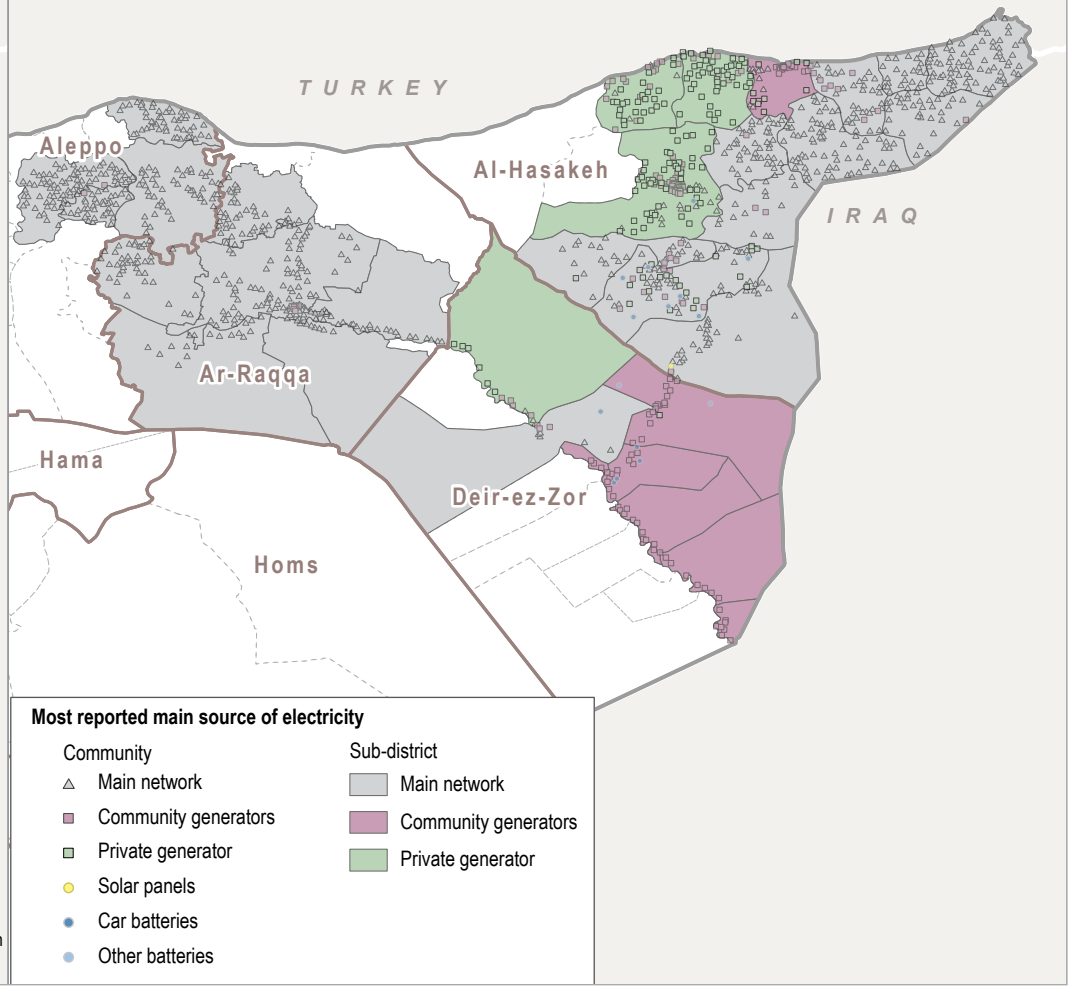
Average hours of electricity per day

Data source: HSOS March 2022



Main source of electricity

Data source: HSOS March 2022

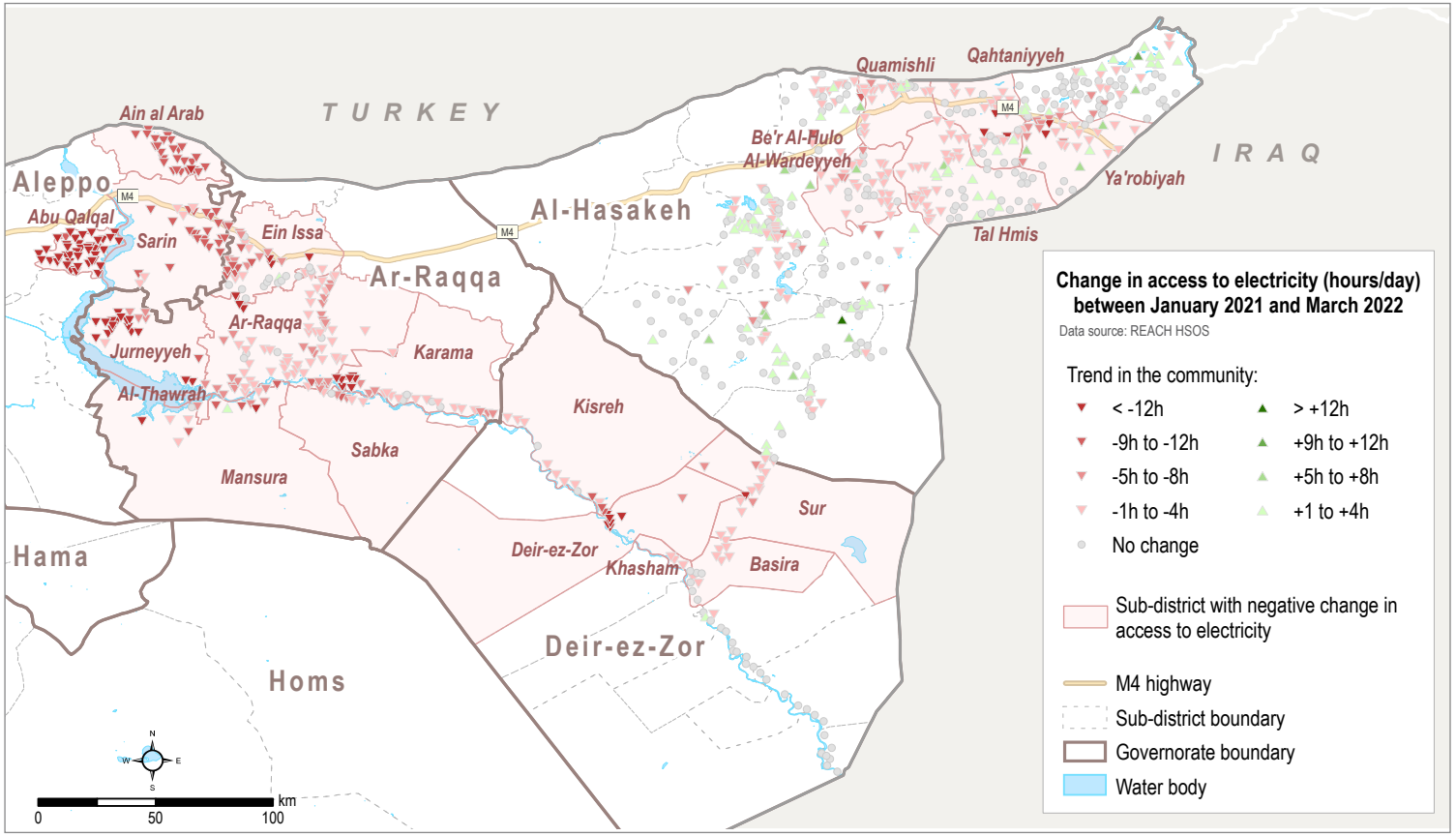


Solar has become particularly relevant as households struggle to access (subsidised) fuel and cover high costs of electricity from generators.[25,28,30] Even though solar power remains accessible even during periods of fuel unavailability and high costs, the cost of solar panels is such that only relatively better-off households can afford it.[28,30] Thus, while alternatives to the network exist, the costs exceed the limited purchasing power of households. This is particularly important in a context where the cost of essential items has risen substantially; the cost of the Standard Minimum Expenditure Bundle (SMEB) increased by 53% year-on-year to March 2022, and by almost 100% since January 2021.▸ Meanwhile, household income has not increased to match the higher costs of living, and this is because the weak economic situation means that wages cannot be increased.[31]

Impacts of Electricity Shortages

Besides private consumption, the lack of electricity is a serious barrier to the functioning of necessary infrastructure. This includes around 200 water pumping stations along the Euphrates which use electricity from the dams.[32] It has also been stated for the whole of Syria that "the shortage of electricity remains the root cause of water supply systems' underperformance or cessation altogether".[20] There have been reports of water treatment systems being bypassed[29] and rationing which aim to save enough energy to supply water pumping stations (and irrigation systems).[26] Especially bypassing water treatment systems poses a large risk to consumers as the water may be contaminated. As few households take measures to make drinking water safer, this may severely affect their health (see health section). Furthermore, hospitals have had to rely on generators and solar power to ensure continued functioning, which increases their costs and decreases their functionality.[20] The food system as well has suffered as for instance mills report shortages of fuel and electricity.[33]

13. Change in Access to Electricity between January 2021 and March 2022▲



Energy shortages, especially in the context of high costs of other power sources, affect all areas of civilian life and the economy. However, it is difficult to estimate the extent of the humanitarian impact caused by the water shortages because the lack of electricity has been an ongoing problem. For instance, there was a clear downwards trend in electricity access and an increased frequency in reports of rationing in 2021.▲ Yet, access was already low (9.8h on average) while rationing was frequent (58%) in January 2021, before water levels dropped. REACH's field team for instance noted the need to rehabilitate the turbines in the dams to improve electricity generation, citing this as a cause for the shortages. Added to that, publicly available information on the energy situation remains scarce and further investigation may be useful.

Agricultural livelihoods have been severely impacted by the water crisis. Rainfed crops largely failed in the previous season while irrigated crops saw large reductions in harvests, leading to a loss of income while food prices have risen. Meanwhile, pastoralists are facing serious issues with sourcing fodder for livestock, leading to large-scale destocking and livestock death. Rainfall levels have remained at a low level this season, causing concern that the livelihoods situation will continue to worsen this year.

Agriculture

Agriculture is one of the most important livelihood sectors in Syria. HNAP estimated that 21% of the population between 18 and 64 works in agriculture, livestock or fisheries in NES, and 27% in rural areas specifically (Summer 2021).[18] In REACH's HSOS▲, KIs in 91% of communities in NES reported that their community relied on agriculture (including livestock or fisheries) to meet basic needs in March. Deir-ez-Zor governorate had the highest rate of reported community dependence on crops (cash crops or food crops), reported by KIs in 92% of communities. For livestock (animal products or live animal sales), the highest rate was observed in Aleppo at 91%.[e]

The agricultural sector in Syria has come under pressure during the last decades due to an increasing frequency and intensity of droughts[35,36] paired with falling groundwater tables.[10] Notably, the drought from 1999-2001 caused a sharp decline particularly in cereal harvests and sheep production.[37] Looking at the drought from 2007 onwards, we again see a strong decline in production with small- and medium-scale farmers being hit hardest and almost all of their livestock herds being lost.[35]

Crop Cultivation

Drought Situation

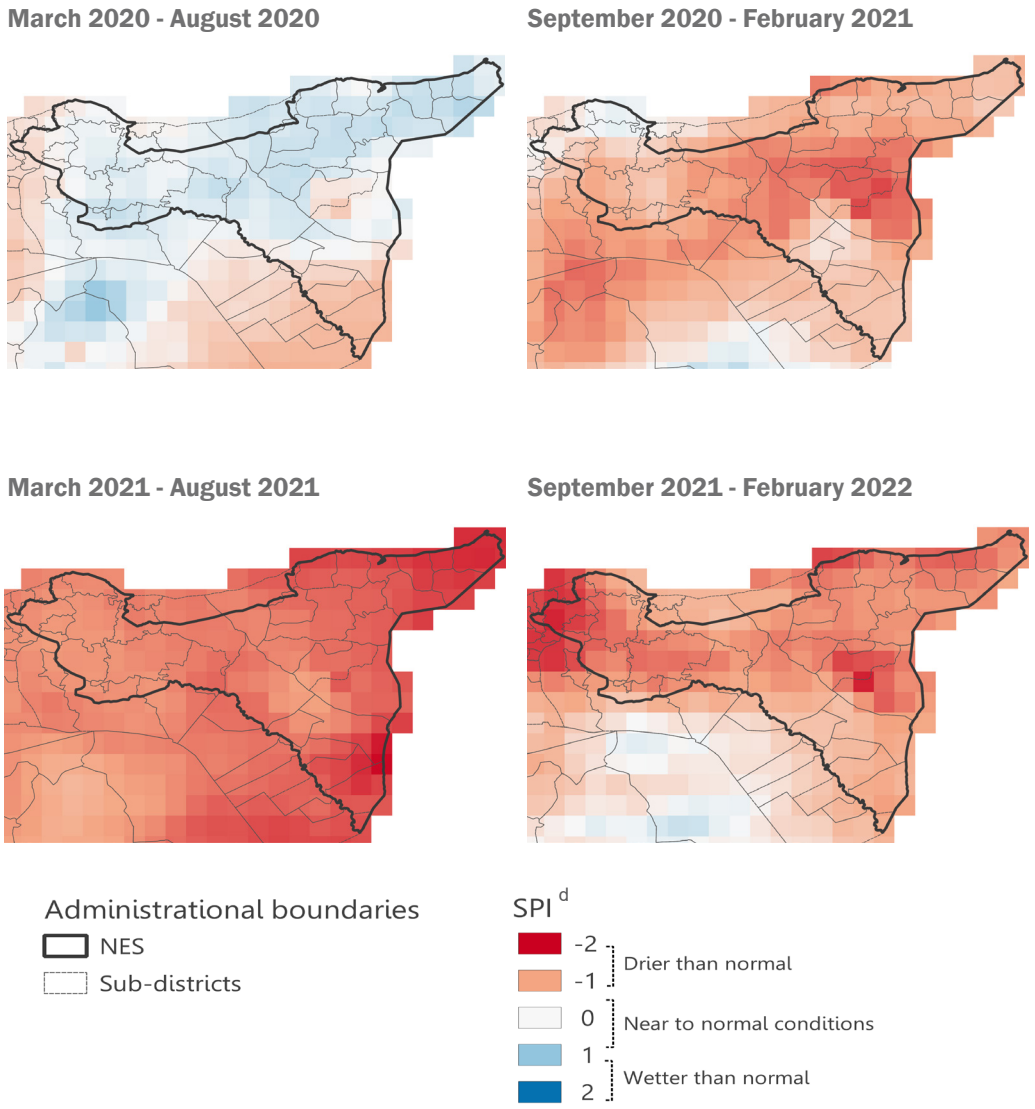
The meteorological drought (i.e. caused by a lack of rainfall) experienced since late 2020 is illustrated in figure 14. It uses the Standard Precipitation Index, which compares the long-term average rainfall with current rainfall.[f] Thus, we see that almost the entire area of NES experienced an extreme shortfall in precipitation in 2021. This sums to about a 51-68% reduction in rainfall in each governorate in the 2020-2021 agricultural season against the long-term average.[1] Together with the delayed onset of rainfall, the early cessation, and with heatwaves starting in April of 2021,[11] this led to extremely low harvests, notably of wheat and barley. For the current season, we again see below-average rainfall in NES, as shown by the SPI; therefore, the Global Drought Observatory reported in March a medium risk of drought impacts on agriculture in NES with parts of Al-Hasakeh governorate at high risk.[38]

Barriers to Irrigation

Irrigation is a highly effective tool for mitigating the impacts of meteorological drought.

(Continues on page 16)

14. Comparison of the 6 Month Aggregated Rainfall Levels with Long-term Averages (SPI)



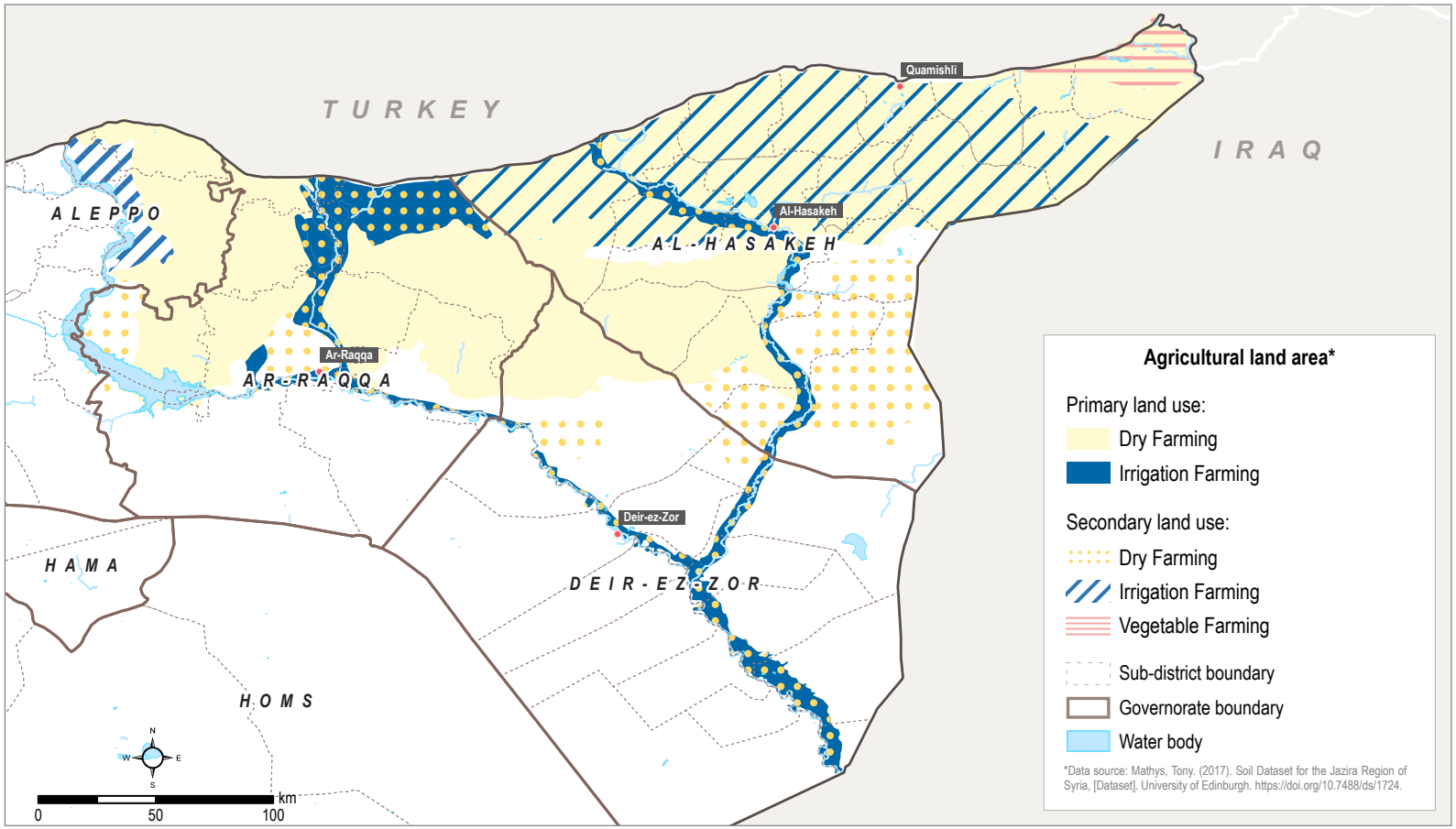
This becomes particularly obvious when considering harvests in the previous season. Figure 15 shows different land use areas using historical data, with yellow indicating rainfed agriculture and blue indicating irrigated agriculture. Irrigation particularly occurs along rivers, notably the Euphrates (West) and Khabur (East). Al-Hasakeh governorate uses groundwater for irrigation, hence permitting irrigation in areas without surface water.[10] Figure 16 shows the areas of cropland lost between 2020 and 2021, with irrigated areas on the Euphrates as well as areas using water from canals north of Ar-Raqqa city having experienced fewer losses. Areas around Khabur river saw losses, likely due to the long-term drying of the Khabur that has been observed.[39] Figure 17 shows cropland losses by land use type. Observations of harvests confirm that while irrigated crops saw strong declines compared to the 2019-2020 season, rainfed crops in large areas of NES failed entirely.[11]

However, access to irrigation water was problematic, partially due to reductions in water flow in the Euphrates and the Khabur. REACH conducted a rapid needs assessment (RNA)▸ in Al-Hasakeh governorate in March. Here, 9 out of a total of 13 KIs in Areesheh, Markada and Shadadah indicated problems with irrigation water being a barrier to agriculture in their subdistrict due to low availability and partially due to the high cost of water. This appears to be a more important problem than elsewhere in Al-Hasakeh. The subdistricts are situated downstream of the biggest dam on the Khabur river, thus receiving less water than areas upstream. REACH staff in Areesheh subdistrict have previously reported problems with irrigation water in the area, noting that during years of low rainfall, the dam cannot be opened to provide water to farmers in Areesheh – and by extension to Markada and Shadadah – posing a large barrier to agriculture.

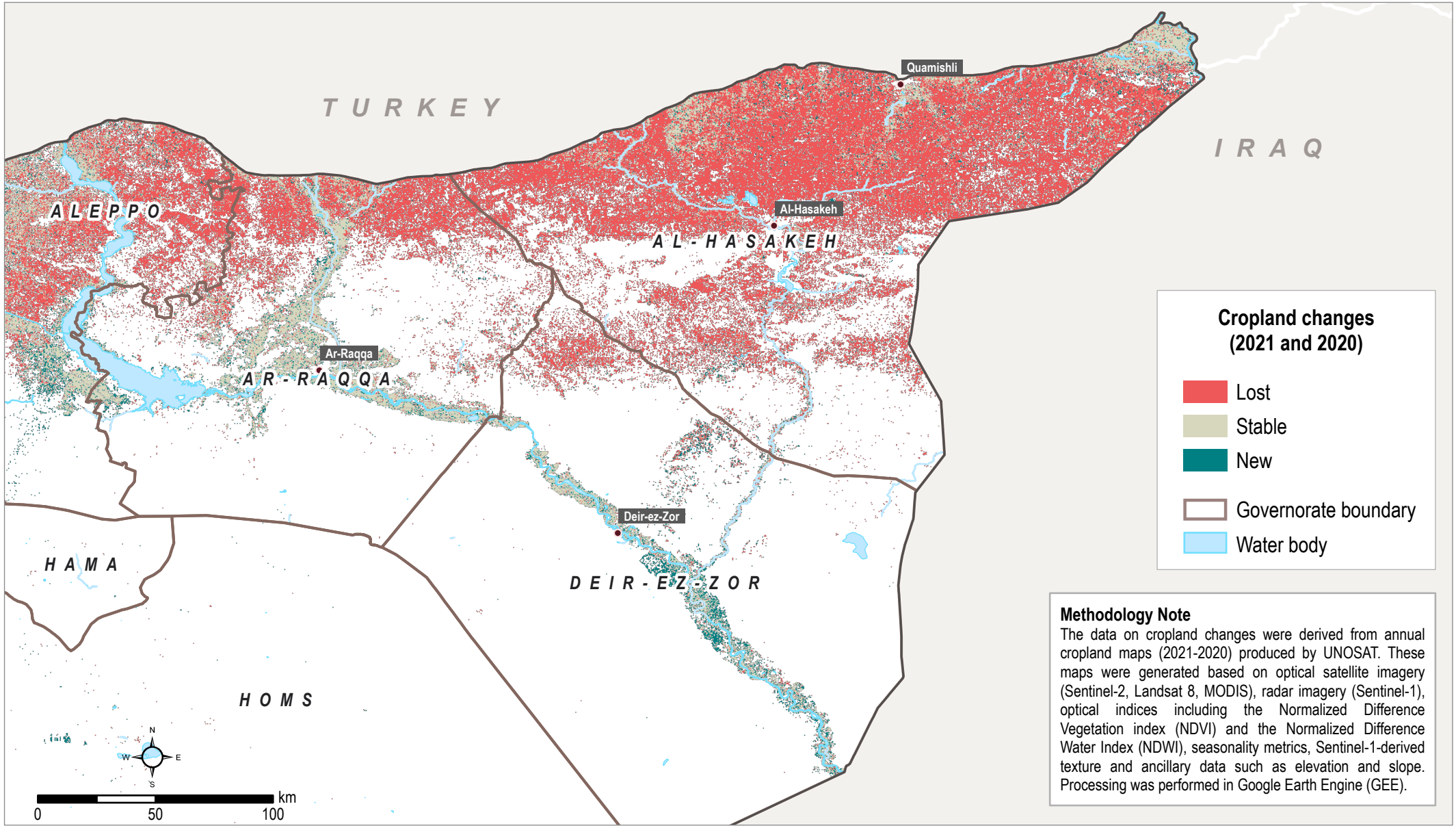
Besides the lack of surface water, HSOS data for March ▴ shows a strong correlation between reported deficiency of rainfall and lack of water for agriculture – where rainfall is lacking, farmers require irrigation water; if this water is abundantly available, the low rainfall poses little barrier to crop cultivation and vice versa.

(Continues on page 18)

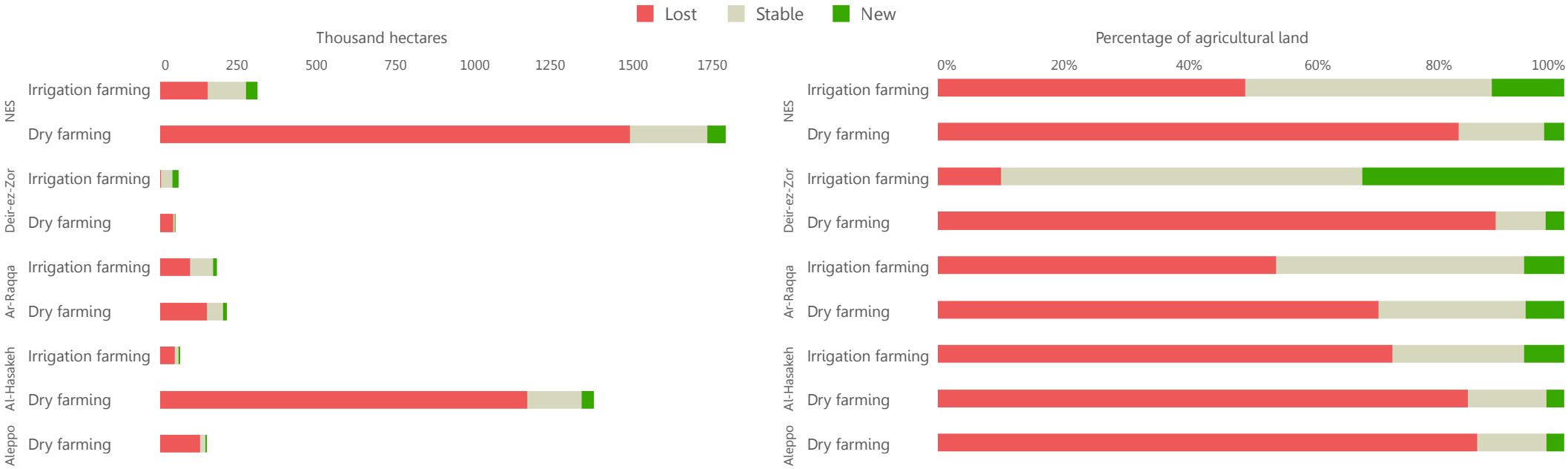
15. Agricultural Primary and Secondary Land Use



16. Cropland Loss from 2020 to 2021



17. Change in Cropland for Areas with Dry Farming or Irrigation Farming as Primary Land Use (2020-2021)



The highest rate of rainfall deficiency in March was recorded in Aleppo governorate, with KIs in 86% of communities reporting this barrier; correspondingly, 69% reported a lack of water for agriculture. Aleppo further lacks resilience against low rainfall levels as it experienced the greatest damage to irrigation infrastructure due to the conflict, together with Al-Hasakeh governorate,[40] with irrigation canals that previously provided water from the Euphrates having been destroyed.[41]

Falling Groundwater Tables

Additionally, groundwater levels have been declining since the 1970s due to a push to increase irrigation.[10] Thus, less water is available, and the cost of accessing it has increased as boreholes need to be deepened and more fuel is required to pump water to the surface.[11] This is exacerbated by rising fuel prices and fuel shortages, as reported by REACH's market monitoring.▸ Note that manually refined fuel is widely available, though at increasing costs, while high-quality fuels were frequently reported to be unavailable. This persistent fuel shortage comes from a lack of refining capacity. Because of this lack in capacity, the oil reserves present in the area cannot be effectively utilised.[25] In REACH's RNA▸ in Al-Hasakeh governorate, 92% of KIs (49 of 53) reported the high cost of fuel for pumps as a barrier, with further 58% reporting the high cost of electricity for pumps and 74% reporting the high cost of solar power. Together with the unaffordability of agricultural inputs such as fertilisers,[11] this explains why operational costs were the most frequently cited barrier to accessing livelihoods from agriculture in HSOS, reported by KIs in over 65% of communities in March.▲[f]

Crop Failures in 2021

In terms of harvest, wheat is Syria's most important winter crop with cotton being the most important summer crop.[5] The FAO reported for the whole of Syria that irrigated wheat productivity halved from 3.2 tonnes per hectare (t/ha) in 2020 to 1.7 t/ha in 2021. Meanwhile, rainfed wheat yields reduced by 2/3 (1.4 t/ha to 0.4 t/ha), going down to zero in Al-Hasakeh and Ar-Raqqa governorates. Thus, after accounting for the increase in area planted, total yields were estimated at 1 million tonnes, just over 1/3 of what was produced the year before. Barley production saw an even stronger decline, with harvests just under 1/9 of the previous year's. This is due to the vast majority of areas not being irrigated

(Continues on page 19)

and total areas planted having been reduced amidst a push to increase wheat production.[11] For cotton harvests, no definitive values for changes in production could be found. However, it is clear that large losses were incurred due in part to decreased cultivation areas in response to high prices of cultivation since the onset of the conflict[42,43] as well as crop failures due to the lack of water compounded by heatwaves in spring.[42] This is particularly relevant as Syria was formerly a major cotton exporter with an export value around 420 m USD in 2010 at 4.4% of total export value[74].

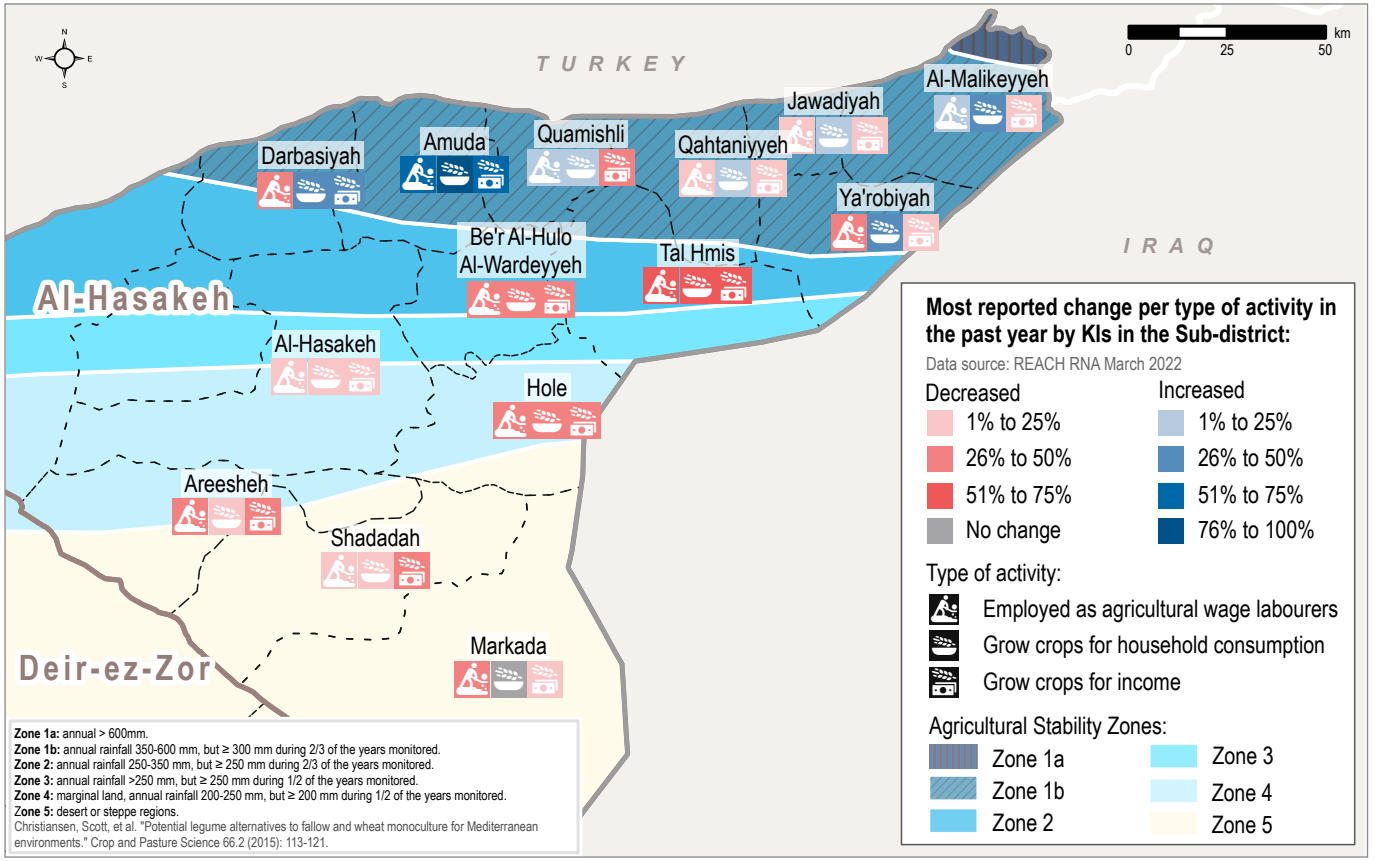
Impact on Farmers' Livelihoods

The RNA in Al-Hasakeh governorate further shows the severe impact of the drought on farmers' livelihoods. 83% of KIs (45 of 54) reported a decrease in the number of people cultivating crops for income.[9] Tal Hmis had the largest reported decrease, with all three KIs reporting a decrease of 51-75% in their subdistrict. If there was a decrease, KIs most frequently reported people compensating for the loss in income by providing (non-military) security services (37 of 45) or moving into construction (36 of 45). For agricultural wage labourers, somewhat fewer KIs reported a decrease (41 out of 54), however the decreases were reported to be stronger and the increases less intense. Furthermore, while 69% of KIs reported that when people stopped growing crops for income, they stayed within the agricultural sector in a different capacity, only 10% reported this for wage labourers. Instead, 98% (40 of 41) reported that daily wage labourers moved into security services and 85% reported movement into the construction sector.

Darbasiyah, a subdistrict on the border to Turkey, stands out with all five KIs reporting a 26-50% increase in the proportion of people cultivating crops. Darbasiyah was hard-hit by the drought with agricultural cropland decreasing by 65%, but it performed better than Al-Hasakeh governorate on average, which experienced an 82% loss in cropland between 2020 to 2021 (see figure 16). Al-Malikeyyeh subdistrict, in the far north-east of Al-Hasakeh, tends to experience the highest levels of rainfall and correspondingly lost the least cropland at 46% (see endnotes). The RNA thus suggests it saw an increase in the number of agricultural wage labourers and little decrease in crop farmers. For a breakdown of changes by sub-district, please see figure 18.

(Continues on page 20)

18. Reported Change in Agricultural Activities between June 2021 and March 2022



To cope with barriers to crop cultivation, borrowing money from friends and family and renting out land were the most commonly reported strategies for both irrigated and rainfed crops in the RNA in Al-Hasakeh governorate. In REACH's HSOS, borrowing is also the most frequently reported strategy for coping with barriers to meeting basic needs, reported by KIs in 91% of communities in March 2022. While borrowing may be effective in bridging short-term gaps in income, the ongoing economic difficulties in Syria over the past have eroded households savings and led to high debt services.[20] HNAP data for summer 2021 suggest that the average household in NES spends 12 USD on debt services each month (8 USD median) compared to an average income of 89 USD (91 USD median), thus severely reducing household's disposable income. This can lead to a vicious cycle of households taking more loans or borrowing more money to cover outstanding debt services, further increasing debt. In addition, 30% of KIs (16 of 53) reported selling of productive assets as a common coping strategy for rainfed crop cultivation, and 25% (13 of 53) did for irrigated crops. This coping strategy was reported by all KIs in Tal Hmis and Hole subdistricts, as well as Areesheh for irrigated crops specifically. By selling productive assets, households reduce their ability to generate income, leaving them even less well-placed to repay debts and cope with future shocks.

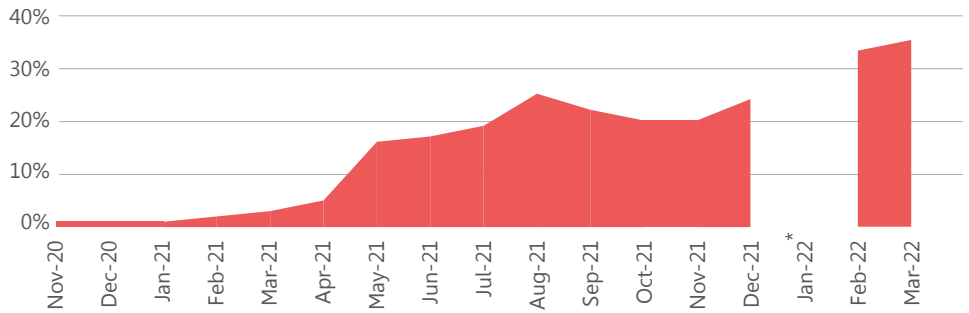
Livestock Farming

Situation Overview

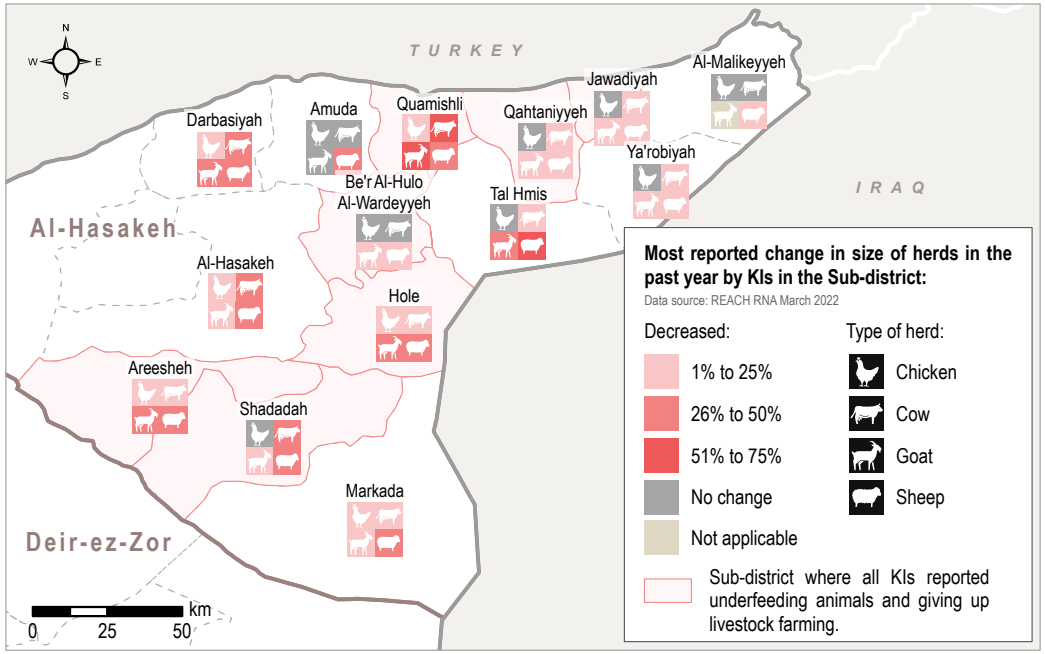
Next to crop agriculture, livestock farming was also hard-hit. Livestock in NES mainly includes smaller ruminants such as sheep and goats with fewer cows and poultry.[11,44] In REACH's HSOS, a lack of fodder was reported by KIs in 68% of assessed communities in March 2022, making it the most frequently named barrier to accessing livelihoods from agriculture, together with high operational costs. These rates were highest in Aleppo governorate at 76%, with the lowest rates (25%) reported in Deir-ez-Zor. This came as pastures dried up earlier than usual due to the lack of rainfall and heatwaves.[11] However, it is also part of a longer trend preventing grazing in the Badia, the steppe in north-eastn Syria. This previously provided the largest source of feed for animals, but has been badly degraded due to overgrazing and access has been inhibited by security concerns,[45] prompting pastoralists to travel to Al-Hasakeh governorate for grazing. Additionally, barley, the most common green fodder crop, saw immense reductions in harvests last year (see Crop Cultivation). The alternatives are processed and mixed feeds, which experienced strong price increases due to increased demand and the high cost of imports.[44] Another solution was to allow animals to feed on unharvestable crops. This allowed crop farmers to reclaim some of the cost invested into by renting their fields out to livestock herders.[11]

(Continues on page 21)

19. Percentage of Assessed Communities Dependent on Livestock in which KIs Reported High Rates of Livestock Death as a Barrier to Livelihoods



20. Change in Herd Size between March 2021 and March 2022



* In January 2022, HSOS KI data was collected in a limited number of communities in NES due to HSOS HH data collection in Hasakeh city. January findings are therefore omitted from the graph.

High Rates of Livestock Death and Destocking

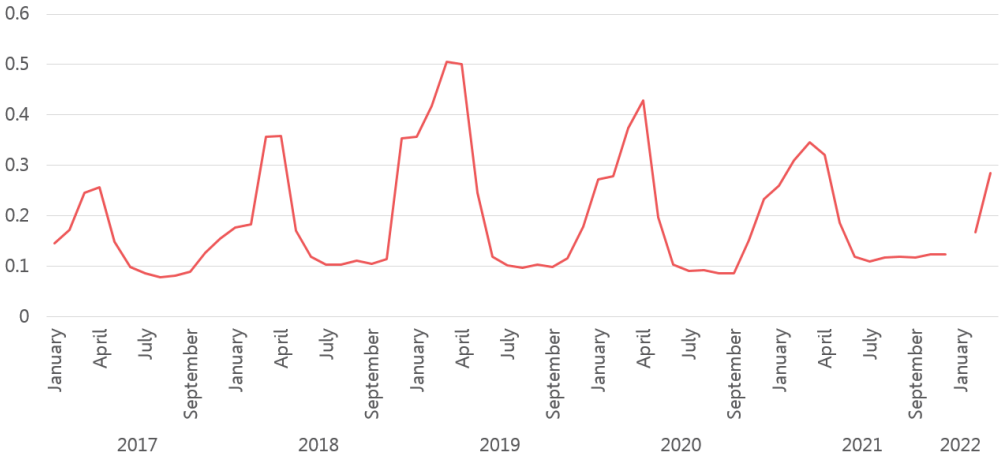
Furthermore, high rates of livestock death as a barrier to agricultural livelihoods for residents was reported by KIs in less than one percent of communities across NES in early 2021. This subsequently increased, reaching 25% in August. After reducing slightly in the following months, rates increased strongly towards March 2022 (see figure 19). In late 2021, the issue of livestock death was most often reported in Al-Hasakeh governorate, noted by KIs in up to 29% of communities that relied on livestock. By March 2022, this had increased to 44%. Meanwhile in Deir-ez-Zor governorate, the proportion of communities in which KIs reported livestock death as a barrier to agricultural incomes rose to 59% in March 2022, exceeding values in Al-Hasakeh governorate.▲ iMMAP associates the sudden livestock deaths in the first two months of 2022 with various barriers to providing quality fodder to animals,[46] which is reflected in the RNA▶ where 94% of KIs (51 of 54) in Al-Hasakeh governorate reported the high cost of fodder as a challenge for livestock rearing. Correspondingly, 83% of KIs reported farmers commonly buying cheaper, lower quality fodder and 69% reported underfeeding animals, both of which may be harmful to animal health. A compounding factor may be the increased risk of disease (reported by 57% of KIs in Al-Hasakeh governorate) associated with malnutrition (28%), as well as the high cost of veterinary services (81%).[11,46]

Besides rates of livestock death being high, many farmers sold parts of their herds to be able to afford fodder for the other animals.[11,46] In REACH's RNA▶ in Al-Hasakeh governorate, almost all KIs for each type of animal reported decreases in herd sizes over the previous year (see figure 20). Sheep were most strongly affected, with 67% (34 of 51) of KIs reporting reductions of over a quarter. However, sheep also had the largest median reported herd sizes at 30 animals, compared to 7 for goats and 2 for cows. With a larger herd, pastoralists may be more easily able to rebuild their herds and thus recover from the drought. However, particularly in situations of recurring droughts, sell-offs and high livestock mortality can lead to a long-term decline in herd sizes and thus incomes for pastoralists. Here, this reduction should be seen in the larger context of the conflict, which has already led to large declines in livestock numbers due to poor living conditions, theft, abandonment, and such.[40,48] Destocking led to a decline in the price for live animals in June 2021 compared to June 2020, most notably for goats and sheep for milk which each saw prices about halve despite high inflation rates. Meanwhile, dairy prices increased strongly, almost doubling for cow's and goat's milk. By contrast, changes in meat prices were smaller and differed by animal.[44]

Spill-over Effects from the Agricultural Sector

It was noted above that agriculture is an important source of income and employment for the Syrian population. Thus, a decline in purchasing power of farmers can impact the larger economy. HNAP data from June 2021 suggests that 72% of household in NES whose main source of income was agriculture (crops, livestock or fisheries) found their incomes to be insufficient.[17] While this compares favourably to other sectors, the positive comparison seems to be due to a better performance in the eastern parts of Aleppo governorate, specifically in Ain al Arab, Menbij and Sarin, three sub-districts on the Euphrates at the Turkish-Syrian border. However, given the prevalence of reports of rainfall and water deficiency, paired with the extremely low vegetation levels[h] up through December (see figure 21), it is most likely that farming households in Aleppo will face lower incomes due to the drought. By comparison, almost all households in Al-Hasakeh governorate reported their incomes as being insufficient if they depended on agriculture, thus leaving agriculturalists as bad off or worse off than almost any other sector. Furthermore, shortages in agricultural produce and barriers to importing substitutes have led to increased food prices and thus to reductions in real income. REACH's market monitoring▶ suggests a 9% increase in food prices month-on-month to March and 56% compared to 12 months earlier. Particularly in light of persistently low levels of rainfall, high risk of drought impacts on agriculture in some areas of NES,[38] and increasing global wheat prices in the wake of the Ukraine crisis – an estimated 3.5 million tonne deficit in global wheat exports from February to March having led to a 62% increase in global wheat prices between January and March[49] – there is a serious risk of further increases in food insecurity due to unaffordability of food products.

21. Normalized Difference Vegetation Index (NDVI) for Aleppo Governorate



Food security is particularly impacted by record low harvests in 2021, as well as ongoing issues with high food prices and barriers to importing food. With current rainfalls remaining low and global food prices rising due to the crisis in the Ukraine, food security is set to worsen further.

High Levels of Food Insecurity

Syria is currently experiencing unprecedented levels of food insecurity.[20] While the drought substantially contributed to this, the situation should be seen in the context of long-term trends in food security. Notably, in 2010, it was already tentatively estimated that over 3.5 million people were food insecure.[50] The conflict exacerbated this in multiple ways – by creating strong barriers to agriculture which increased dependence on imports while creating barriers to cross-border supplies, and by eroding purchasing power, thus decreasing households' abilities to cope with high food prices.[40,51] COVID-19 has further worsened the situation by causing disruptions to supply chains and decreasing incomes, leading to a 60% increase in food insecurity in one year, up to 12 million people in the whole of Syria in 2021.[52] This situation is likely to continue deteriorating given extremely low harvests in 2021,[11] paired with new barriers to imports due to the Ukraine crisis.[49,53]

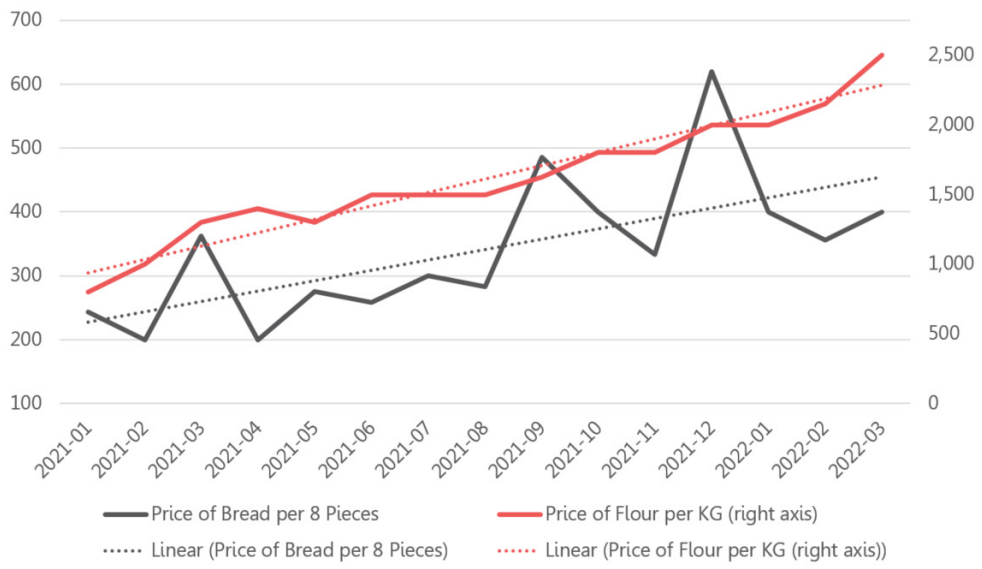
Impacts of Drought-Related Crop Failure

NES is the main food-producing area in Syria, and thus relies heavily on local production. This is particularly true for bread, with the region previously having been self-sufficient in wheat.[54] However, 2021 saw the failure of rainfed crops and strong reductions in irrigated wheat.[11] Bread has now been rationed, with reports of bakeries substituting up to 20% of wheat with corn.[31,55] Figure 22 shows the price of bread and flour over the past year. Noticeable here is that flour prices more than doubled year-on-year with a relatively continuous increase. Meanwhile, bread saw a 78% increase with strong fluctuations across the year. These fluctuations predominantly correspond with changes in subsidy regimes, with September 2021 and December 2021 seeing increases in prices of subsidised bread[56] and decreases in support to bakeries. This particularly affected Al-Hasakeh in September[57] and Deir-ez-Zor in December, though the situation in Deir-ez-Zor was later resolved through reinstated support.[58] Note that bread is heavily subsidised in NES, with one report suggesting that consumer prices of subsidised bread only represents around 25% of total production cost.[58] This then also explains the low cost of bread relative to flour, with flour seeing lower subsidies. Decreases in quality and, more recently, partial replacement of wheat with corn flour have mitigated price rises.[55,59]

Furthermore, regional differences in bread prices are large. Deir-ez-Zor governorate had the highest prices in February of 2022 at 900 SYP (~0.25 USD for an 8-piece bundle) according to REACH's Market Monitoring, around three times as high as in other governorates. This is a strong departure from the situation in November 2021, during which bread prices in Deir-ez-Zor were substantially lower than prices in Al-Hasakeh governorate. iMMAP reported for November that while Deir-ez-Zor had the lowest functionality of bread processing facilities, costs of bread production were lowest in Aleppo and Deir-ez-Zor.[33] However, provisions of subsidised wheat reportedly differed by governorate, with bakeries in Deir-ez-Zor resorting to buying unsubsidised wheat from local markets in the hopes that they might later be reimbursed. However, the administration announced that it would postpone flour payments until further notice and additionally announced late in November 2021 that it would reduce support to bakeries by 20%. This led to bakeries closing in strike and widespread protests as the population lost access to bread.[59,60] The situation only improved after authorities announced they would support bakeries such that they could work for two to three days a week.[59]

(Continues on page 23)

22. Development of Flour and Bread Prices in NES (in SYP)



Beyond the cost of bread, food prices increased across the board in the past year. The Survival Minimum Expenditure Bundle (SMEB) for food increased by 56% year-on-year to March 2022 (see Figure 23). September 2021 saw a relatively strong increase after a few months of smaller changes, brought on by a slightly stronger currency deflation paired with increases in prices of some foods, notably bread.

Cost of Food Exceeds Household Purchasing Power

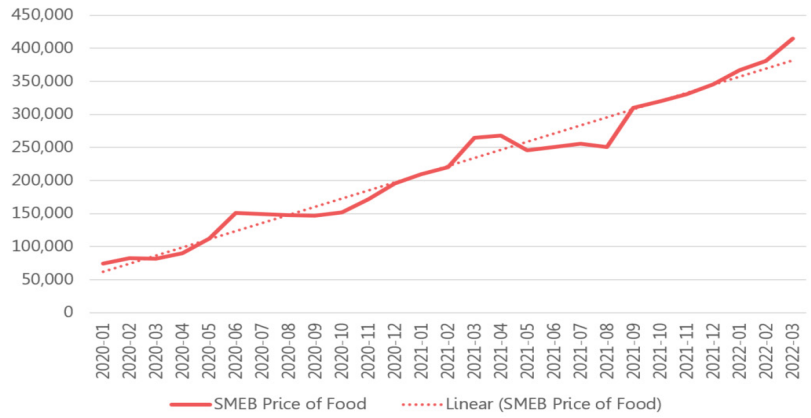
Data suggests that households have been struggling to cover rising food costs. In REACH's HSOS, KIs in 82% of assessed communities reported in March that households cannot afford food. Deir-ez-Zor stands out with KIs in every community reporting this barrier, while the lowest rate was observed in Ar-Raqqa at 73%. In fact, HNAP data for summer 2021 suggests that mean expenditure on food was 61 USD (median 47 USD) while mean income was 89 USD (median 91 USD),[17] suggesting that the majority of household income is spent on food. The highest relative expenditures were recorded in Menbij subdistrict, Aleppo governorate, where the ratio was 95%. This is highly problematic as KIs in 92% of communities reported in March that incomes did not cover the cost of living, according to REACH's HSOS.

Coping strategies reflect the problems with affordability, as purchasing food on credit and borrowing money (reported in 79% of communities), buying less preferred and lower quality foods (76%), and buying food with money usually spent on other things (67%) are most frequently reported in the March 2022 round of HSOS. REACH further conducted an RNA in March 2022 in which KIs reported decreases in farming for income and agricultural wage labour in most subdistricts in Al-Hasakeh. However, there were notable increases in the number of households growing crops for own consumption in many subdistricts (see figure 24). Own food production may be beneficial to food security as it makes households less dependent on the functioning of food markets, thus increasing resilience against price spikes, barriers to access, and such.

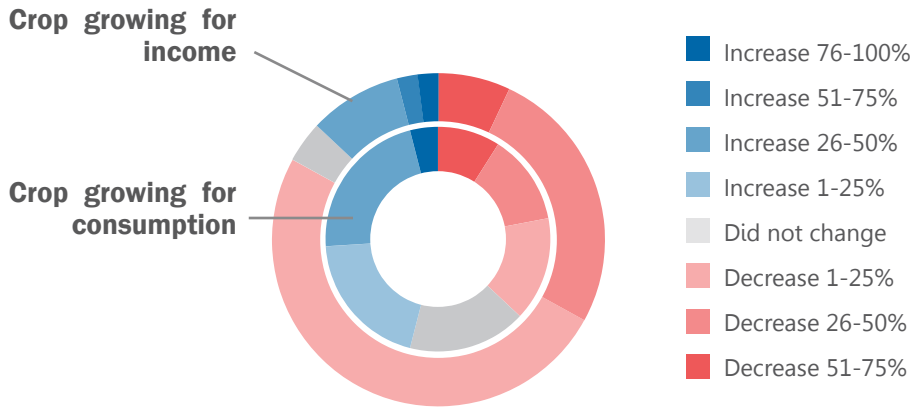
Conclusions for Food Security

Both high levels of relative food expenditure and the (common) use of multiple coping strategies are indicators of high food insecurity, showing that households have difficulties in acquiring enough quality food and that they are vulnerable to fluctuations in the cost of food. The World Food Programme reported for February 2022 that NES had some of the highest levels of insufficient food consumption, affecting 70% of households in the whole of Ar-Raqqa[i] and 60% in Al-Hasakeh.[61] The severity of this food insecurity is reflected not only in the number of coping strategies used, but also in the use of more extreme coping strategies. KIs in 20% of assessed communities reported households skipping meals, and 19% reducing meal sizes, to cope with the lack of food in March 2022. Adults are also particularly strongly affected as they often go without food to ensure that vulnerable household members can eat.[20] This was reported by KIs in 8% of communities in March 2022. The current situation is set to worsen further in 2022[20] due to the previous year's low food production[11] leading to diminished food reserves and eroded purchasing power, while the difficult geopolitical situation of Syria[58] and rising global food prices[62] make food imports expensive.

23. SMEB Price of Food (in SYP)



24. Change in Proportion of Households Growing Crops between June 2021 and March 2022



The crisis has mainly impacted health through reduced access to safe drinking water and water for hygiene, as well as through reduced food security. Of particular concern are waterborne diseases as well as high rates of malnutrition. However, malnutrition monitoring in NES is incomplete and requires further attention.

Reductions in Hygiene

The changes to water consumption resulting from the crisis may have substantial impacts on human health through reductions in water availability, increased reliance on unsafe sources of water, and decreased food availability. The lack of access to and high cost of water reportedly led households to reduce their use of water for hygiene.▲ Specifically, KIs in 32% of communities reported in July and August of 2021 that households bathed less frequently; 32% reported in June that laundry was done less often; and 12% reported reduced handwashing in August.▲ This comes with a range of issues, including the spread of infectious diseases such as COVID-19[63] and the risk of skin disease.[64]

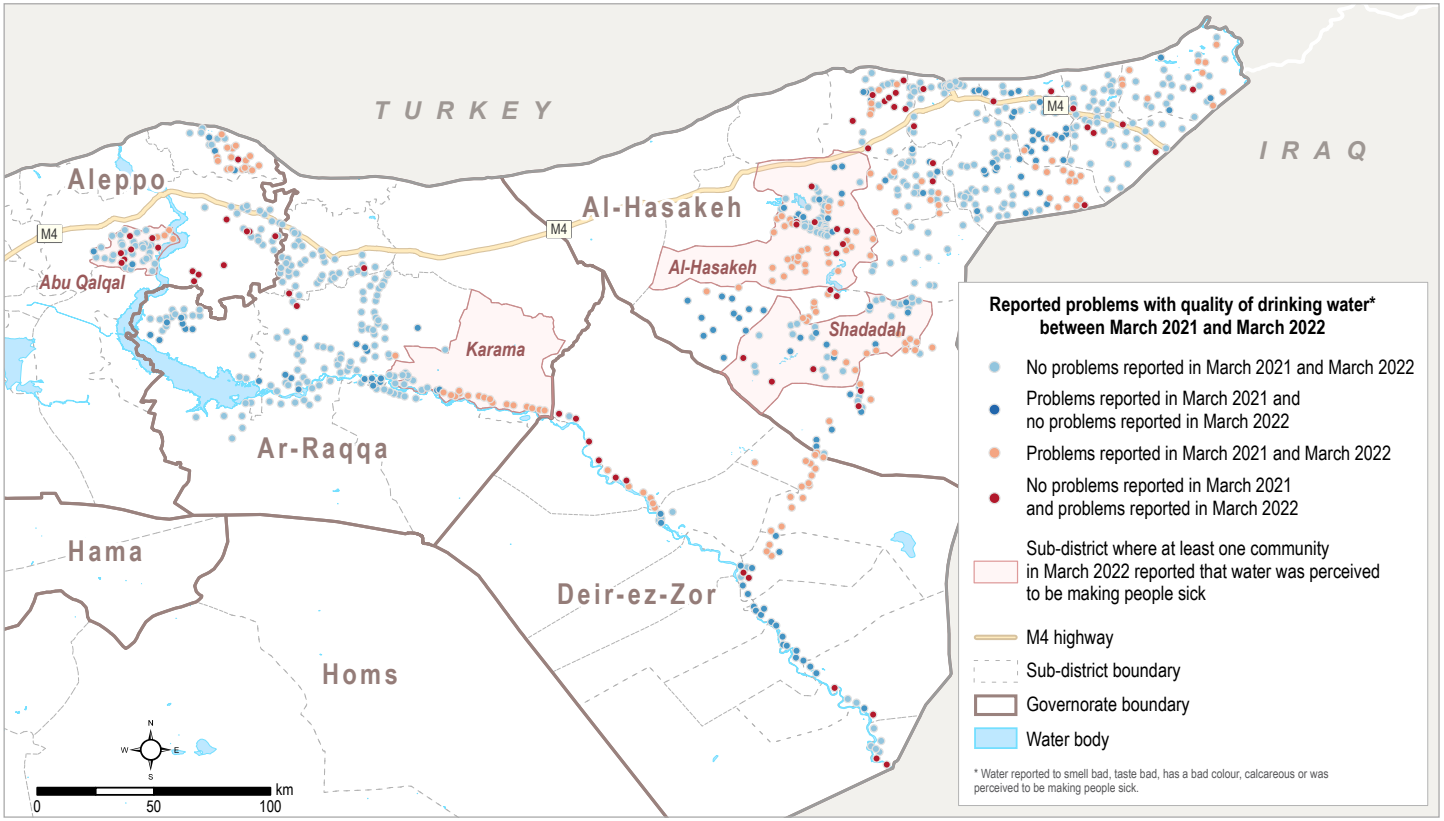
Low Water Quality

In addition, in 2021 there was an increase in communities for which KIs reported the use of private boreholes and wells as the primary water source while use of the piped network decreased. For drinking water specifically, KIs reported a greater reliance on water trucking last summer (see section Water Availability).▲ Boreholes allow access to groundwater, which is of mixed quality in Syria. Around 40% has high levels of sulphate or salt, making it unsuitable for consumption.[10] Furthermore, PAX reported on high levels of surface and groundwater pollution through leakages of oil and oil waste, unsafe waste disposal, fertilisers[j], and discharge of untreated sewage.[65] For NES, KIs in 80% of assessed communities reported that their community was not connected to the sewage network,▲ which likely impacts the quality of local water resources and increases the risk of waterborne diseases. In Ar-Raqqa and Deir-ez-Zor governorates in particular, sewage is directly evacuated into the Euphrates.[20] Not only does this impact communities on the Euphrates, but also communities sourcing water from trucks that rely on the river.

Given the issues with water quality, groundwater and water from trucks often require treatment to be safe for consumption. Chlorine for instance can be used to inactivate bacteria and viruses. Free residual chlorine then indicates that enough chlorine was used to initially sanitise the water, and that the water is

(Continues on page 25)

25. Change in Reported Problems with Quality of Drinking Water between March 2021-2022▲



protected from contamination during storage.[66] The safety of stored water is particularly important as many households rely on water previously stored as a coping mechanism.▲ However, testing conducted by HNAP in the whole of Syria last summer suggests that 19% of water from trucks and, much more significantly, 63% of water from closed wells had no residual chlorine.[67] This water was hence unprotected, making households vulnerable to waterborne diseases. Furthermore, the only difference households commonly make between drinking water and water for other uses is that they store water differently. The method of storage may protect the water from contamination, but does not make unsafe drinking water safer. Meanwhile, only 18% reported treating their water (boiling, chlorinating, filtering), according to HNAP data from summer 2021.

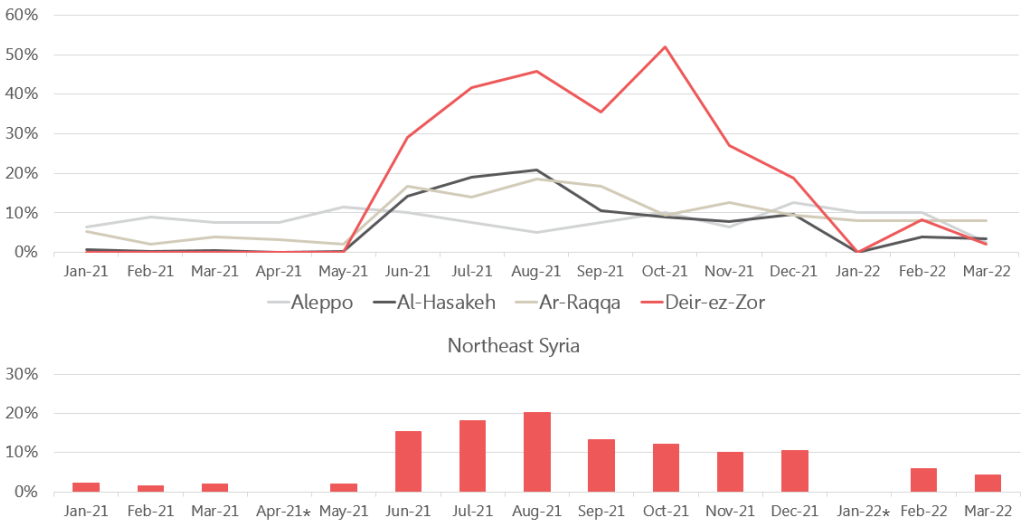
As a consequence, problems with drinking water were commonly reported in HSOS, with KIs in 35% of assessed communities reporting some issues with water in March 2022.▲ Figure 25 shows changes in reported problems with drinking water; dark red dots indicate that problems were reported in March 2022 in a community although none were reported last year. The most common issue was the water being calcareous (high levels of calcium carbonite), which is generally not harmful but may be unpleasant to consumers.[68] More concerningly, higher numbers of KIs reported that water was perceived to be making people sick last summer. At its highest point, in August of 2021, this was reported by KIs in 19% of assessed communities. Communities who reportedly relied on a mix of the network and trucking, or only private trucking, for drinking water were disproportionately affected at 19% and 32% respectively in August 2021. So too in Deir-ez-Zor, which saw the highest rates of reporting of this barrier – 53% in October, the majority of which was associated with water from trucks.[k] A common disease associated with contaminated water, but also food and reduced personal hygiene, is diarrhoea.[69] The WHO reported increased levels of acute diarrhoea in NES in 2021 compared to 2020, particularly from late March through June 2021. The highest caseload was reported in the last week of June at over 5,000 cases in a single week, compared to less than 3,000 the year before.[70] Cases in February 2022 were slightly elevated compared to 2021, though remaining below 2020 levels.[71] Cases of bloody diarrhoea were generally less common, but numbers were clearly elevated in September of 2021, around twice as high as the year before (around 300 cases per week).[70] Overall, diarrhoea is currently the second leading cause of morbidity, second only to influenza-like disease (including suspected COVID-19).[71]

Malnutrition

Besides the acute health impacts of diarrhoea, it also increases the risk of malnutrition.[69] Given the current food security issues outlined previously, the risk of malnutrition is currently high. While monitoring is incomplete, it seems that cases of malnutrition have risen since the onset of the water crisis.[6] Save the Children reported on cases of mothers going without food in favour of buying clean water, and subsequently struggling to produce enough and high-quality breastmilk. They further conducted a study in five communities in NES, which found that 7% of children between 6-59 months had severe acute malnutrition, and 13% had moderate acute malnutrition.[72] One NGO conducted localised assessments in Ar-Raqqa governorate, finding that 13% of under-5-year-olds suffered from global acute malnutrition, of which 3% suffered from severe acute malnutrition. For the whole of Syria, OCHA has reported increased levels of malnutrition, stunting (suggesting chronic malnutrition) and wasting (suggesting acute malnutrition) in children in the past year.[20] While these studies are not representative for the whole of NES, they indicate a high prevalence malnutrition.

Malnutrition has severe health impacts, particularly for children, leading to increased mortality, higher rates of disease, poor mental development and school performance, amongst others.[73] Thus, in light of poor harvest in 2021,[11] pre-existing barriers to imports[58], rising global food prices and shortages due to the conflict in the Ukraine,[49,53] it is important to closely monitor the food and nutrition situation in NES.

26. Water Perceived to Be Making People Sick (as % of assessed communities)



* In April 2021 and in January 2022, HSOS KI data was collected in a limited number of communities in NES. Regional findings are therefore omitted from the graph.

Footnotes

a. REACH HSOS data asks KIs what proportion of households in their community had access to sufficient water. Responses are classed in intervals of 20% (0%, 1-20%, 21-40% etc.). The average here is calculated by taking the midpoint of the interval (0%, 10%, 30% etc.). The 20% insufficiency reported here is the average for assessed communities, rather than of the assessed households.

b. The reduced use of the private network appears to have been compensated through the increased use of private boreholes and wells.

c. In August, a KI in one community reported the piped network as the primary water source.

d. For the Standard Precipitation Index (SPI), historical rainfall data is fitted to a probability distribution. This means that the differences between current rainfall and the long-term average can be related to how much annual difference would be expected (in terms of standard deviations). An SPI of less than -2 suggests extreme dryness (2 standard deviations lower than the long-term mean), and is extremely unlikely. Note that this only refers to meteorological drought and does not capture streamflow in rivers, groundwater levels, or such.

e. Note that this reliance on agriculture is based on KI reports of agriculture or livestock being a common source for meeting basic needs in their community, and thus does not necessarily reflect the number of people that rely on agriculture. For a subdistrict level breakdown of the percent of working aged population engaged in agriculture, please see Figure 2 in source 34, which shows particularly high rates of agriculture in parts of Aleppo and Deir-ez-Zor.

f. Reported at the same frequency as lack of access to fodder for livestock.

g. Note that a distinction is made between people who cultivated crops for income, which are people who own, rent, or otherwise have access to land on which they grow crops, and agricultural wage labourers, who are hired by farmers to work on land that is not their own.

h. Vegetation here is quantified using the NDVI, which uses satellites to measure vegetation greenness. It is useful in understanding both the density and the health of vegetation, with higher values indicating a higher density and greenness.

i. Including areas of the governorates outside of NES.

j. Fertiliser can lead to eutrophication of water, which occurs when nutrient levels in water increase. This leads to strong aquatic plant growth, depleting oxygen in the water and potentially causing harmful algae bloom which may be toxic to humans. Eutrophication has notably occurred in the Khabur river.[65]

k. KIs in 69% of communities (24 of 35) who reported a combination of the network and trucking as their primary source and 54% (19 of 35) who reported private water trucking reported that they perceived the water to be making people sick. For those who predominantly used the private network, only 13% reported this (2 of 15).

Sources

Changes in Cropland Areas

The data on cropland area referenced on p.18 (figure 18) and the changes to cropland map on p.17 (figure 17) was derived from annual cropland maps (2017-2021) produced by UNOSAT. These maps were generated based on optical satellite imagery (Sentinel-2, Landsat 8, MODIS), radar imagery (Sentinel-1), optical indices including the Normalized Difference Vegetation index (NDVI) and the Normalized Difference Water Index (NDWI), seasonality metrics, Sentinel-1-derived texture and ancillary data such as elevation and slope. To differentiate cropland from other land cover classes (e.g. water or urban areas), supervised image classification (Random Forest) was applied using training samples that were collected through visual interpretation of satellite imagery.

NDVI Graph

The data for the NDVI graph shown on p.21 (figure 21) is generated based on optical satellite imagery (Sentinel-2). Non-cropland was masked out using 10m annual cropland maps produced by UNOSAT; as the cropland map of the season 2021/2022 is not available yet, NDVI images of this season were masked with the cropland map of 2020/2021. This could lead to less accurate NDVI trends for the current season 2021/22, as active crop fields might be excluded and inactive crop fields included.

Groundwater Analysis

The GRACE satellite measures anomalous changes in gravity compared to long-term averages. At monthly scales, changes in gravity are primarily due to terrestrial water movement. Gravitational changes can therefore be converted to Terrestrial Water Storage (TWS) changes, i.e., changes in water thickness (mm). TWS is a sum of snow water, soil moisture, surface water, and groundwater storage. The groundwater storage (GWS) is defined as the water stored below the root zone soil layer and above the bedrock and derives by modeling and subtracting soil, surface, and surface water from TWS.

GWS = TWS - RootZoneSoilMoisture - SnowWaterEquivalent – CanopyInterception

SPI Methodology

The Standard Precipitation Index (SPI) describes the probability of variation from the normal precipitation over multiple years of data, on a monthly (or multiple months) time step (McKee et al., 1993). SPI is defined by the z-score deviation of the mean rainfall for a given reference period (e.g., given month of the year) in units of the standard deviation. Positive SPI values indicate greater than long-term mean rainfall (wet conditions) while negative values indicate lower than long-term mean rainfall (dry conditions).

To compute SPI, Climate Hazards Group InfraRed Precipitation With Station (CHIRPS) data CHIRPS data were used. CHIRPS have a spatial resolution of 0.05 degrees (≈ 5.5km) and a temporal resolution of one day starting in 1981.

SPI was computed in Google Earth Engine (GEE) following recommended practices by UNOSAT.

Due to limitations in GEE, a gamma probability function, which is commonly used to calculate SPI, could not be applied. Therefore, results should be interpreted as estimations of SPI.

1. Food and Agriculture Organization of the United Nations (FAO). (2021b). Syrian Arab Republic : Precipitation analysis, 1980-2021. https://www.fao.org/emergencies/resources/documents/resources-detail/en/c/1444881/

2. NES WASH Working Group. (2022b). Euphrates Water Level Dashboard.

3. REACH. (2021a). Briefing Note: Humanitarian Situation Overview in Northeast Syria. https://www.impact-repository.org/document/reach/b2f66abb/REACH_SYR_Briefing-Note_Humanitarian-Situation-Overview-in-Northeast-Syria_June-2021.pdf

4. iMMAP. (2021c). Water Dynamics, Crises, and Challenges in Northeastern Syria.

5. Humanitarian Access Team (HAT). (2021a). Drought, Pollution and the Euphrates : Measuring agriculture water stress in northeast Syria.

6. Food Security Cluster. (2021). WATER CRISIS IN NORTHERN AND NORTHEAST SYRIA Immediate Response and Funding Requirements. https://fscluster.org/sites/default/files/documents/response_plan_water_crWoSs_in_northern_and_northeast_syria_september_2021.pdf

7. European Commission - Copernicus Emergency Management Service. (2022a). GDO - Global Drought Observatory: Compare Monthly Maps. https://edo.jrc.ec.europa.eu/gdo/php/index.php?id=2075

8. European Commission - Copernicus Emergency Management Service. (2022b). GDO - Global Drought Observatory: MapViewer. https://edo.jrc.ec.europa.eu/gdo/php/index.php?id=2001

9. European Commission - Copernicus Emergency Management Service. (2020). Standardized Precipitation Index (SPI). https://edo.jrc.ec.europa.eu/documents/factsheets/factsheet_spi.pdf

10. Baba, A., Al Karem, R., & Yazdani, H. (2021). Groundwater Resources and Quality in Syria. Groundwater for Sustainable Development, 100617. https://doi.org/10.1016/j.gsd.2021.100617

11. Food and Agriculture Organization of the United Nations (FAO). (2021a). Special Report : 2021 FAO Crop and Food Supply Assessment Mission to the Syrian Arab Republic. https://www.fao.org/3/cb8039en/cb8039en.pdf

12. Adamo, N., Al-Ansari, N., Sissakian, V. K., Laue, J., & Knutsson, S. (2018). The Future of the Tigris and Euphrates Water Resources in View of Climate Change. Journal of Earth Sciences and Geotechnical Engineering, 8(3), 59-74. https://www.diva-portal.org/smash/get/diva2:1199706/FULLTEXT01.pdf

13. Mueller, A., Detges, A., Pohl, B., Reuter, M. H., Rochowski, L., Volkholz, J., Woertz, E. (2021). Climate change, water and future cooperation and development in the Euphrates-Tigris basin. Cascades. https://www.cascades.eu/wp-content/uploads/2021/11/Euphrates-Tigris-Report_Final.pdf

14. WASH Working Group. (2021). Euphrates Crisis Dashboard.

15. Office for the Coordination of Humanitarian Affairs (OCHA). (2021). Syria: Alouk Water Station. https://www.unicef.org/mena/media/12066/file/OCHA%20Syria_%20Alouk%20Flash%20Update_FINAL[77].pdf.pdf

16. NES WASH Working Group. (2022a). Alouk Station and Himme Reservoir - Daily Status.

17. Humanitarian Needs Assessment Programme (HNAP). (2021). Demographic, Socioeconomic, Priority Needs & WASH Household Survey.

18. HNAP. (2021). Summer 2021 Report Series - Socioeconomic Situation.

19. Humanitarian Access Team (HAT). (2021b). Syria Year in Review 2021.

20. Office for the Coordination of Humanitarian Affairs (OCHA). (2022). Humanitarian Needs Overview - Syrian Arab Republic.

21. REACH. (2022). Northeast Syria Market Monitoring Exercise - Snapshot: 6th-13th December 2021. https://www.impact-repository.org/document/reach/905ddce1/REACH_SYR_Northeast_Situation-Overview_Market-Monitoring_Sep_2021.pdf

22. Layall, N., & Shaar, K. (2021). Three signs of impending famine in Syria absent immediate action. In: Operations & Policy Center. https://opc.center/three-signs-of-impending-famine-in-syria-absent-immediate-action/?fbclid=IwAR3FWtCUOsxuzGdPz0gHcZBmPYL2JX8eVMcrZV_4U6NU3Wjj4KZDHzH7Jq4

23. Al-Monitor Staff. (2021). NGOs in northeast Syria warn of low water levels in the hydroelectric dams. Al-Monitor. https://www.al-monitor.com/originals/2021/05/ngos-northeast-syria-warn-low-water-levels-hydroelectric-dams

24. Amini, A., Zareie, S., Taheri, P., Yusof, K. B. , & Mustafa, M. R. u. (2016). Drought Analysis and Water Resources Management Inspection in Euphrates–Tigris Basin. In (Ed.), River Basin Management. IntechOpen. https://doi.org/10.5772/63148

25. Christou, W. (2021a). Fuel shortage chills northeast Syria as oil production lags. Al-Monitor. https://www.al-monitor.com/originals/2021/03/syria-administration-fuel-gas-bread-people.html

26. Al-Kassab, H. (2021). As the level of the Euphrates River drops, Syrian civilians on its banks pay the price. Syria Direct. https://syriadirect.org/as-the-level-of-the-euphrates-river-drops-syrian-civilians-on-its-banks-pay-the-price/

27. Mohamed, D. (2022). The Reason For The Increase In Rationing Hours. North Press Agency. https://npasyria.com/92194/

28. al-Midan, A. (2021). Syria's east Deir ez-Zor regions lack power, residents use alternatives. North Press Agency. https://npasyria.com/en/58664/

29. Hataher, S., & Shaar, K. (2021). Syria's Electricity Sector After a Decade of War: A Comprehensive Assessment. https://middleeastdirections.eu/new-publication-wpcs-syrias-electricity-sector-after-a-decade-of-war-a-comprehensive-assessment-sinan-hatahet-and-karam-shaar/

30. al-Shuweikh, B. (2021). Solar power the alternative to supply electricity in Syria's Hasakah countryside. North Press Agency. https://npasyria.com/en/61897/

31. Balanche, F. (2022). How to Preserve the Autonomy of Northeast Syria. The Washington Institute for Near East Policy. https://www.washingtoninstitute.org/policy-analysis/how-preserve-autonomy-northeast-syria

32. NES WASH Working Group. (2022c). The 2021 Euphrates Water Crisis in North-East Syria: Story of a WASH response.

33. iMMAP. (2021d). Wheat-to-Bread Processing Facilities Mapping. https://reliefweb.int/sites/reliefweb.int/files/resources/NES-WtB-Summary-Report-November_V2_020222.pdf

34. North East Syria Agriculture Working Group (AWG), iMMAP, Food Security and Livelihood Unit (FSLU), & Geoinformatics Unit. (2021). Crop Monitoring and Food Security Situation Update. https://immap.org/product/crop-monitoring-and-food-security-situation-update-in-north-east-syria/

35. Kelley, C. P., Mohtadi, S., Cane, M. A., Seager, R., & Kushnir, Y. (2015). Climate change in the Fertile Crescent and implications of the recent Syrian drought. Proceedings of the national Academy of Sciences, 112(11), 3241-3246. https://doi.org/10.1073/pnas.1421533112

36. Ülker, D., Ergüven, O., & Gazioglu, C. (2018). Socio-economic impacts in a changing climate: Case study Syria. International Journal of Environment and Geoinformatics, 5(1), 84-93. https://doi.org/10.30897/ijegeo.406273

37. Al-Riffai, P., Breisinger, C., Verner, D., & Zhu, T. (2012). Droughts in Syria: an assessment of impacts and options for improving the resilience of the poor. Quarterly Journal of International Agriculture, 51(892-2016-65162), 21-49. https://ageconsearch.umn.edu/record/155471/files/2_Al-Riffai.pdf

38. European Commission - Copernicus Emergency Management Service. (2022c). Global Drought. https://edo.jrc.ec.europa.eu/gdo/php/index.php?id=2001

39. Daoudy, M. (2022). Scorched Earth - Climate and Conflict in the Middle East. Foreign Affairs. https://www.foreignaffairs.com/articles/middle-east/2022-02-22/scorched-earth

40. Food and Agriculture Organisation of the United Nations (FAO). (2017). Counting the cost : Agriculture in Syria after six years of crisis. https://www.fao.org/emergencies/resources/documents/resources-detail/en/c/878213/

41. World Food Programme. (2022a). Irrigation means food on the table for a family in Syria. https://www.wfp.org/stories/irrigation-means-food-table-family-syria

42. Merhi, A. (2021). From second largest exporter to importer: Syria loses "white gold" [translated from Arabic]. al-Akhbaar. https://al-akhbar.com/Syria/327793

43. North Press Agency. (2021). On World Cotton Day, what about Syrian farmers? https://npasyria.com/en/65748/

44. iMMAP. (2021b). Livestock Market Systems Rapid Assessment. https://reliefweb.int/sites/reliefweb.int/files/resources/iMMAP-Livestock-Rapid-Market-Systems-Assessment-in-Northeast-Syria.pdf

45. AFP. (2021). Syrian shepherds suffer with grazing lands a no-go zone. https://www.france24.com/en/live-news/20210507-syrian-shepherds-suffer-with-grazing-lands-a-no-go-zone

46. iMMAP. (2022). Northeast Syria Flash Report - Deterioration of the Livestock Feed and Fodder Market. https://reliefweb.int/report/syrian-arab-republic/northeast-syria-flash-report-deterioration-livestock-feed-and-fodder

47. Schwartzstein, P., & Zwijnenburg, W. (2022). We fear more war, we fear more drought. In: PAX for Peace. https://reliefweb.int/report/syrian-arab-republic/we-fear-more-war-we-fear-more-drought-how-climate-and-conflict-are

48. Hardan, M. (2021). Syrian livestock depleted by war, failing economy. Al-Monitor. https://www.al-monitor.com/originals/2021/02/syria-livestock-sector-agriculture-animals-prices-imports.html

49. Graham, N., & Pe'er, I. (2022). Putin's invasion of the Ukraine threatens a global wheat crisis. Atlantic Council. https://www.atlanticcouncil.org/blogs/econographics/putins-invasion-of-ukraine-could-spark-a-global-food-crisis/

50. United Nations Human Rights Council. (2010). Report of the Special Rapporteur on the right to food, Olivier De Schutter. http://www2.ohchr.org/english/bodies/hrcouncil/docs/16session/A.HRC.16.49.Add.2_en.pdf

51. Woertz, E. (2013). What do Syrians eat? Food and the war economy. openDemocracy. https://www.opendemocracy.net/en/what-do-syrians-eat-food-and-war-economy/

52. iMMAP. (2021a). COVID-19 Situation Analysis. https://immap.org/wp-content/uploads/2016/12/Final-Copy-for-publication-First-Annual-Review-Syria-Situation-Analysis_June-2021.pdf

53. Mauvais, L. (2022). From sovereignty to dependence: How Russia's war threatens food security in Syria. Syria Direct. https://syriadirect.org/from-sovereignty-to-dependence-how-russias-war-threatens-food-security-in-syria/

54. Christou, W. (2021b). Syrians in Kurdish-administered regions struggle with price of bread. Al-Monitor. https://www.al-monitor.com/originals/2021/02/syria-northeast-kurdish-administration-bakeries-bread-price.html

55. COAR. (2022). Syria's Wheat Crisis Foreshadows Famine. https://coar-global.org/2022/01/10/syrias-wheat-crWoSs-foreshadows-famine/

56. Syrian Observatory for Human Rights. (2021). Broad popular discontent \ Autonomous Administration raises price of bread loaf to 500 SYL. https://www.syriahr.com/en/223253/

57. REACH. (2021b). Northeast Syria Market Monitoring Exercise - Snapshot: 6th-13th September 2021. https://www.impact-repository.org/document/reach/905ddce1/REACH_SYR_Northeast_Situation-Overview_Market-Monitoring_Sep_2021.pdf

58. Rantisi, A. (2022). The alternative solutions for turbulent "Semalka" - Conflict of interest shadowing border crossings in Autonomous Administration regions. https://english.enabbaladi.net/archives/2022/03/conflict-of-interest-shadowing-border-crossings-in-autonomous-administration-regions/

59. Masri, Z., al-Mahmoud, H., & al-Jeratli, K. (2021). Syrias Wheat Crisis Foreshadows a Famine. enab baladi. https://english.enabbaladi.net/archives/2021/12/syrias-wheat-crisis-foreshadows-a-famine/

60. Humanitarian Access Team (HAT). (2021c). Weekly Report : 3-9 December 2021.

61. World Food Programme. (2022b). Syria mVAM Bulletin Issue no. 64: February 2022. https://reliefweb.int/sites/reliefweb.int/files/resources/WFP-0000138069.pdf

62. BBC. (2022). Ukraine war causes giant leap in global food prices, says UN. https://www.bbc.com/news/business-61036715

63. Médecins Sans Frontiers. (2021). Northern Syria: Acute water crisis poses serious health risks. https://www.msf.org/lack-funding-northern-syria-causes-water-crWoSs-and-serious-health-problems

64. Centers for Disease Control and Prevention (CDC). (2020). Health Implications of Drought. https://www.cdc.gov/nceh/drought/implications.htm

65. Zwijnenburg, W., Nahas, N., & Vasquez, R. J. (2021). War, Waste, and Polluted Pastures. https://paxforpeace.nl/media/download/PAX_WWPP_v2.2.pdf

66. Center for Disease Control and Prevention. (2022). Free Chlorine Testing. Retrieved 23rd March 2022 from https://www.cdc.gov/healthywater/global/household-water-treatment/chlorine-residual-testing.html

67. WASH Cluster (2021). WoS - WASH Assessment 2nd Round 2021 - May/June.

68. McVean, A. (2019). Is hard water dangerous to drink? McGill Office for Science and Society. Retrieved 07.04.2022 from https://www.mcgill.ca/oss/article/health-you-asked/you-asked-hard-water-dangerous-drink

69. World Health Organisation. (2017). Diarrhoeal disease. Retrieved 07.04.2022 from https://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease

70. World Health Organisation. (2021). EWARS Monthly Epidemiological Bulletin: Syria - NES : December of 2021 (Epi weeks 48-52). https://reliefweb.int/sites/reliefweb.int/files/resources/nes_epi_bulletin_december.pdf

71. World Health Organisation. (2022). EWARS Monthly Epidemiological Bulletin: Syria - NES : February of 2022 (Epi weeks 5-8). https://reliefweb.int/sites/reliefweb.int/files/resources/nes_epi_bulletin_february_2022.pdf

72. Save the Children. (2022). Syria 11 Years: Children Still Being Bombed, Facing Hunger and Malnutrition. https://www.savethechildren.net/news/syria-11-years-children-still-being-bombed-facing-hunger-and-malnutrition

73. Martins, V. J., Toledo Florêncio, T. M., Grillo, L. P., Franco, d. C. P., M., M., P. A., Clemente, A. P., . . . Sawaya, A. L. (2011). Long-Lasting Effects of Undernutrition. https://doi.org/10.3390/ijerph8061817

74. Simoes, A.J.G., Hidalgo, C.A. (2021). The Economic Complexity Observatory: An Analytical Tool for Understanding the Dynamics of Economic Development. Workshops at the Twenty-Fifth AAAI Conference on Artificial Intelligence. https://oec.world/en/visualize/tree_map/hs92/export/syr/all/show/2010/